Australian Government

Australian Centre for International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/017 v1
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Project Variation

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Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/017
Project title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Proposal stage	Full Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/09/2019
Proposed finish date	[redacted]

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1 Project Summary

1.1 Background and Justification

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupts access to vital spawning, nursery and feeding habitat. The LMB fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, will be operational in 2019. Xayaburi Dam blocks the entire width of the river, presenting an impassable barrier to all fish species. Significant investment (US$300M) to provide for fish passage was incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world. Nevertheless, the facilities need to be rigorously assessed to determine if they meet the design specifications.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. The dam design includes a series of 70 different moveable gates which can be configured to alter fish pass flow in order to improve passage rates for specific species and/or specific seasonal flows. The project team will be able to, within the funding envelope on offer, adaptively alter the configuration of the fishway and determine if different settings alter passage rates for particular fish species and their life stages, and for different seasonal flow rates. This will provide XPCL with operational recommendations to optimise the performance of their facilities overall. This represents a substantial challenge and the question of whether the fish passage facilities will be effective in allowing a large proportion of fish numbers and species to pass is a question that the developer, Government of Lao PDR and scientists are all keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential to be developed in regions where poor people are dependent on natural resources. The Xayaburi facilities provide an opportunity to design and commence experiments to test the efficiency of the fish passage design, and to apply/adapt learnings to other sites.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods that will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and *in situ*. These trials will be used to install a functional tag detection system which will be used. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust approaches to calculating fish pass efficiency. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Assess upstream fish passage within the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the 30-year concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). The overall project budget, excluding the SRA commitment, is split between three cash contributors [redacted] XPCL are providing an estimated FOI Act s. 47
[redacted], as significant additional in-kind support over the three year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defendable, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used to improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its support or publication of results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to other sites, for example, both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities and monitoring programs. The research methods developed here may lead to a new set of standards that can be applied at other sites.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams) (Commission 2010). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB (Hortle 2007, Baumgartner et al. 2016). Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein (ICEM 2010). Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction (Amornsakchai et al. 2000). The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade (Commission 2010), there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong's productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB (Orr et al. 2012). All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing a productive river fishery. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 95% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. This work was done by a US company and did not involve Australian expertise. XPCL has invested US$300 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America (Williams 2008), but where investment only targets salmon species. XPCL invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site. The purpose was to exchange information especially in relation to possible future

research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.2 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households (Hortle 2007). Most rural Asian citizens are actively involved in inland capture fisheries and river, and fishery health is crucial to securing food and income for local communities (Dugan et al. 2006, Millar et al. 2018). The Xayaburi Dam was expected to have a potential impact on upstream food resources; which is why a fish pass is being constructed. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It will also address an important planning need across the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development (Dugan et al. 2006). Irrigation development has negatively impacted inland fisheries (Dudgeon 2000). This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating positive outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing (Siason et al. 2010). Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has brought together an international team of private, developmental and governmental sectors to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to develop methods which will be available to quantify fisheries migration studies into the future.

2.3 Relationship to other ACIAR investments and other donor and partner-country activities

2.3.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (Australian Government AusAID 2012). By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies if the fish pass is effective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising female professionals to use the newly established research infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining robust fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome 'Agriculture, Fisheries and Water'. Hydropower development is one of the most significant water management issues in the LMB; and Xayaburi Dam, being the first site, is of particular significance and international interest. This project has been initially established as a four-year initiative with cash funding provided by [redacted] Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due in December 2019. To maintain continuity for project staff, the large follow-on project must commence in August 2019. FOI Act s. 47

2.3.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in researching the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies on all aspects of fish passage (upstream and downstream). XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.4 Research questions

2.4.1 Xayaburi fishpass overview

Specific design parameters were incorporated into the dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Fig. 1). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

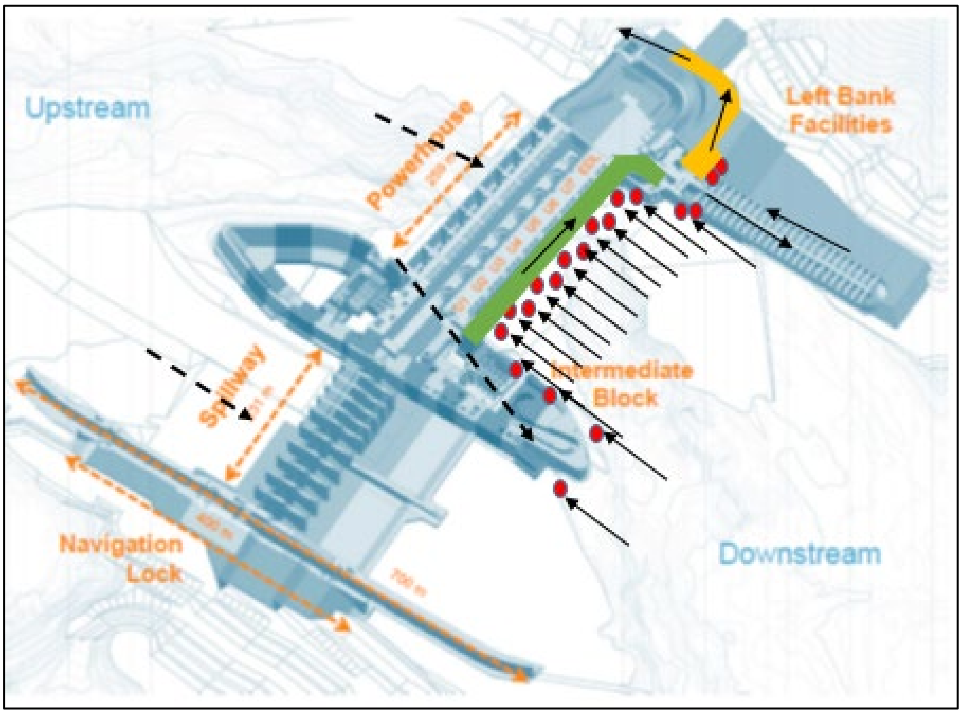


Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

2.4.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	**Potential research methods**
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	**Potential research methods**
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

2.4.3 Request from XPCL: Final selection of Research Questions

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, is beyond the scope of the available budget so the ACIAR/DFAT team is only focusing on methods to assess upstream fish passage at this stage. Consequently, the research questions posed are:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

2.4.4 Previous work on fish species selection for passage

There have been a number of fish studies done in the region of the dam as part of the environmental approval process, as well as earlier studies – in both the published and grey literature. These have generated a list of 308 potential adult species in the region, many of which are migratory.

Part of the GoL conditions of approval was that XPCL are required to provide for migratory fish to pass through the dam. To ensure the fish passage design catered to the slowest swimming species, FishTek, a British consulting company, performed a series of fish passage trials to identify the swimming abilities of key species. The swimming abilities of the slowest species formed the basis for the final design decisions for the fishway engineering. The GoL and XPCL agreed on a list of 26 potential migratory adult species (Table 2) that were the most important to monitor for effective passage. Their criteria for importance were based on a combination of food security and conservation significance.

XPCL contracted fishermen surveys to identify important species to the local fishers and communities (Team consulting, 2014). Using this study and others done in the region, we have highlighted in Table 2 (in bold) those species considered important for food security for local communities.

Thus, fish species selection in the project will be based on:

i) Those species that have been listed as important to pass through the fish passage by the GoL/XPCL, which includes species important to food security for local communities and conservation significance, and

ii) Those species that can be successfully tagged, released and monitored.

2.5 Gender focus

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong River bank in Xayaburi and Luang Prabang provinces, with seven of these requiring relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP has to enhance the quality of life for the project affected people (PAPs) and to minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Our research team is playing a very small, but important, role within XPCL's community consultation process. Our team will participate within the XPCL monitoring framework. In particular, we will engage with the XPCL consultation framework through our Lao government partners to ensure our decisions about fish species selection in relation to food security are endorsed by locals; including men and women. We also plan to include a Lao national on a project reference panel, so will report to them on our level of engagement with communities and inclusion of gender perspectives on key decisions, particularly regarding species selection.

Consideration of gender within the research team

Our research team consists of XPCL staff, Laos government (LARReC) and university staff (NUOL) and the Australian team. The XPCL monitoring team was selected by the company and staff were allocated to our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately, this has provided a gender structure among the project team which is predominantly male.

Outside the nominated project team in-country, the Australian team strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female Australian honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, but that the team is more balanced.

3 Research strategy and partnerships

3.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass, upstream, large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems.

The logical sequence for the proposed research is to:

1. Perform laboratory and *in situ* trials of three techniques (PIT detection antennas, electrofishing boat and a long-term tagging study) to optimise tag and recapture methods
2. Implement these methods at the dam site

3. Perform real-time monitoring of upstream fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual upstream fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, to report on the daily operation of the fish pass
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. Most of the current knowledge pertaining to the effectiveness of fishway designs has been for temperate species, and/or has come from laboratory-based trials (Mallen-Cooper 1992), whereas very little knowledge has been obtained via *in situ* field-based evaluations (Baumgartner et al. 2012). Indeed, only two *in situ* fishway evaluations have been published thus far in the LMB (Baumgartner et al. 2012, Baumgartner et al. 2018). At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defendable; and
c) When combined, provide an overall picture of upstream fish pass effectiveness.

4.1 Project aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities to move fish upstream.

The project team has been asked to provide advice on optimizing fish passage performance, not to set targets for triggering changes in operational procedures. We will select a subset of the 70 moveable gates within the fish passage design as reference points for fish pass performance. Each of these reference points will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. The results for various species, life stages and times of the year will be used to establish maximum achievable passage rates for each target species. These rates will be used to advise when and what operational changes should be made to the fishway to optimise the fishway's effectiveness for the target species, life stages and/or times of year.

The specific objectives are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

We note that passing fish downstream, including eggs and larvae, is also a significant challenge at the site. However, at this stage the team has only been asked to focus on upstream moving fish through the fish pass facilities. Downstream movement studies are equally important but, at this stage, are beyond the scope of the available budget and

request from XPCL. The team are very experienced with downstream movement work and can consider additions at a later stage if requested and appropriately resourced.

4.2 Research activities, methods and outputs

4.2.1 Monitoring upstream fish movement at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods (Williams 2008). Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters) (Williams 2008). In terms of fish monitoring research, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation, thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field

6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system), but have low overall ongoing running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely (Castro-Santos et al. 1996). At other dam sites world-wide, PIT data is being used to advise daily operations in relation to upstream migration rates. For instance, Bonneville Dam on the Columbia River (USA) has an elaborate set of fish passes and PIT systems (Williams 2008). The PIT systems report daily fish movement rates, both upstream and downstream, to a cloud-based database. Scientists monitor, in real time, passage rates and species arrivals. The PIT systems also report entrance efficiency and percentage passage rates based on pre-calculated algorithms. When different species arrive, or passage rates change, the flow rates through the dam gates or fishway channel are changed to maximise efficiency. These are ways in which PIT data can be used to provide real-time feedback between fish movement efficiency and dam operations.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

Integrity: This is the critical component of any system. A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

Veracity: It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system, a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events.

Reliability: This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency.

In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance (Castro-Santos et al. 1996). They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Selection of fish tracking technologies relevant to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL need to demonstrate through their research and monitoring program that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific upstream fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate fish are moving upstream.

PIT tags were determined to be a suitable technology upon which to base initial trials for upstream migration studies. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully (Castro-Santos et al. 1996, Baumgartner et al. 2010), (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in*

and *ex-situ*. Based on successes at other dam sites internationally (Castro-Santos et al. 1996, Baumgartner et al. 2010), PIT tagging has been identified as the most suitable technique. If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase (18 months): There is the actual testing (offsite) and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation.

(2) Operational Implementation (18 months): Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise the Xayaburi fishway's adjustable settings and integrate fish movement requirements into dam operation management.

4.2.6 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a “high dam” fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA) (Williams 2008). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System (PTAGIS) framework. PTAGIS is a large, spatially integrated upstream fish migration monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is ‘pinged’ within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement (Downing et al. 2001, Williams 2008).

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass (Barrett and Mallen-Cooper 2006). Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative

benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales) (Barrett and Mallen-Cooper 2006). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to that based on PTAGIS (See https://www.ptagis.org/). With two such systems operating successfully in cascade rivers internationally, and with a cascade proposed for the LMB, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

4.2.7 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a 'loop' that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency (K. Pomorin pers. comm.). PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway 'slots' to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions. The team have identified research questions that could be answered using a PIT system installed into the slots (of various widths) located along the length of the fish passage (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each is necessary.

Stage 2: Obtain detailed engineering drawings. The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped to identify optimal design configurations.

Stage 3: **Construct prototype antennas and set up 'in the dry'.** KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions; Figure 2). The antennas, as indicated in the options diagrams over page, will be constructed. The efficiency tests will be performed scientifically. Antennas will be tested for a range of width's and length's and two tag sizes will be assessed (23 mm tag and 12mm tag). The 12 mm tag is preferable as it is much smaller and produces a lower "tag burden" on fish. However, it has a smaller read-range

than the 23mm tag. Determining if 12 mm tags will perform efficiently with large antennas is essential. The approach will be to construct and establish each antenna, take five tag readings (each of a 12 mm and 23 mm tag) and record the read distances (in cm). These readings will be plotted to provide an efficiency map for each antenna morphology. This approach is considered world-standard for antenna efficiency tests.

Figure 2. Slots where antennas are proposed to be installed and possible configurations.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the *ex situ* test in stage four in terms of percent number of tagged fish detected (See Table 3 for list of fish passage criteria to be assessed), we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these *in situ* tests will then advise the locations where fixed antennas should be located.

Additionally, and based on *ex situ* testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway. Here we will initially focus on the entrance and exit locations of the fishway. A ‘bank’ of antennas will be fitted to the entrance slots; a second ‘bank’ will be fitted to the exit slots.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

4.2.8 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable

because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others) (Thorstad et al. 2013). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

<u>*Research activities*</u>

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 300 migratory species at the Xayaburi site and at least 26 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Two previous fish studies have been conducted at the site. The first, by “Team Consulting”, and the second by “FishTek”. These studies firstly, quantified the species present on site and, secondly, determined the swimming ability of these species to inform fishway design. These data, along with information from the community consultations as to which species are important food sources, was used to generate a shortlist of potential priority species for fish passage. (Table 2). The fish pass infrastructure was designed specifically to accommodate these species. What is unknown is whether these species are optimal candidates for PIT tagging. It is proposed, to test the efficacy of PIT tagging for each species under laboratory conditions.

Stage 2: Construct a fish hatchery facility to house the wild caught fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction is due for completion in June 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial ACIAR-funded work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish (Grieve et al. 2018a). So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days (Grieve et al. 2018a). However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the batch of tagged fish to inform on fishway operation.

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

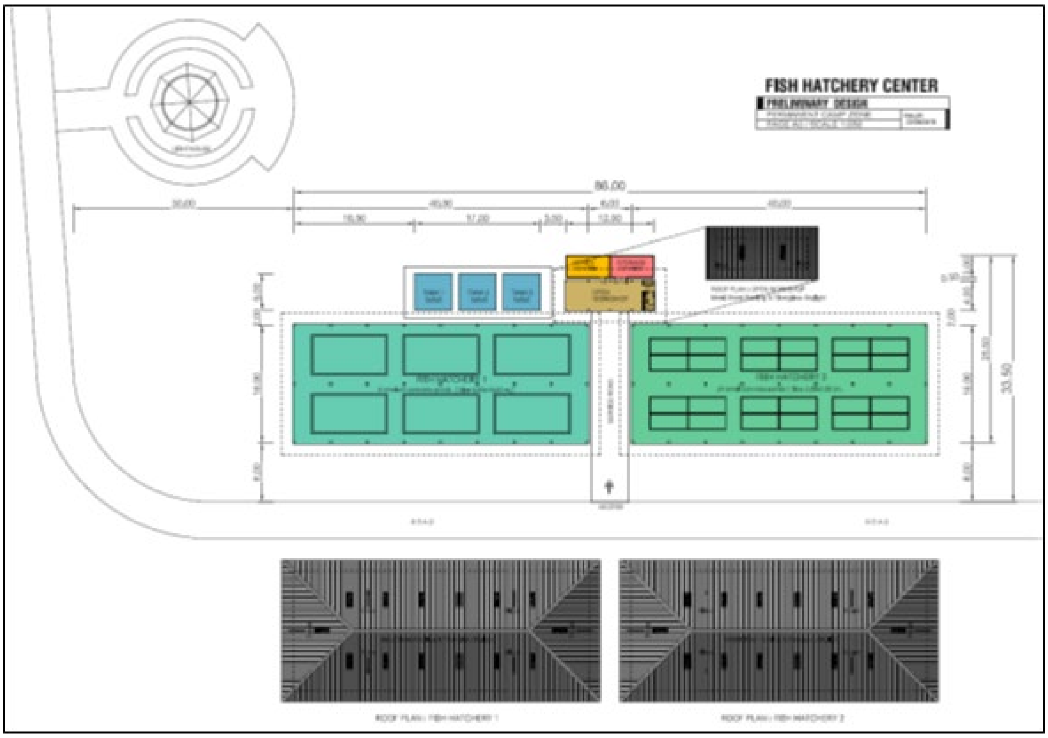
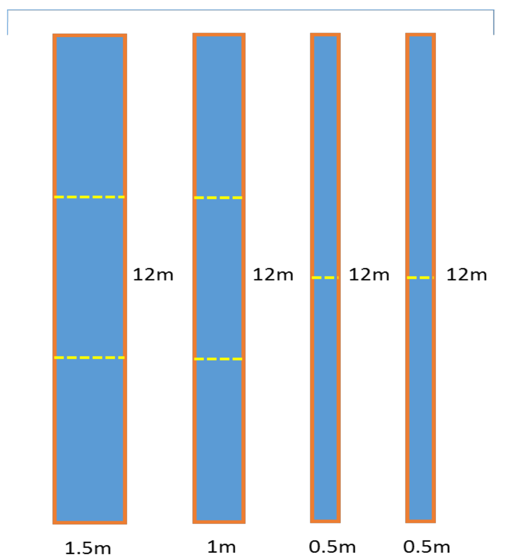


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	**Diagram**
Maximum predicted number of antennas for each width of fish slot in the fish passage: three antennas for the wider slots (1.5 and 1m), and two for the two narrower slots (0.5 m). antenna fitted into the 12m high fish slots. Number of slots to be fitted = 8.	

4.2.9 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. However, gill netting is a harsh technique that can cause stress and, in extreme cases, impact survival. Tagging a fish that has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish (Sigourney et al. 2005). It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL has provided all funds to purchase the vessel and will allocate contractors to fit out the vessel. This was on the basis that CSU can guide operation and train Lao government, University and XPCL staff in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish (Bohlin et al. 1989). It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival (Burkhardt and Gutreuter 1995). It is widely used in Australia, and Charles Sturt University will run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river; therefore, combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. There are two commonly applied approaches to electrofishing; the "grunt method" and the "power transfer" method.

For the "grunt" method, the boat is started and the voltage settings gradually raised until the generator is significantly working to input electricity into the water. It is the most commonly applied approach in Australia.

For the "power transfer method", the electrofisher settings are optimised to the water conductivity. "Power transfer theory" predicts that electrofishing will be optimised when the conductivity of the fish matches that of the water. As such, voltage and amperage settings can be optimised depending on the water conductivity in order to match, as closely as possible, the target species.

For this research component, we will compare the "grunt" and "power transfer" fishing methods. We will need to firstly determine the "conductivity" of the target species. This is achieved by using a multimeter to measure the conductivity of target fish. Then we will

manipulate the voltage settings of the electrofishing unit (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong. For each electrofishing “shot” all species will be collected, measured and weighed. Statistical analyses will be performed to determine if any differences exist between the two methods.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into the Mekong River Commission Design Guidelines for Mainstem Dams.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

Table 2. List of migratory adult species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Green indicates the upstream migration season and yellow the downstream migration season. Imp column indicates the primary importance of the species whether for food, conservation or income.

Species	Imp	Local name	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Cyclocheilichthys enoplos	F	Pa Joke												
Cyclocheilichthys repasson	F	Pa Joke-sai												
Henicorhynchus lobatus	F	Pa Sroi												
Labeo chrysophekadion	F, I	Pa Pia												
Hemibagrus nemurus	F, C, I	Pa Kod												
Mekongina erythospila	F	Pa Sa-ee												
Sikukia gudgeri	F	Pa Mang												
Chitala sp.	F, I	Pa Tong												
Pangasius macronema	F, C, I	Pa Yorn												
Hemisilurus mekongensis	F, C, I	Pa Dangdaeng												
Phalacronotus apogon	F, I	Pa Sa-ngua												
Bagarius suchus	F, I	Pa Khae												
Paralaubuca typus	F	Pa Teab												
Tenulosa thibaudeaui	F	Pa Mak-pang												
Pangasianodon hypophthalmus	F, C, I	Pa Sway												
Cyprinus carpio carpio	F, I	Pa Nai												
Yasuhikotia modesta	C	Pa Kiaw-Gai												
Macrochirichthys macrochirus	F	Pa Fak-pa												
Pristolepis fasciata	F, C	Pa Chang-yeab												
Pangasius bocourti	F, C, I	Pa Phor												
Pangasius conchophilus	F, C, I	Pa Mong												
Pangasius larnaudii	F, C, I	Pa Thay-po												
Phalacronnotus bleekeri	F, C, I	Pa Sa-ngua												
Wallago attu	F, C, I	Pa Kaow												
Hemibagrus filamentus	F, C, I	Pa Kod-rueng												
Pangasianodon gigas	C	Pa Buek												

4.2.10 Research component 4: Measuring upstream fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study the project team were to use PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations which are all being applied to the work at Xayaburi. So the team are starting from a strong knowledge and experience base.

For application at Xayaburi there is a defined chronological sequence that needs to be completed in order to arrive at this research component. For example, the antennas must be installed, then it will be possible to use the PIT system to determine the overall efficiency of the fish pass. The tag validation trials must have been completed, and we must be able to collect sufficient sample sizes of fish. Some of this is seasonal and some will vary annually. So the proposed species list will need to be revised on an opportunistic basis.

Once all stages are completed, and if the PIT tag system reveals that the fish pass is demonstrated to be sub-optimal (for one or more species), then the dam constructors have incorporated a series of 70 different moveable gates which can be configured to alter fish pass flow in order to determine if improved passage has been achieved. So the project team will be able to adaptively alter the configuration of the fishway and determine if different settings alter passage rates.

It is important to emphasise here that optimal passage rates are difficult to set at this fish pass facility. Our approach will be to record the current rates, seek to understand where design points could be improved and manipulate the adjustable gates to optimise passage rates. So our aim is to achieve a change in percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation (using methods developed in research component 2). Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will shed tags, there will be a need to re-tag fish in every year to maintain a sufficient sized pool of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating at maximum efficiency.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	~~Conclude~~ Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	Covid has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos Assumes that remote training will be effective To minimise risk, training will continue under the instruction of Dr Wayne Robinson (whilst he is based in Laos)	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on Covid-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during Covid travel restrictions	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.7	Project steering committee meeting (May need to be delayed depending on Covid-19)	Hold team meeting on site	Nov 2020 Or pushed into early 2021 if travel restrictions continue	All milestones are met	Project progress is on track

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	~~Aug 2022~~ Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are four main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission and community beneficiaries.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway for upstream migrants.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.

The Mekong River Commission (MRC) is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “Mainstem Dam Hydropower Guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a “Joint Environmental Monitoring Initiative” (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. There is some overlap between the JEM initiative and the proposed research plan. Where overlap exists, then is an opportunity to ensure that so that results can inform the environmental monitoring requirements and standards for future dams. We will also be the first to have trialled many of these technologies on the Mekong. So there is significant interest from the JEM team, where there is obvious mutual interests, to integrate their training of local staff with the technologies being implemented on site. Of prime importance is that the process of fish selection for testing considers the food security needs of impacted communities. The interests of community beneficiaries will be considered by inclusion of a civil society representative on the Advisory Panel.

Project extension and communication

Project extension and communication will be promoted to the extent agreed by project partners, and by the terms negotiated through the reference panel. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam

and it is important research results are presented in a defendable manner. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect these items and is unwilling for the technical details of its product to enter the public domain during the research phase. XPCL also have commercial-in-confidence considerations. With these issues in mind, the project team has entered into a confidentiality arrangement where no public project messaging will be made without the approval of all parties. Thus, extension and outreach will need to be carefully managed throughout project implementation.

4.4.2 Capacity building

Partner countries
Fish passage technology and implementation, as pertaining to hydropower dams, will provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL has a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from our research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Covid has created significant disruptions to international travel. The disruption has restricted access to the Xayaburi site and created additional administrative requirements to obtain permission to gain access. A reduced ability to visit site will place an increasing reliance on remote learning. The team as had discussions with Darren Grigg, a videographer from Grigg media, to develop a series of instructional videos. These will be developed and passed onto Lao-based staff as reference items. These will be important over the short (during Covid restrictions) and long term (if new staff enter the project team).

Australian team
Australian researchers will benefit from involvement in the project. The tropical rivers of South East Asia offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes than they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with future hydropower development activities.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, there is potential to link with the Mekong River Commission’s JEM initiative and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Action Plans', which take the activities and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These annual plans are devised before each New Year, and assessed at the end. These Action Plans then inform Progress Reports.

Medium-term cycles

The yearly reports and a forum, will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year, and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program

- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai (XPCL employed) scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) Factors influencing PIT antenna efficiency at high dam fishways
  (b) Tag retention and mortality in key Lower Mekong Basin species
  (c) Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers
  (d) Optimising electrofishing for deployment in the Lower Mekong Basin
- A project final report
- Abstracts published in conference proceedings

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed FOI Act s. 47v (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.6 Intellectual property and other regulatory compliance

See Section 7. Appendix A.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site, and the overall fish pass performance has implications at a site, national and international level. Site based impacts relate to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and the development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam’s day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we plan to influence the design and construction of other dams into the future (Figure 5).

Importantly, our team focusing on upstream migration only will limit the extend of applicability to other dams. It is important to note that, if the majority of fish are migrating upstream to recolonize habitat, or to spawn, it follows that these fish may need to move downstream at a later date to complete important life history stages. Focusing on upstream migration, at least initially, effectively mitigates a series of risks because our team is only focusing on one aspect initially. Thus, the political pressure to provide answers to <u>all</u> migration questions is significantly reduced by this focused scope.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The “gold standard” Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs.

Long term (strategic):

1) PIT tagging incorporated into the Mekong River Commission Design Guidelines for Mainstem Dams
2) PIT tag systems installed at other mainstem dam sites
3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key South East Asian economies on a common issue.

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across South East Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

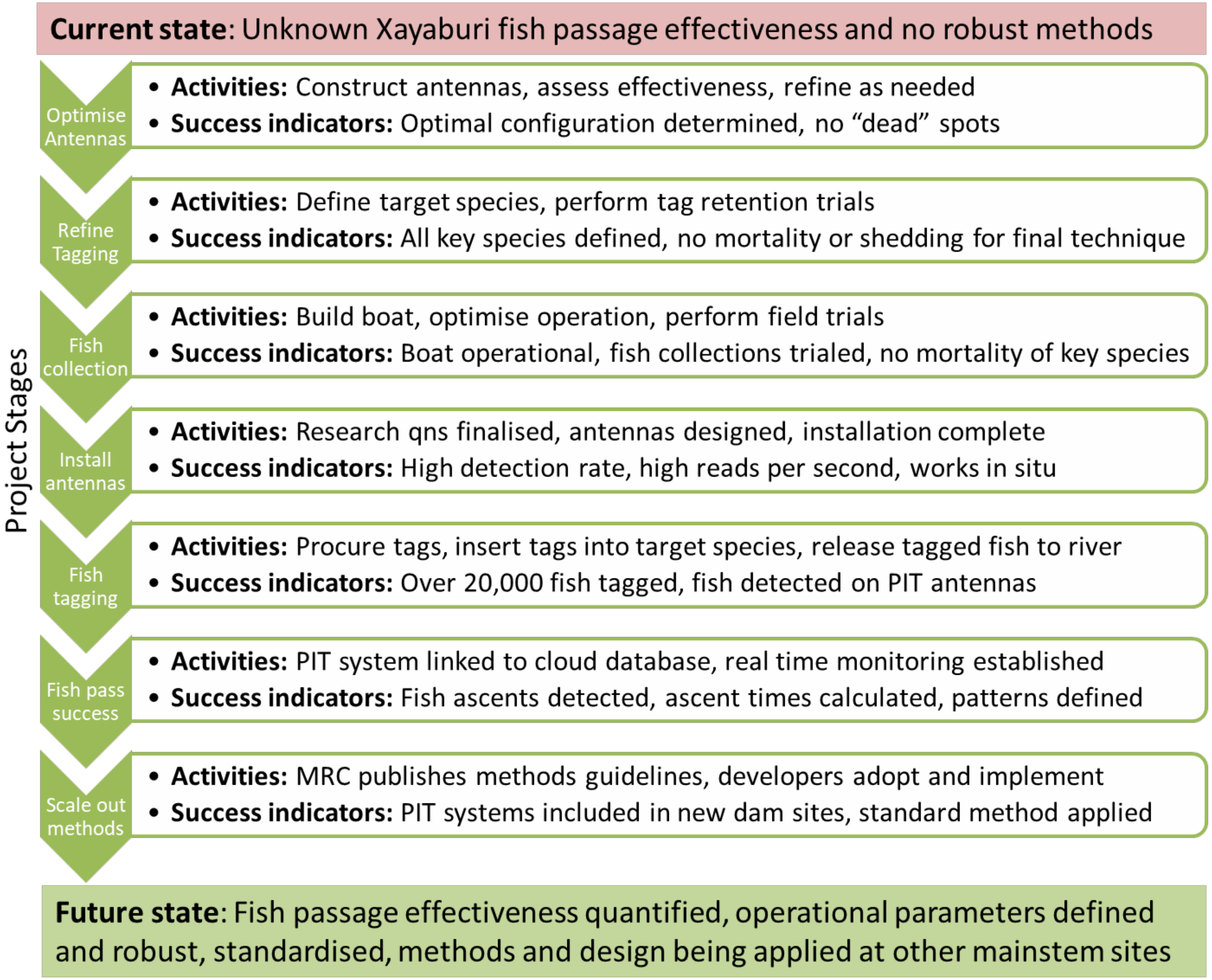


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the LMB and globally. It is important to note that the methods being developed will be applied in the LMB for the first time. Further, the implementation is occurring at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground, but we recognise that there are many assumptions and challenges that may lead to compromised data and outputs. To mitigate this risk, we have consulted with a biostatistician experienced in the Australian hydroelectric research field to advise on how to ensure statistically robust methods in the event of each possible failure point.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring upstream movement using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility for their research and monitoring program, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. <u>PIT tagging</u>: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. <u>Electrofishing:</u> A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating masters students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have conditional approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is imported from outside over the short term and built through a steady stream of learned graduates over the longer term.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hands-on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.4 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by participating in MRC dam guidance discussions and development where appropriate. An important platform for these discussions will be through the reference panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4 Community impacts

The science justifying fish passage implementation is sound (Williams 2008, Baumgartner et al. 2016). Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems. The research impact of this project is within the footprint of the Xayaburi Dam

site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner that can influence these outcomes, particularly through the Advisory Panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards (Commission 2010). The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction cost is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $300M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year (Nam et al. 2015). Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to meet the performance specifications set by the GoL, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region, while recognising the immense technical challenges we face in realising these results.

5.4.2 Social impacts

It is expected that effective fishway construction on mainstem dams will ultimately maintain fisheries productivity, although many technical and operational challenges must be overcome before this is verified through the project. The local benefits to communities from this research are maintained food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls in decision-making (Siason et al. 2010, Baumgartner et al. 2016)

Local communities will directly benefit through unchanged access to fish for food and income if the Xayaburi facilities are demonstrated to work. Nonetheless, if the Xayaburi facilities are demonstrated to not work effectively, this research will be critical to informing XPCL’s business decisions about which aspects of the fish pass to target for maximising improvements to triple bottom line outcomes.

Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed and operated, any fish that move upstream through the dam will become accessible to the upstream villages, thus creating an equitable access to the resource. However, there are likely to be considerable negative social impacts as there are numerous unknowns about the design and function of the fish passage infrastructure. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative social impact, considering the reliance of the capture fishery of the LMB for food security and income (Nam et al. 2015). Apart from those adverse effects due to dam construction and forced relocation, is the likely overall reduction, to some extent, in fish passage compared to pre-dam conditions, leading to a reduced abundance and range of fish species accessible to fishers. The project is likely to indirectly improve social benefits by minimising this negative impact - through advice to XPCL on operational management to optimizing fish passage at the Xayaburi Dam, and more broadly to the GoL on standardised tools and protocols for fish tagging and monitoring, and improvements in fish passage design for future hydropower development.

Therefore, demonstrating fish passage functionality through robust research is very important for XPCL to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The Xayaburi fish pass facilities were constructed to ensure fish are able to pass the dam. The overall aim is to demonstrate, through sound operation and integration into dam operations, fish pass effectiveness. The overall aim is to ensure fish communities upstream of the dam do not decline. The flow on effects to livelihoods and nutrition are being measured through the XPCL community program.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the region can be measured by the ability to influence Mekong River Commission mainstem dam guidelines, ensuring new dams include functional fish passes, as well as adopt standard monitoring methods.

6 Project management

6.1 Management aspects

6.1.1 Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be

responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work. A recommendation from these consultations was to establish a Project Reference Panel consisting of the major stakeholders that would be regularly briefed and consulted regarding project progress and outcomes.

Under the contract terms of the first phase of research (the SRA), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated the panel meet on an annual basis, at the dam site.

The Project Reference Panel will have advisory status, and consist of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited plus representation of Lao nationals (Figure 2).

They will conduct their business in confidence which will be defined by a terms of reference will be established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly-funded data must be openly available according to ACIAR’s contractual requirements, and also that that some IP will be required to remain commercial-in-confidence.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. We need to respect that our research team are invited ‘guests’ on the project site. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support.

The data sharing and publication arrangements therefore need to be carefully considered and discussed and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

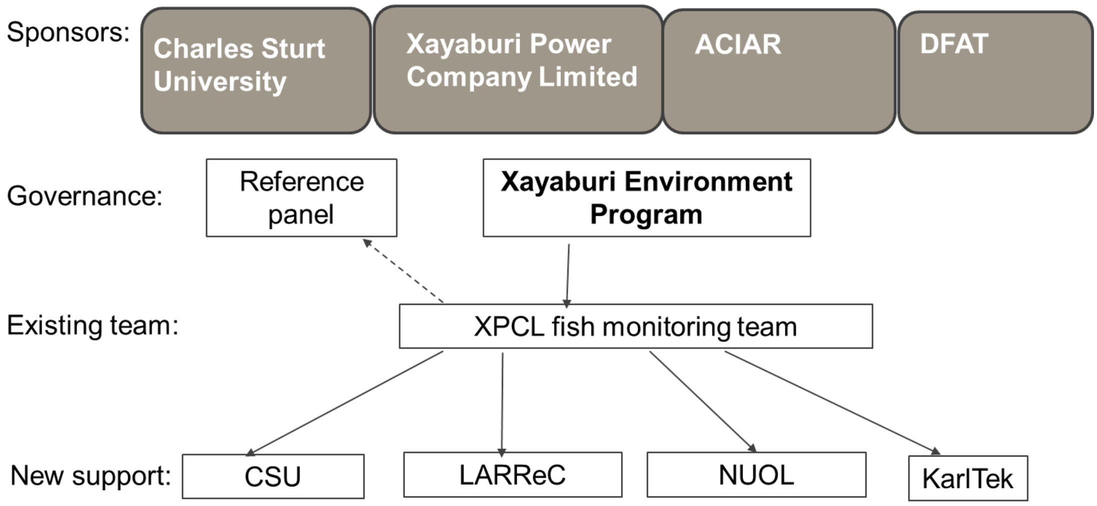


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will integrate within existing governance arrangements.

6.1.2 Mid and final project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR "mid-project review" (after 18 months) and "end of project review" processes.

6.1.4 Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables
- Development of instructional videos and manuals as reference items

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role on-ground in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Douangkham Singhanouvong (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]	[redacted]	[redacted]	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Coordinator and Government rep	[redacted]	[redacted]	[redacted]	[redacted]
Douangkham Singhanouvong	M	Living Aquatic Resources Research Centre	Deputy Director	Coordinator and Government rep	[redacted]	[redacted]	[redacted]	[redacted]
Thonglom Phommavong	M	National University of Laos	Research Associate	Collaborating scientists	[redacted]	[redacted]	[redacted]	[redacted]
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	[redacted]	[redacted]	[redacted]	[redacted]
Phousone Vorsane	M	National University of Laos	Research Associate	Field technical support	[redacted]	[redacted]	[redacted]	[redacted]
Saleumphone Chantavong	M	Living Aquatic Resources Research Centre	Research Associate	Field technical support	[redacted]	[redacted]	[redacted]	[redacted]
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	[redacted]	[redacted]	[redacted]	[redacted]
Michael Raeder	M	Xayaburi Power	Owner Representative	Owner representative	[redacted]	[redacted]	[redacted]	[redacted]
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Collaborating Scientist~~	[redacted]	[redacted]	[redacted]	[redacted]
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	[redacted]	[redacted]	[redacted]	[redacted]
John Dore	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	[redacted]	[redacted]	[redacted]	[redacted]
Casual Staff	TBA	Charles Sturt University	TBA	Assistance with fieldwork or other project requirements	[redacted]	[redacted]	[redacted]	[redacted]

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Name	Gender	Agency	Position at agency	Project Responsibilities	% on Project	% paid by ACIAR	% in-kind	Estimated total days in country
Wayne Robinson	M	Charles Sturt University	Research Fellow	Field and biometric support	[redacted]	[redacted]	[redacted]	[redacted]
Lauren Withers	F	Australian Volunteers	Volunteer	Project support	[redacted]	[redacted]	[redacted]	[redacted]
Garry Thorncraft	M	National University of Laos	Research Associate	Collaborating Scientist	[redacted]	[redacted]	[redacted]	[redacted]
Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental Monitoring	Project support	[redacted]	[redacted]	[redacted]	[redacted]
Jarrod McPherson	M	Charles Sturt University	Research assistant	Field support and coordination	[redacted]	[redacted]	[redacted]	[redacted]
Nathan Ning	M	Charles Sturt University	Scientist	Manuscript preparation and writing	[redacted]	[redacted]	[redacted]	[redacted]
Chris Barlow	M	IP Matters	Director	High level support and writing	[redacted]	[redacted]	[redacted]	[redacted]
Darren Grigg	M	Grigg Media	Videographer	To produce a series of instructional videos on PIT tagging and fish husbandry	[redacted]	[redacted]	[redacted]	[redacted]

6.3 Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

Name	Gender	Agency	Position at agency	Project Responsibilities	% on Project	% paid by ACIAR	% in-kind	Estimated total days in country (for panel activities)
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	[redacted]	[redacted]	[redacted]	[redacted]
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	[redacted]	[redacted]	[redacted]	[redacted]
~~Jürgen Geist~~	~~M~~	~~Technical University of Munich~~	~~Chair of Aquatic Systems and Director of FITHydro initiative~~	~~Reference panel member~~	[redacted]	[redacted]	[redacted]	[redacted]
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	[redacted]	[redacted]	[redacted]	[redacted]
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	[redacted]	[redacted]	[redacted]	[redacted]
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	[redacted]	[redacted]	[redacted]	[redacted]

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Name	Gender	Agency	Position at agency	Project Responsibilities	% on Project	% paid by ACIAR	% in-kind	Estimated total days in country (for panel activities)
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member	[redacted]	[redacted]	[redacted]	[redacted]
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Reference panel member~~	[redacted]	[redacted]	[redacted]	[redacted]
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	[redacted]	[redacted]	[redacted]	[redacted]

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required.

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

6.4 Summary details of key participants' roles and responsibilities

Name	Summary and role
Dr Lee Baumgartner Charles Sturt University, Associate Professor	[redacted]
Jarrod McPherson Charles Sturt University	[redacted]
Thanasak Poomchaivej Xayaburi Power Company	[redacted]
Dr Michael Raeder Xayaburi Power Company Limited	[redacted]
Garry Thorncraft National University of Laos	[redacted]

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Name	Summary and role
Dr Oudom Phonekhampheng National University of Laos	[redacted]
Douangkham Sinhanouvong Living Aquatic Resources Research Centre	[redacted]
Karl Pomorin KarlTek Pty Ltd	[redacted]
Dr Nathan Ning Charles Sturt University	[redacted]
Dr Chris Barlow Fish Matters IP	[redacted]
Lauren Withers (and others) Australian Volunteer	[redacted]

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Name	Summary and role
Phousone Vorsane (NUOL) and Saleumphone Chantavong (LARReC)	[redacted]
Thonglom Phommavong (NUOL) Khampheng Homsombath (LARReC)	[redacted]
Wayne Robinson (CSU)	[redacted]
Darren Grigg (Grigg Media)	[redacted]

6.5 Summary details of proposed reference panel participants

Name	Summary and role
Jody Swirepik (chair) Australian Government	[redacted]
Dr Elizabeth Pope Snowy Hydro	[redacted]

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Name	Summary and role
~~Prof Jürgen Geist~~ ~~Technical University of Munich~~	~~Prof Jürgen Geist, Technical University of Munich. He is the~~ [redacted]
Dr Daniel Deng PNNL	[redacted]
Dr Michael Raeder XPCL	[redacted]
Lao citizen representative TBA	[redacted]
Dr Ann Fleming ACIAR	[redacted]
Dominique Vigie DFAT	[redacted]

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6.6 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including

Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR. CSU has extensive experience with PIT system data analysis and installations throughout Australia and has extensively collaborated with researchers and the Australian government on the installation of fish monitoring systems since 2001. There are no other universities in Australia with such extensive experience and networks for fishway monitoring.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (HDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

7 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

7.1 Administrative details

Project ID	FIS/2017/017
Project title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Assessment provider	Lee Baumgartner
If not Australian project leader, provide title	
Date of assessment	~~15th May 2019~~ 17th June 2020

7.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

Does the project involve:	**Yes**	**No**
provision of germplasm by Australia to a partner country?		X
provision of germplasm from a partner country to Australia?		X
provision of germplasm from or to an IARC or another organisation and a project participant?		X
use of germplasm from a third party		X
material subject to plant breeders/variety rights in Australia or another country?		X

If “yes” to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	**Details of plant or animal germplasm exchange**

Proprietary materials, techniques and information

[redacted]

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“Data” means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

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[redacted]

7.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

[redacted]

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Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

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Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If "yes", for each applicable country provide brief details.

[redacted]

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[redacted]

FOI Act s. 47

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FOI Act s. 47

Australian Government

Australian Centre for International Agricultural Research

Research Agreement

Information for ACIAR Commissioned Organisations

Aug 2023

Research Agreement

Effective from August 2023, ACIAR has a new approach for contracting all new Research Projects (>$500,000) and Small Research Activities (<$500,000) with its Commissioned Organisations.

The existing Letter of Agreement, which attached our Standard Conditions and Project Documents, has been replaced with a new Research Agreement. The new Research Agreement contains a set of Base Terms for use for commissioning Small Research Activities and a set of Additional Terms, which augment the Base Terms, and are used when commissioning Research Projects.

The Additional Terms include a Collaboration Services Agreement template, a new contracting instrument template to be used as the agreement between the Commissioned Organisation and any in-country Collaborating Institution(s).

New ‘Research Agreement’ Template

The table below sets out how the new agreement templates replace our existing instrument templates.

Existing Instrument	New Instrument	Contracted Parties
Letter of Agreement	Research Agreement	ACIAR and the Commissioned Organisation
Standard Conditions	Research Agreement Annex B (Additional Terms)	ACIAR and the Commissioned Organisation
Project Arrangement • Annex 1 of Subsidiary Arrangement	Research Agreement Annex B Schedule 1 (Collaboration Services Agreement)	Commissioned Organisation and Collaborating Institution(s)
Deed of Agreement	Research Agreement Annex B Schedule 1 (Collaboration Services Agreement)	Commissioned Organisation and Collaborating Institution(s)
Project Documents • Attachment A of Project Arrangement • Attachment B of Letter of Agreement	• Research Agreement Annex A (Project Documents) • Subsidiary Arrangement Annex A (Project Documents)	N/A
Subsidiary arrangement	Subsidiary arrangement (without Project Arrangement)	ACIAR and Country Partner

Table 1 – New instruments replacing existing instruments

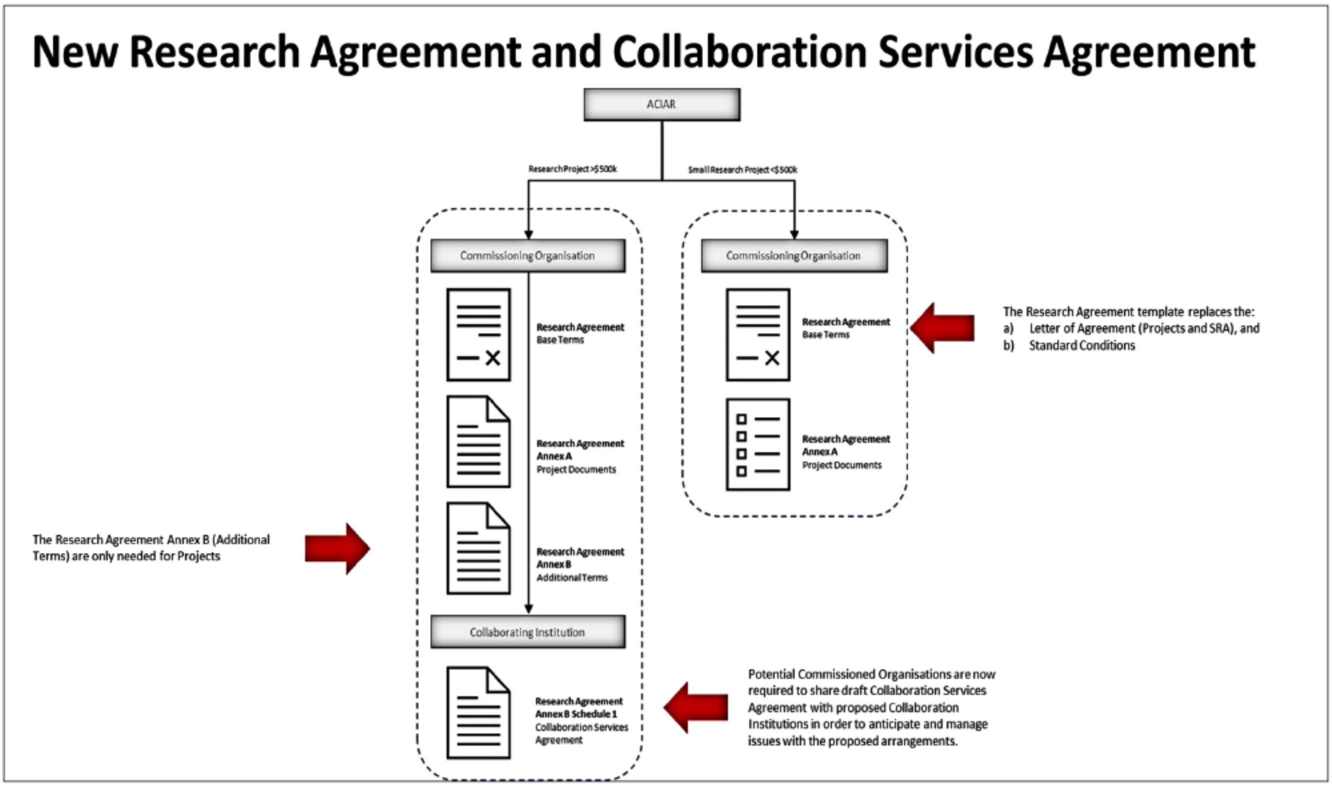

Figure 1 – Diagram of New Research Agreement and Collaboration Services Agreement structure

New 'Collaboration Services Agreement' Template

The new **Collaboration Services Agreement** creates a formal agreement between the Commissioned Organisation and the in-country Collaborating Institution(s). It replaces the need for Commissioned Organisation to prepare and enter a separate subcontract with the Collaborating Institution(s).

The Commissioned Organisation and its Collaborating Institution(s) can propose Special Conditions to amend existing terms or propose new terms and conditions. Commissioned Organisations will be expected to independently negotiate the acceptance of any proposed Special Conditions or other changes to the Collaboration Services Agreement with the Collaborating Institution(s).

ACIAR is not a party to the Collaboration Services Agreement and will not negotiate on behalf of Commissioned Organisations, nor the Collaborating Institution(s). However, ACIAR is still a key stakeholder and will conduct a review and approval any Special Conditions or other changes to the Collaboration Services Agreement, ensure they align with ACIAR's policies, practices and the terms of any relevant international arrangements.

For Research Projects with multiple Collaborating Institutions, the Commissioned Organisation will need enter into a separate Collaborating Services Agreement, with each Collaborating Institution.

If you have any questions about these new arrangements, please contact the Program Support Officer or Research Program Manager for your Research Project or the contact below.

CONTACT

[redacted]

FOI Act s. 47f

Australian Government

Australian Centre for International Agricultural Research

Research Agreement

between the

Commonwealth of Australia

represented by the

Australian Centre for International Agricultural Research

and the

Commissioned Organisation

Agreement Details

Project Title	[Project Title]
ACIAR *Name:*	The Commonwealth of Australia represented by the Australian Centre for International Agricultural Research
Australian Business No.	34 864 955 427
Postal Address	GPO Box 1571, Canberra ACT 2601, AUSTRALIA
Physical Address	ACIAR House, 38 Thynne Street, Fern Hill Park, Bruce ACT 2617
ACIAR Contract Manager	Name [Name] Position [Position] Tel. [Telephone Number] Email [Email Address]
Commissioned Organisation	
Name	[**Name**]
Registered Business No.	[Business No. – ABN is AU]
Postal Address	[Postal Address]
Physical Address	[Physical Address]
Australian Entity	Yes ☐ No ☐ ***NOTE****: selection of whether the Commissioned Organisation is an Australian Entity will affect the application of clauses under this Agreement as further detailed in clause 3.*
Commissioned Organisation Contract Manager	Name [Name] Position [Position] Tel. No [Telephone Number] Email [Email Address]
Term	
Commencement Date	[Commencement Date]
Completion Date	[Completion Date]
Financial Limitation	[Financial Limitation]
Withheld Sum	AUD 20,000.00
Project Leader	As detailed in the Project Document.
Key Personnel	The Project Leader and other Personnel of the Commissioned Organisation: either identified as 'Key Personnel' in the Project Document, or listed immediately below.
Subcontractors	
Requirement for Personnel to sign confidentiality deeds	Yes ☐ No ☐ ***NOTE****: If the requirement applies, ACAIR may require the Commissioned Organisation's Personnel to sign deeds of confidentiality under clause 14.1(d).*
Reports	
Annual Report(s)	Annual reports are to be provided each Financial Year of the Term by the following 14 July, other than for the final Financial Year of the Project (where a Final Report is required instead).
Final Report	A final report is to be provided within 60 days of completion of the Project
Other Report(s)	[insert]
Reviews	
Final Review	To be conducted 8-12 months before completion of the Project.
Mid-Term Review	[To be held within the first 12-36 months of the Term or N/A].
Special Conditions	[special conditions or N/A] [**Note to Drafters**: if ACIAR agrees to amend one of the terms and conditions, we would note that in this Special Conditions in the form of "*clause X is deleted and replaced with the following…..*" so that all agreements contain the same standard terms and conditions. All Special Conditions needs to be approved by Procurement before finalisation.]
CGIAR IA Principles Apply?	Yes ☐ No ☐ ***NOTE****: If CGIAR IA Principles apply, payment arrangements will be in accordance with clause 9.2 and intellectual property arrangements will be in accordance with clause 13.5..*
Complex Activity	Yes ☐ No ☐

	***NOTE**: If this Agreement relates to a Complex Activity, the Additional Terms will form part of this Agreement in accordance with clause 2.*
Collaborating Country	[insert or N/A]
Collaborating Institution	**[**insert or N/A**]**

Table of Contents

Research Agreement between ACIAR and the Commissioned Organisation

BACKGROUND

ACIAR has requested that certain services be carried out pursuant to the Project, and the Commissioned Organisation has agreed to provide the Services on the terms of this Agreement.

THE PARTIES AGREE AS FOLLOWS:

1. Interpretation

1.1 **Definitions**. In this Agreement, unless a contrary intention appears, capitalised terms have the meaning provided in the Agreement Details and:

Acquittal Report	has the meaning provided in clause 9.4.
Additional Terms	means the additional terms that are included as Annexure B, if the Agreement Details specifies this Agreement as relating to a Complex Activity.
Adverse Event	occurs, in respect of a Party, if (a) the Party is the subject of winding up or liquidation proceedings, whether voluntary or compulsory, otherwise than for the purpose of and followed by, a reconstruction, amalgamation or reorganisation (b) if the Party has become insolvent, bankrupt or is subject to the appointment of a receiver, manager or an inspector to investigate its affairs, enters into any arrangement or composition with its creditors generally, or is unable to pay its debts as and when they become due, or (c) if execution is levied upon all or any part of the assets of the Defaulting Party, provided that no breach occurs if the execution is contested in good faith or if within 5 Business Days after it is levied payment is made in full to the judgment creditor in question of all amounts owing to the judgment creditor.
Agreement	means this agreement, and includes the Background, the Agreement Details and the documents set out in clause 1.3 (as applicable).
Agreement Details	means the details set out in the table at the front of this Agreement.
Approved Subcontractor	means a third party to be engaged by the Commissioned Organisation for provision of sub-contracted Services that has been approved in writing by ACIAR, but does not include a Collaborating Institution.
Background IP	means IP Rights that are in existence prior to the date of this Agreement, or are brought into existence independently of this Agreement, and which are used in, or is otherwise required for the use of, the Project IP.
Budget	means the budget set out in Annexure B of the Project Document.
Commonwealth	means the Commonwealth of Australia.
Confidential Information	means information of a Party (**Disclosing Party**) that is by its nature confidential and: (a) is designated by the Disclosing Party as confidential, or

(b) that another Party (**Receiving Party**) knows or ought to know is confidential,

but does not include information which:

(c) is or becomes public knowledge other than by:

(i) breach of this Agreement, or

(ii) any other unlawful means

(d) is in the possession of a Receiving Party without restriction in relation to disclosure before receipt from the Disclosing Party, or

(e) has been independently developed or acquired by the Receiving Party,

and the burden of establishing any exceptions referred to in subclauses (c) to (e) above is on the Receiving Party.

Control means, in relation to a body corporate, the ability of any person directly or indirectly to exercise effective control over the body corporate (including the ability to determine the outcome of decisions about the financial and operating and other policies of that body corporate) by virtue of the holding of voting shares, units or other interests in that body corporate or by any other means.

Deliverables means the deliverables of the Project as specified in the Project Document.

Due Date means the date that a Deliverable is due for submission to ACIAR, as specified in the Project Document.

Exploit means, in respect of IP Rights:

(a) 'exploit' as defined in the *Patents Act 1990* (Cth), and

(b) to the extent that any IP Rights relates to works subject to copyright, to reproduce, modify, publish, adapt and communicate the works to the public.

Financial Year means the period from 1 July to 30 June of the following year.

IP Rights means statutory and other proprietary rights in respect of patents, designs, plant breeders' rights, trade marks, circuit layouts, copyright, confidential information, know-how and all other intellectual property rights as defined in Article 2 of the *Convention Establishing the World Intellectual Property Organisation of July 1967*.

International Arrangements means arrangements that establish the operating framework for the Project including such matters as: intergovernmental arrangements, sub-contracts with Approved Sub-Contractors, contracts between the Commissioned Organisation and any Collaborating Institutions, the arrangements covering matters such as customs assistance, in-country security, indemnities and intellectual property rights.

Moral Rights means the right of attribution of authorship, the right not to have authorship falsely attributed and the right of integrity of authorship granted to authors under the *Copyright Act 1968* (Cth).

Parties means ACIAR and the Commissioned Organisation (and their respective successors and permitted assigns), and **Party** means either one of them.

Payment Period means, unless otherwise specified in the Project Document, the periods:

1 January to 30 June, or

1 July to 31 December,

except that the period will be reduced in length relevantly if the Commencement Date or Completion Date falls within the period.

Payments	means the payments ACIAR will make available to the Commissioned Organisation in consideration of receipt of the Services as specified in the Budget, to be made available by ACIAR in accordance with the terms of this Agreement, and **Payment** means any one of those payments.
Personnel	means, in respect of a party, the: employees, officers, agents, students and sub-contractors of that party and, in respect of the Commissioned Organisation, includes the Key Personnel.
Primary Terms	has the meaning provided in clause 1.3.
Project Document	means the document set out in Annexure A to this Agreement, as amended from time to time in accordance with this Agreement.
Project IP	means IP Rights created by or on behalf of the Commissioned Organisation as a result of performing the Services or otherwise in the course of expending the Payments.
Services	means the services (including Deliverables) that the Commissioned Organisation is required to provide under this Agreement.

1.2 **Interpretation**. Unless a contrary intention appears, in this Agreement:

(a) words imputing a gender include any other gender

(b) a business day means a day which is not a Saturday or Sunday or a public holiday in the place where a notice is to be received or a particular activity is to be performed, and if a day on or by which an obligation must be performed or an event must occur is not a business day, the obligation must be performed or the event must occur on or by the next business day

(c) the singular includes the plural and vice versa

(d) another grammatical form of a defined word or expression has a corresponding meaning

(e) a reference to a statute or other law includes regulations and other instruments under it and consolidations, amendments, re-enactments or replacements of any of them

(f) a reference to a document includes the document as novated, altered, supplemented or replaced from time to time

(g) a reference to a person includes a natural person, partnership, body corporate, association, governmental or local authority or agency or other entity, and includes and includes the person's permitted successors, substitutes (including persons taking by novation) and assigns

(h) 'including', 'includes', 'such as' and 'in particular' do not limit the generality of the words which precede them or to which they refer

(i) 'month' means a calendar month and 'year' means a calendar year

(j) any agreement, representation, warranty or indemnity by two or more parties (including where two or more persons are included in the same defined term) binds them jointly and severally

(k) any agreement, representation, warranty or indemnity in favour of two or more parties (including where two or more persons are included in the same defined term) is for the benefit of them jointly and severally

(l) a rule of construction does not apply to the disadvantage of a Party because the Party was responsible for the preparation of this Agreement

(m) paragraph headings are inserted for convenient reference only and have no effect in limiting or extending the language of provisions to which they refer

(n) all references to dollars are to Australian dollars, unless otherwise specified, and

(o) a reference to a clause is a reference to a clause of these Primary Terms, and a reference to a Schedule, or Annexure is a reference to a schedule or annexure of this Agreement.

1.3 **Order of Priority.** In the event and to the extent of any inconsistency, the components of this Agreement will be interpreted in the following order of priority:

(a) the Special Conditions (if any)

(b) where applicable under clause 2, the Additional Terms

(c) these clauses 1 to 21 (**Primary Terms**), and

(d) the Project Document.

2. Additional Terms

Where the Agreement Details identify this Agreement as a Complex Activity, this Agreement includes the Additional Terms. Where the Agreement Details do not identify this Agreement as a Complex Activity, the Additional Terms do not form part of this Agreement.

3. Country Specific Clauses

The Parties acknowledge and agree that:

(a) if the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details, clauses 15.6, 19.9, and 19.19 will apply to this Agreement and clause 19.10 will have no effect, and

(b) if the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details, clause 19.10 will apply to this Agreement and clauses 15.6, 19.9, and 19.19 will have no effect.

4. Term

4.1 Subject to clause 4.3, the term of this Agreement will commence on the Commencement Date and, subject to extension under clause 4.2 or earlier termination under clause 16, will end on the Completion Date (**Term**).

4.2 The Term may be extended upon the mutual agreement of the Parties, including in circumstances where ACIAR has granted an extension of time under clause 7.2.

4.3 If the International Arrangements enabling the Project have not been established to the satisfaction of ACIR prior to the Commencement Date, the term of this Agreement shall commence upon ACIAR being satisfied (in its absolute discretion) that such International Arrangements have been established.

5. Services

The Commissioned Organisation will perform the Services:

(a) in a proper and professional manner exercising all appropriate care, diligence and attention, and in accordance with ethical scientific practice

(b) in furtherance of the objectives of the Project

(c) so as to provide any Deliverables and reports by the Due Dates and otherwise as required under this Agreement (including as specified in the Project Document)

(d) without limitation to clause 10, using Personnel of the requisite scientific calibre

(e) at the times and in the manner specified in this Agreement (including as specified in the Budget and the Project Document more generally) or otherwise agreed by the Parties, and

(f) in accordance with:

(i) applicable law, and

(ii) the reasonable directions of ACIAR.

6. Project Leader

In addition to any tasks designated for the Project Leader in the Project Document, the Project Leader will be responsible for coordinating all Services to be provided by the Commissioned Organisation and will liaise with ACIAR regularly regarding Project progress.

7. Delays

7.1 Notwithstanding clauses 9.4(a)(iv) and 9.5(c), upon becoming aware of any (actual or potential) delay in provision of Services the Commissioned Organisation will immediately notify ACIAR in writing of: the relevant background circumstances, the likely length of delay, and the steps the Commissioned Organisation has and will take to minimise the length and effect of the delay (**Delay Notice**).

7.2 Following receipt of a Delay Notice, ACIAR will determine, acting reasonably, whether to grant an extension of time to perform all or part of any remaining Services.

8. Subcontracting

8.1 The Commissioned Organisation will not subcontract performance of Services other than to Approved Subcontractors. For the purposes of this clause 8.1, the subcontractors specified in the Project Document and the Subcontractors listed in the Agreement Details constitute Approved Subcontractors.

8.2 The Commissioned Organisation remains responsible for performance of the Services by its subcontractors, including Approved Subcontractors.

9. Payment

9.1 In consideration of performance of the Services, ACIAR will make the Payments to the Commissioned Organisation, in advance and in accordance with the Budget.

9.2 If the Agreement Details specify that the CGIAR IA Principles apply, then the Parties acknowledge that Payments shall be made pursuant to clause 9.1 according to the following process:

(a) all Payments shall be made to the Commissioned Organisation via the International Bank for Reconstruction and Development (**IBRD**) as the Trustee of the CGIAR Fund for this Agreement

(b) in respect of each of the Payments, ACIAR will seek an invoice from IBRD, and

(c) following receipt of an invoice from IBRD, ACIAR will make the relevant Payments to IBRD with instructions to disburse those Payments to the Commissioned Organisation.

9.3 The Commissioned Organisation acknowledges it is responsible for payment of, and accounting to ACIAR for, all expenditure of Payments and all costs and expenses incurred in performing the Services.

9.4 Within 30 days of the end of each Payment Period or receiving a Withheld Payment under clause 9.5(e), the Commissioned Organisation will provide ACIAR (in a format as specified by ACIAR from time to time) a report including the following details:

(a) for the relevant Payment Period and detailed on an item-by-item basis, an accurate account of:

(i) Payments received

(ii) Payments expended, including details of how Payments have been expended

(iii) Payments not expended, and

(iv) if the amount of Payments not expended exceeds 20% of Payments made available for the relevant Payment Period, the reasons for any delay in spending or committing Payments, and

(b) sign-off by the Project Leader, and certification of the accuracy of details provided in acquittal report by an authorised officer of the Commissioned Organisation,

together an **Acquittal Report**.

9.5 Notwithstanding clauses 9.1 and 9.2:

(a) Payments are subject to appropriation being made by the Parliament of the Commonwealth for those Payments

(b) ACIAR will only advance Payments for the next Payment Period following:

(i) receipt of a satisfactory Acquittal Report for the previous Payment Period, and

(ii) if the Commissioned Organisation is required to provide ACIAR reports under clause 15.1 during earlier Payment Periods, satisfactory provision of such reports.

(c) in respect of any previously advanced Payments (or part thereof) not expended during earlier Payment Periods (**Unspent Payments**), ACIAR may reduce the Payment for the next or a future Payment Period, and the Financial Limitation, by all or part of the amount of the Unspent Payments.

(d) unless otherwise agreed in writing by ACIAR:

(i) Payments will not exceed the Financial Limitation

(ii) ACIAR will not be liable for expenses incurred other than as provided for in the Budget, or for any services other than Services, and

(iii) the Commissioned Organisation must return any Payments not properly earned or expended within 30 days of ACIAR accepting the final Acquittal Report.

(e) ACIAR will withhold the Withheld Sum from the final Payment pending acceptance of a satisfactory Final Report, following which:

(i) ACIAR will provide the Commissioned Organisation the Withheld Sum within thirty (30) days of ACIAR accepting the Final Report, and

(ii) the Commissioned Organisation must provide ACIAR a final Acquittal Report for the Project within thirty (30) days of receipt of the Withheld Sum.

10. Personnel and Personal Property

10.1 The Commissioned Organisation will provide adequate and competent Personnel to perform the Services.

10.2 The Commissioned Organisation will notify ACIAR immediately if any Key Personnel become unavailable to continue performance of Services or otherwise progress the Project.

10.3 ACIAR may require the Commissioned Organisation to, at the cost of the Commissioned Organisation, promptly replace Personnel with replacement Personnel approved by ACIAR if:

(a) the circumstance set out in clause 10.2 arises, or

(b) ACIAR has any reasonable grounds to require removal of Personnel from the Project, including in circumstances where Personnel perform Services in another country and, while not citizens of that country, become involved in the political affairs of that country.

10.4 As between the Parties, the Commissioned Organisation will be solely responsible for the remuneration and the work, health and safety of its Personnel, and must ensure that such Personnel comply with the Commissioned Organisation's obligations under this Agreement (including in relation to the ownership of IP Rights and obligations of confidentiality).

10.5 The Commissioned Organisation is responsible for its personal property (and the property of any of its Personnel involved in performing the Services, including any Key Personnel) and for any loss of property or damage caused to it.

11. Project Supplies

11.1 The Commissioned Organisation will arrange the procurement and delivery of all equipment and supplies required for the Project, including those specified in the Project Document (**Supplies**), and may apply Payments to do so where specified in the Project Document.

11.2 The Commissioned Organisation will: exercise administrative control over, manage the security, maintain and keep in good repair, and (where applicable) repair or replace, the Supplies.

11.3 Ownership of Supplies will vest in the Commissioned Organisation from the date of purchase.

12. Travel

12.1 For all travel of Commissioned Organisation Personnel pursuant to this Agreement:

(a) the Commissioned Organisation is responsible for arranging and paying for the travel and allowances of the Personnel, which may be paid from the Payments if allocated for in the Budget, and provided that:

(i) all air travel is purchased in economy/excursion class or lower fares and for the most direct and economical routing (the Commissioned Organisation may reroute or upgrade at its expense), and

(ii) any per diem paid from the Payments to the Personnel while on travel must not exceed the schedule of maximum per diems in effect at ACIAR

(b) without limitation to clause 10.4, the Commissioned Organisation is solely responsible for the security and safety of its Personnel and must make its own enquiries in relation to travel advice. ACIAR has no responsibility or liability for any injury, death, loss or damage suffered or expenses incurred relating to travel undertaken by Commissioned Organisation Personnel

(c) the Commissioned Organisation will provide prior written notice to ACIAR, including a travel schedule and details of its Personnel undertaking the travel (and of any accompanying dependants), in the form of a 'Travel Advice Note' as available on the ACIAR website accessible at http://aciar.gov.au/travel, and

(d) the Commissioned Organisation will provide a travel report in accordance with clause 15.3.

13. IP Rights and moral rights

IP Rights

13.1 ACIAR and the Commissioned Organisation will have regard to the provisions of and fulfil all relevant obligations under international arrangements to which Australia is a signatory relating to intellectual property and biological resources including:

(a) the *International Treaty on Plant Genetic Resources*

(b) the FAO trustee arrangements with international agricultural research centres

(c) the *Convention on Biological Diversity*

(d) the *Agreement on Trade Related Aspects of Intellectual Property Rights*, and

(e) and the provisions of the *International Union for the Protection of New Varieties of Plant*.

Transfer and exchange of germplasm by the Commissioned Organisation and/or sub-contractors will be subject to materials transfer and acquisition agreements and in accordance with the Convention on Biological Diversity. This clause 13.1 will be interpreted such that the relevant obligation is that which was in effect at the time of the action in question.

13.2 ACIAR and the Commissioned Organisation agree, in respect of any Project IP, that:

(a) in a Collaborating Country, the Project IP shall vest upon creation in the Collaborating Institute that is located within the relevant Collaborating Country, and if there is more than one Collaborating Institute located in that Collaborating Country, those Collaborating Institutes shall own the Project IP in that Collaborating Country as joint owners;

(b) in Australia, the Project IP shall vest upon creation in the Commissioned Organisation (and clause 13.3 shall apply);

(c) in respect of all countries and territories outside Australia and any Collaborating Countries, in accordance with the cooperative nature of the Project and recognising that it will be desirable to use or exploit advances or discoveries which may be made in the course of the Project and under this Agreement, ACIAR and the Commissioned Organisation will discuss and will jointly determine:

(i) the equitable apportionment of ownership of any Project IP arising from the Project

(ii) the management, control and payment of costs in respect of any steps to obtain and maintain registration of IP Rights in respect of Project IP

(iii) the equitable apportionment of profits, royalties or licence fees relating to such Project IP

(iv) the equitable licensing of such Project IP

(v) the equitable licensing of any Background IP of a Party as necessary to enjoy the full benefits of the Project and the Project IP, and

(vi) where it is within their power, the equitable licensing of such other IP Rights (including third party IP Rights) as is necessary to enjoy the full benefits of the Project and the Project IP

and clause 13.4 shall apply.

13.3 Unless otherwise agreed pursuant to clause 13.2(c), where ownership of the Project IP vests in the Commissioned Organisation, the Commissioned Organisation grants to ACIAR a permanent, irrevocable, royalty free, world-wide, non-exclusive licence (including a right to sublicense) to exploit, use, reproduce, modify, publish, adapt and communicate to the public the Project IP.

(e) .

13.4 In fulfilling their obligations under the clause 13.2(c), ACIAR and the Commissioned Organisation will have regard to relevant considerations including:

(a) their respective intellectual and other contributions

(b) their respective contributions of Background IP, material, research effort and proprietary work

(c) the facilities and funding provided by the Parties, and

such other relevant considerations as they may mutually determine.

13.5 If the Agreement Details specify that CGIAR IA Principles apply:

(a) clauses 13.2 to 13.4 will not apply

(b) the Parties agree that all Intellectual Assets, as defined in the CGIAR Principles on the Management of Intellectual Assets (**CGIAR IA Principles**) and Project IP will be dealt with in accordance with CGIAR IA Principles and that all Project IP will be used for the public good

(c) the Commissioned Organisation acknowledges that:

(i) as a member of the Consortium of International Agricultural Research Centres, the Commissioned Organisation must ensure that all agreements and contracts it enters (including any confidentiality, partnership, collaboration, development, licensing, distribution, material transfer agreements), comply with the CGIAR IA Principles

(ii) ACIAR supports the vision and objectives of the CGIAR, and supports the dissemination of the results of research as a public good, and

(iii) accordingly, Project IP will be managed in a manner consistent with CGIAR IA Principles

(d) ACIAR, the Commissioned Organisation will consider whether to register/ apply for (or allow third parties to register/apply for) patents and/or plant variety protection (**IP Applications**) over the Intellectual Assets. In accordance with CGIAR IA Principles, the Parties agree that no such IP Applications will be made unless they are necessary for the further improvement of such Intellectual Assets or for the public good. The Parties acknowledge that all IP Rights will be exercised consistently with Articles 6.1 to 6.3 of the CGIAR IA Principles

(e) ACIAR and the Commissioned Organisation will grant or will secure the grant to each other of a permanent, irrevocable, royalty free, worldwide, non-exclusive licence (including a right to sublicense its rights to third parties) to Exploit the Project IP. Where Parties propose to sublicence its rights under this clause 13.5(e), they will ensure that any sublicence will be on the same or substantially the same terms and conditions as the licence such party has from the other.

13.6 The Commissioned Organisation will promptly notify ACIAR of the details of any Project IP. Any notification will be treated as Confidential Information by ACIAR.

13.7 Unless otherwise expressly agreed in writing by the Parties, this Agreement does not affect the ownership of Background IP.

13.8 The Commissioned Organisation warrants to ACIAR that to its actual knowledge and belief, following all diligent and reasonable enquiries, at the date that ACIAR first consents to use, or otherwise uses, Background IP supplied by the Commissioned Organisation pursuant to this Agreement (as applicable):

(a) it is the owner of, or is otherwise entitled to use, the Background IP

(b) it is entitled to grant any licences to such Background IP made pursuant to this Agreement, and

(c) the exercise by ACIAR of its rights in such Background IP granted pursuant to this Agreement will not infringe the IP Rights of any third party.

13.9 Where the Commissioned Organisation intends to publish any article or paper of an academic, scientific or technical nature in regard to the Services or this Agreement, or to place any advertisement requesting applications from persons to perform any part of the Services, any such publication or advertisement must acknowledge the funding and other support provided by ACIAR in regard to this Agreement and must comply with ACAR Branding Guidelines available on the ACIAR website https://www.aciar.gov.au/branding-guidelines.

13.10 The Commissioned Organisation may report details of this Agreement in non-specialist media provided:

(a) it acknowledges the funding and support provided under this Agreement by ACIAR, and

(b) if the subject of the proposed media report may be controversial, the Commissioned Organisation will, prior to submission for publication, request ACIAR's written consent.

Moral Rights

13.11 ACIAR and the Commissioned Organisation:

(a) acknowledge the existence of Moral Rights conferred on the authors of any Works which are created in carrying out this Agreement or which exist as part of the Background IP

(b) will immediately notify the other Party in writing:

(i) upon becoming aware of a possible infringement of Moral Rights of an author of any Works referred to in clause 13.11(a), and

(ii) upon becoming aware of a claim for infringement of Moral Rights being made against a Party by an author of any Works referred to in 13.10(a), and

(c) will, following notice under clause 13.11(a), meet to negotiate in good faith (involving, where possible, the author of the relevant Works) the appropriate steps to resolve the matter to the satisfaction of the Parties and the author.

14. Confidentiality of Information

14.1 Each Party will:

(a) keep Confidential Information of the other Party confidential and will not, without the other Party's prior written consent, disclose or permit the same to be disclosed to any third party

(b) use reasonable endeavours (including labels or verbal notification) to ensure that the receiving Party is aware of the confidential nature of Confidential Information at disclosure

(c) take reasonable steps to provide for the safe custody of Confidential Information of the other Party and to prevent unauthorised access to or use of such Confidential Information, and

(d) ensure that its Personnel comply with the obligations of confidentiality imposed upon it by this clause 14, including in the case of the Commissioned Organisation (if specified in the Agreement Details and where required by ACIAR thereafter), by ensuring that its Personnel to execute deeds of confidentiality in favour of ACIAR consistent with this clause 14.

14.2 The obligations on the Parties under this clause 14 will not be taken to have been breached to the extent that a Party:

(a) discloses Confidential Information of the other Party to its:

(i) Personnel, and

(ii) legal, financial or other professional advisers,

who have a need to know for the purposes of this Agreement (and only to the extent that each has a need to know), provided the disclosure is made subject to an obligation of confidentiality in accordance with clause 14.1(d), or

(b) discloses Confidential Information of the other Party to the extent required to be disclosed:

(i) by law including under court subpoena, parliamentary order, under the *Freedom for Information Act 1982* (Cth) (or equivalent legislation) or as part of discovery during legal proceedings

(ii) to any government agency, authority, department or minister, or to any parliamentary committee, or

(iii) by the rules of a stock exchange,

provided that to the extent reasonably possible, prior written notice of such required disclosure is given to the disclosing Party to enable it to seek to challenge the disclosure of its Confidential Information.

14.3 At any time upon written request, a Party must return all documents in any form which embody Confidential Information of the other Party, provided that a Party may retain one copy of such Confidential Information as necessary to meet its reasonable record-keeping requirements subject to an obligation to keep such copy confidential in accordance with this clause 14.

14.4 Each Party's obligations under this clause 14 survive expiration or earlier termination of this Agreement and continue until the Confidential Information disclosed to it lawfully becomes part of the public domain.

15. Reports, Records, Review and Evaluation

Reports

15.1 The Commissioned Organisation must provide ACIAR the Reports at the times specified in the Agreement Details, and any other reports as reasonably requested by ACIAR (such as interim final reports, project factsheets, and other ad hoc reports).

15.2 Where a self-assessment of the potential for significant environmental impacts under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) has been produced and accepted pursuant to this Agreement, the Commissioned Organisation will provide ACIAR with a report by 14 July each year on the implementation and effectiveness of the risk management procedures identified in the self-assessment.

15.3 Within 30 days of completion of any travel referred to in clause 12.1, the Commissioned Organisation will provide ACIAR a trip report including the travel itinerary and all information reasonably required by ACIAR to enable ACIAR to monitor the Project.

15.4 Each report provided under this clause 15 must be accurate, complete and detailed to enable ACIAR to confirm the true status of the Project, and (where applicable) prepared in accordance with the 'Guidelines for Annual Reports' available on the ACIAR website www.aciar.gov.au (**Guidelines**).

Access to documents

15.5 In clause 15.6, ‘document’ and ‘Commonwealth Contract’ have the same meaning as in the *Freedom of Information Act 1982* (Cth).

15.6 If:

(a) the Commissioned Organisation is identified as an ‘Australian Entity’ in the Agreement Details

(b) this Agreement (or a subcontract of this Agreement) is a Commonwealth Contract, and

(c) the Commonwealth has received a request for access to a document created by, or in the possession of, the Commissioned Organisation (or any of its Personnel) that relates to the performance of this Agreement (and not to the entry into of this Agreement),

the Commonwealth may at any time by written notice require the Commissioned Organisation to provide the document to the Commonwealth, and the Commissioned Organisation must, at no additional cost to the Commonwealth, promptly comply with the notice.

Records

15.7 The Commissioned Organisation must, at its cost, for the period commencing on the Commencement Date and ending seven years after expiry or termination of this Agreement (**Bookkeeping Period**), keep (and ensure its Personnel keep) adequate books and records, in accordance with international accounting standards, in sufficient detail to enable the determination of how Payments have been expended, and the determination of any other amounts paid or payable under this Agreement (**Records**).

15.8 The Commissioned Organisation must, at its cost, keep (and ensure that its Approved Subcontractors keep) accurate hardcopy or digital scientific records relating to the Project – such records will include detailed, witnessed laboratory notebooks (which may be kept in digital or hardcopy format) sufficient to document any discoveries or inventions made in the course of the Project (**Scientific Records**).

Reviews

15.9 In addition to the Reviews that ACIAR may undertake as specified in the Agreement Details, ACIAR may at any time during the Term, undertake (through its Personnel or its appointed nominee(s)) to review and evaluate this Agreement and the exercise of rights and obligations relating to it (including in respect of the performance of Services). To facilitate any such review, the Commissioned Organisation will at its cost promptly provide any financial, technical or such other information (including Records and Scientific Records) as is required by ACIAR, provide ACIAR with access to Personnel participating in the Project to enable interview and general cooperation, and will at all reasonable times permit persons authorised by ACIAR to have access to the premises upon which the Services are being, or have been, performed.

15.10 ACIAR may at any time during the Bookkeeping Period, direct that the Records be examined by an independent accountant nominated by ACIAR and will permit the accountant to take copies or extracts from the Records. The Commissioned Organisation will give the accountant all assistance, access and facilities necessary to enable the accountant to verify the Records and will supply such other information as may be necessary or proper to verify how Payments have been expended.

Post Project Updates

15.11 Upon request at any time in the ten (10) years following completion of the Project, the Commissioned Organisation will use all reasonable endeavours to provide ACIAR updates in respect of the current outcomes and impact of the Project, having regard to Project objectives (**Post Project Update**). Each Post Project Update will (as all reasonable endeavours enable) include:

(a) details of Project impacts (including scientific impacts, capacity-building impacts, community impacts and environmental impacts)

(b) details of steps take to obtain the full benefit of Project outcomes

(c) where applicable, details of how Project outcomes could be better used to benefit communities, and

(d) learnings as to what future projects may be conducted to benefit communities in respect of the Project outcomes and topics related to the Project.

15.12 The Commissioned Organisation may charge ACIAR a fee for complying with clause 15.11, provided that:

(a) such fee is reasonable and commensurate with the effort involved in complying with clause 15.11, and

(b) the Commissioned Organisation has provided written notice to ACIAR of the amount of such fee (the notified amount calculated to comply with clause 15.12(a)) prior to commencing activities in compliance with clause 15.11.

Accessing Premises

15.13 In accessing the premises of the other Party (**Host**), a Party (**Visitor**) will:

(a) give reasonable written notice to the Host, such notice identifying the representatives of the Visitor to attend the Host's premises

(b) ensure that its representatives comply with all policies of the Host with respect to their attendance (including policies relating to health and safety, security, and standards of conduct) and otherwise comply with all reasonable directions, and

(c) procure that its representatives will (if required) sign a confidentiality agreement in favour of the Host to protect the confidentiality of any Confidential Information of the Host.

16. Termination and Reduction

Termination due to circumstances outside the control of the Parties

16.1 Should acts of God, fire, storm, flood, earthquake, explosion, accident, acts of a public enemy or terrorism, war, political upheaval, rebellion, insurrection, sabotage, epidemic, quarantine restrictions, industrial dispute, withdrawal of necessary support for the Project by a host nation government listed in the International Arrangements, transportation embargo or failure or delay in transportation render the completion of the Project impossible or unfeasible, either Party may terminate this Agreement upon providing the other with three months' written notice.

Termination

16.2 ACIAR may terminate or sever part of this Agreement without cause at any time by giving written notice to the Commissioned Organisation which must, on receipt, immediately cease all work and take appropriate action to mitigate any loss and prevent further costs being incurred with respect to the Services.

16.3 Without prejudice to any other rights ACIAR may have under this Agreement or at law, ACIAR may terminate or sever part of this Agreement for default by providing the Commissioned Organisation written notice if:

(a) the Commissioned Organisation breaches any term of this Agreement where that breach is not capable of remedy

(b) the Commissioned Organisation undergoes a change in Control or is subject to an Adverse Event

(c) the Commissioned Organisation or its Personnel engage in conduct that, in the reasonable opinion of ACIAR, is detrimental to the reputation of ACIAR or the Commonwealth, or

(d) if the Commissioned Organisation breaches any term of this Agreement where the breach is capable of remedy and the breach is not remedied within 14 days of receipt of notice in writing from ACIAR.

Effect of termination (or partial termination)

16.4 If this Agreement is terminated pursuant to clause 16.1, ACIAR may recover (and the Commissioned Organisation agrees to return) any Payments provided to the Commissioned Organisation that have not been expended as at the date the Commissioned Organisation was notified of termination.

16.5 Where this Agreement is terminated, wholly or in part, under clause 16.2, ACIAR must pay invoices in respect of:

(a) all reasonable amounts due in accordance with clause 16.2 for Services performed by the Commissioned Organisation in accordance with the terms of this Agreement up until the date of termination, and

(b) the equivalent of any liabilities or expenses of the Commissioned Organisation relating to the terminated Services which are substantiated, and which are properly incurred by the Commissioned Organisation, to the extent that those liabilities or expenses cannot be mitigated, but no other amount,

provided that in no event will ACIAR be required to pay any loss of prospective profits.

16.6 For the purposes of clauses 16.2 and 16.3, ACIAR may elect to sever part of this Agreement (**Partial Termination**) by notifying the Commissioned Organisation that it no longer requires the Commissioned Organisation to provide a particular Service, in which case:

(a) the Commissioned Organisation will cease to provide that Service

(b) ACIAR will no longer be obliged to provide any Payments in respect of that Service (and any Payments made available on account of the future performance of that Service will be returned to ACIAR), and

(c) this Agreement will be construed, and its provisions will be enforceable by and against the Parties, as if references to the Services the subject of that Partial Termination, and Payments made (or to be made) available in respect of those Services, were severed from the Contract.

16.7 If ACIAR notifies the Commissioned Organisation of termination of this Agreement under clause 16.3, ACIAR may, in addition to terminating this Agreement:

(a) recover any Payments provided to the Commissioned Organisation for Services or other obligations that have not been fulfilled or performed

(b) be regarded as discharged from any further obligations under this Agreement, and

(c) pursue any additional or alternative remedies provided by law.

17. Insurance

17.1 The Commissioned Organisation will, for so long as any obligations remain in connection with this Agreement, effect and maintain with reputable and substantial underwriters the following insurance:

(a) workers' compensation for an amount required by any relevant legislation

(b) in relation to Services performed in Australia, public liability insurance for an amount of not less than $20,000,000 per claim and $20,000,000 in aggregate

(c) in relation to Services performed outside Australia, adequate insurance against claims by third parties resulting from acts or omissions of the Commissioned Organisation in carrying out the Services, and

(d) adequate travel and medical insurance for any domestic and international travel undertaken on behalf of this Agreement by its Personnel.

17.2 Within 14 days of a written request from ACIAR, the Commissioned Organisation must provide ACIAR with a copy of any insurance policy (or related certificates of currency) effected in accordance with this clause 17 and of all receipts for payments of premiums.

17.3 The requirement of clause 17.1(c) will not apply in relation to work performed in a particular country if ACIAR has agreed in writing that such insurance is not available in relation to the performance of the Services in that country.

17.4 The Commissioned Organisation will ensure that any Approved Subcontractor maintains appropriate insurances.

17.5 Notwithstanding the above, the Commissioned Organisation may undertake self-insurance arrangements with ACIAR's prior written approval.

18. Indemnity

18.1 The Commissioned Organisation indemnifies ACIAR and the Personnel of ACIAR (**Those Indemnified**) from and against any loss (including legal costs and expenses on a solicitor/own client basis), or liability, incurred or suffered by any of Those Indemnified arising from any claim, suit, demand, action or proceeding by any person where such loss or liability was caused by any breach of a term or condition of this Agreement or wilful misconduct or unlawful or negligent act or omission of the Commissioned Organisation and the Personnel of the Commissioned Organisation in connection with the Services.

18.2 The Commissioned Organisation's liability to indemnify Those Indemnified under clause 18.1 will be reduced proportionally to the extent that any unlawful or negligent act or omission of Those Indemnified contributed to the loss or liability.

18.3 Neither party shall be liable to the other Party for any special, indirect or consequential loss or damages arising under or pursuant to this Agreement (including without limitation for loss of profits or an anticipated saving or benefit).

19. Compliance with laws and policies

Modern Slavery

19.1 In these additional terms 19.1 to 19.3:

(a) **Guiding Principles on Business and Human Rights** means the United Nations' Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework available at https://www.ohchr.org/documents/publications/ guidingprinciplesbusinesshr_en.pdf.

(b) **Modern Slavery** has the same meaning as it has in the *Modern Slavery Act 2018* (Cth).

19.2 The Commissioned Organisation must take reasonable steps to identify, assess and address risks of Modern Slavery practices in the operations and supply chains used in the provision of the Services, having regard to the Guiding Principles on Business and Human Rights.

19.3 If at any time the Commissioned Organisation becomes aware of Modern Slavery practices in the operations and supply chains used in the performance of this Agreement, the Commissioned Organisation must as soon as reasonably practicable take all reasonable action to address or remove these practices, including where relevant by addressing any practices of other entities in its supply chains.

Prohibited dealings

19.4 The Commissioned Organisation must ensure that it and any individuals, persons, entities or organisations involved in the Project, including its Personnel, are not:

(a) directly or indirectly engaged in preparing, planning, assisting or fostering a terrorist act

(b) listed terrorist organisations for the purposes of the *Criminal Code Act 1995* (Cth) (details of listed terrorist organisations are available at https://www.nationalsecurity.gov.au/Listedterroristorganisations/Pages/default.aspx)

(c) subject to sanctions or similar measures under the Charter of the United Nations Act 1945 (Cth) or the Autonomous Sanctions Act 2011 (Cth) (details of individuals and entities are available at: https://dfat.gov.au/international-relations/security/sanctions/Pages/consolidated-list.aspx)

(d) listed on the 'World Bank's Listing of Ineligible Firms and Individuals' posted at https://www.worldbank.org/en/projects-operations/procurement/debarred-firms

(e) owned, controlled by, acting on behalf of, or at the direction of individuals, persons, entities or organisations referred to in clauses 19.4(a) to 19.4(d) above, or

(f) providing direct or indirect support, resources or assets (including any grant monies) to individuals, persons, entities or organisations referred to clauses 19.4(a) to 19.4(d).

19.5 Where the Commissioned Organisation becomes aware that there are reasonable grounds to suspect it or any of its Personnel has or may have contravened any part of clause 19.4, the Commissioned Organisation must:

(a) notify ACIAR and confirm that information in writing as soon as possible, which must be no later than within 24 hours

(b) immediately take all reasonable action to mitigate the risks, and

(c) take any other action required by ACIAR.

Security Requirements

19.6 The Commissioned Organisation must perform its obligations to the highest professional standards and comply with the security requirements for the protection of official information: as detailed in the Commonwealth Protective Security Policy Framework available at: https://www.protectivesecurity.gov.au/Pages/default.aspx as amended from time to time; and as advised by ACIAR from time to time during the term of this Agreement.

Public Interest Disclosure

19.7 Public officials (including service providers under a Commonwealth contract) who suspect wrongdoing within the Commonwealth public sector can raise their concerns under the *Public Interest Disclosure Act* 2013 (Cth). Prior to making a disclosure, refer to information available at: http://www.ombudsman.gov.au/about/making-a-disclosure/information-for-disclosers.

19.8 All Public Interest Disclosure matters (relating to this procurement) should be referred to:

Name/Position:	**Chief Financial Officer**
Address:	Chief Financial Officer ACIAR House GPO Box 1571, Canberra, ACT 2601
Telephone:	(02) 6217 0500

Compliance with relevant legislation and policies

19.9 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must:

(a) observe the same standards and obligations that are imposed on Commonwealth personnel under the *Work Health Safety Act 2011* (Cth) or where relevant any state or territory law and regulations applicable to work health and safety

(b) comply with the obligations imposed under the *Lobbying Code of Conduct* (Cth), if applicable

(c) comply with all relevant legislation of the Commonwealth, or of any State, Territory or local authority under any agreement entered into with the Commonwealth including:

(i) the *Crimes Act 1914* (Cth)

(ii) the *Disability Discrimination Act 1992* (Cth)

(iii) the *Racial Discrimination Act 1975* (Cth)

(iv) the *Sex Discrimination Act 1984* (Cth)

(v) the *Age Discrimination Act 2004* (Cth) and the *Age Discrimination (Consequential Provisions) Act 2004* (Cth)

(d) comply with all applicable workers compensation laws, and

(e) comply with such other Commonwealth and agency policies relevant to the performance or provision of the Services and notified in writing to the Commissioned Organisation.

19.10 If the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must comply with all laws and standards corresponding or equivalent to those listed in clause 19.8 in the country or territory in which the Commissioned Organisation is based or in which Services are performed (as applicable).

Child safety

19.11 If any part of the Project involves the Commissioned Organisation employing or engaging Personnel in a manner that requires the Personnel by local law to have a working with children check (or equivalent) to undertake the Project or any part of the Project, the Commissioned Organisation agrees:

(a) to comply with all local law relating to the employment or engagement of people who work or volunteer with children in relation to the Project, including mandatory reporting and working with children checks (or equivalent), and

(b) if requested, provide the Commonwealth at the Commissioned Organisation's cost, an annual statement of compliance with this clause 19.11, in such form as may be specified by the Commonwealth.

Privacy

19.12 In clauses 19.13 and 19.14, capitalised terms have the meaning provided in the *Privacy Act 1988* (Cth) (**Act**).

19.13 The Commissioned Organisation must in undertaking this Agreement comply with all applicable privacy laws including, to the extent that the Australian *Privacy Act 1988* (Cth) applies to any of its activities under this Agreement by:

(a) complying with the Australian Privacy Principles and with any registered, applicable APP Code or Registered CR Code, and

(b) cooperating with any reasonable request or direction of ACIAR in relation to an inquiry, audit or other exercise of powers or functions, by the Information Commissioner under that Act.

19.14 Where the Act applies:

(a) if the Commissioned Organisation becomes aware that there are reasonable grounds to suspect that there may have been an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its performance of the Services, the Commissioned Organisation agrees to:

(i) notify ACIAR in writing as soon as possible, which must be no later than within three (3) days of becoming aware, and

(ii) unless otherwise directed by ACIAR, carry out an assessment in accordance with the requirements of the Act, and

(b) if the Commissioned Organisation is aware that there are reasonable grounds to believe there has been, or where ACIAR notifies the Commissioned Organisation that there has been, an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its provision of the Services, the Commissioned Organisation must:

(i) take all reasonable action to mitigate the risk of the Eligible Data Breach causing serious harm to any of the individuals to whom the Personal Information relates

(ii) unless otherwise directed by ACIAR, take all other action necessary to comply with the requirements of the Act, and

(iii) take any other action as reasonably directed by ACIAR.

19.15 Where privacy or data breach laws of another territory apply, the specific obligations of the Commissioned Organisation under clause 19.14 shall be modified only as necessary to ensure compliance with the privacy or data breach laws of that territory.

Fraud and Anti-Corruption

19.16 The Commissioned Organisation warrants that neither it nor its Personnel will make or cause to be made, receive or seek to receive any offer, gift or payment or benefit of any kind, which could be construed as an illegal or corrupt act, either directly or indirectly to any individual or organisation in relation to the execution of this Agreement.

19.17 Without limitation to any other clause of this Agreement, the Commissioned Organisation must comply with ACIAR's Fraud Policy Statement and guidance on reporting any allegations or concerns regarding fraud within the Project which is available at: https://www.aciar.gov.au/Standard-Contract-Conditions-and-Intellectual-Property-Policy.

19.18 On request, the Commissioned Organisation will provide for ACIAR's review and acceptance a fraud control plan that details actions the Commissioned Organisation will undertake in order to identify, report and manage instances of actual or potential fraud. The fraud control plan will specify what audit procedures and audit frequency will be applied.

19.19 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting its obligations under this clause 19, the Commissioned Organisation must comply with the requirements of the Commonwealth Fraud Control Framework or any replacement guidelines, in force from time to time, available at http://www.ag.gov.au/Integrity/counter-fraud/fraud-australia/Documents/CommonwealthFraudControlFramework2017.DOCX

Conflict of interest

19.20 The Commissioned Organisation warrants that, to the best of its knowledge after making diligent inquiry, at the date of signing this Agreement no conflict of interest exists or is likely to arise in the performance of its obligations under this Agreement.

19.21 If, during the performance of the Services a conflict of interest arises, or appears likely to arise, the Commissioned Organisation must:

(a) notify ACIAR immediately in writing

(b) make full disclosure of all relevant information relating to the conflict, and

(c) take such steps as ACIAR requires to resolve or otherwise deal with the conflict.

20. Taxes & Invoices

Stamp Duty and other taxes

20.1 Subject to clauses 20.2 and 20.3, the Commissioned Organisation must pay all:

(a) stamp duty (including penalties and interest) assessed or payable in respect of this Agreement and the undertaking of the Project, and

(b) all taxes, duties and government charges imposed or levied in Australia or overseas in connection with the performance of this Agreement.

GST

20.2 In clause 20.3:

(a) subject to clause 20.2(b), a word or expression defined in the *A New Tax System (Goods and Services Tax Act) 1999* (Cth) (**GST Act**) has the meaning given to it in the GST Act, and

(b) where a taxable supply takes place outside Australia in a territory that imposes a goods and services tax, value added tax, or similar, then references in this clause to GST, GST Liability, and GST Law will refer to the applicable tax, tax liability and legislation in that territory and clause 20.3 will be read and construed accordingly.

20.3 Unless otherwise specified in the Budget, amounts that ACIAR is required to pay under this Agreement are calculated on a GST-exclusive basis. Where the Commissioned Organisation becomes liable to remit any amount of GST in respect of any Supply it makes to ACIAR in accordance with this Agreement (**GST Liability**), the amount otherwise payable by ACIAR under this Agreement will be increased by the amount of the GST Liability, or any lesser amount required by law. The increased amount will be payable by ACIAR in the same manner and at the same time as other amounts payable under this Agreement; and where required, the Commissioned Organisation will provide a tax invoice that may enable ACIAR, if permitted by the, to claim a credit or refund, a notional credit refund, of GST.

21. Miscellaneous

Warranties

21.1 The Commissioned Organisation warrants that it has all necessary permissions and is entitled to undertake the Services and that it is not subject to any agreement, policy, arrangement or otherwise, which is inconsistent with or would otherwise restrict its ability to undertake the Services and vest or licence IP Rights under clause 13.

Approvals and consents

21.2 Except where this Agreement expressly states otherwise, a Party may, in its discretion, give conditionally or unconditionally or withhold any approval or consent under this Agreement.

Entire agreement

21.3 This Agreement contains the whole of the agreement between the Parties with respect to its subject matter and supersedes any and all other representations or statements by a Party whether oral or in writing and whether made prior or subsequent to the date of this Agreement.

Notices

21.4 All notices, requests, demands and other communications under this Agreement will be in writing directed to the representative specified in the Agreement Details (which may be updated by providing a notice to the other Party in accordance with this clause 21.4) and will be deemed to have been given: (i) immediately if delivered by hand, (ii) on the seventh day following postage if delivered by express post; and (iii) on the next business day in the location of the recipient's address if sent by email.

Negation of Employment, Partnership and Agency

21.5 The Commissioned Organisation will not by virtue of this Agreement be, or for any purpose be deemed to be, an officer, employee, partner or agent of ACIAR or the Commonwealth, or as having power or authority to bind or represent ACIAR or the Commonwealth, and will not represent itself, and will ensure that its Personnel do not represent themselves, as such.

Applicable Law

21.6 This Agreement will be governed by and construed in accordance with the laws of the State of Victoria. The Commissioned Organisation submits to the jurisdiction of the courts of Victoria and any court competent to hear appeals from those courts.

Waiver

21.7 A waiver by either Party in respect of any breach of a condition or provision of this Agreement must be made in writing and will not be deemed to be a waiver in respect of any continuing or subsequent breach of that provision, or breach of any other provision. The failure of either Party to enforce any of the provisions of this Agreement at any time will in no way be interpreted as a waiver of such provisions.

Authority and consents

21.8 Any and all rights, powers, authorities and discretions expressed in this Agreement or in the specifications to be conferred upon or vested in ACIAR may be exercised by any person designated for that purpose by the Commonwealth minister responsible for ACIAR.

21.9 Except as expressly provided in this Agreement, ACIAR may conditionally or unconditionally in its absolute discretion give or withhold any consent or approval under this Agreement.

Assignment

21.10 The Commissioned Organisation must not assign or attempt to assign or otherwise transfer or encumber any right or obligation arising out of this Agreement except with the written consent of ACIAR.

Variation to this Agreement

21.11 This Agreement may only be amended by a written instrument signed by the Parties.

No Merger

21.12 The rights and obligations of the Parties under this Agreement do not merge on completion of any transaction contemplated by this Agreement.

Further acts

21.13 A Party, at its own expense and within a reasonable time of being requested by the other Party to do so, must do all things and execute all documents that are reasonably necessary to give full effect to this Agreement and the transactions contemplated by it.

Severance

21.14 A term or part of a term of this Agreement that is illegal or unenforceable may be severed from this Agreement and the remaining terms or parts of the term of this Agreement will continue in force.

Costs and Expenses

21.15 Each Party will bear its own costs and expenses in relation to the negotiation, preparation, execution, delivery and completion of this Agreement and any related documentation.

Counterparts

21.16 This Agreement may be executed in counterparts. All executed counterparts constitute one document. Counterparts may be exchanged and relied on in facsimile or digital scanned form.

Survival

21.17 Without limitation to the express provisions of this Agreement or those clauses of this Agreement which are intended or capable of having effect following the expiry or termination of this Agreement, the following clauses will survive the expiry or termination of this Agreement: clauses 1 to 3, 10.4, 10.5, 13 to 15, 16.4, 16.5, 16.7,17, 18, 20, 21.3, 21.5, 21.6, 21.7, 21.10, 21.12, 21.14, 21.16 and this clause 21.17.

EXECUTED as an Agreement

Signed for and on behalf of the **Commonwealth of Australia** as represented by the **Australian Centre for International Agricultural Research ABN 34 864 955 427** by its duly authorised delegate

_________________________________ ←

Signature of delegate

____

Name of delegate (print)

____

Position of delegate (**print**)

ON: [**insert date**] ______/______/_________ ←

Executed by **[Type here]** by its duly authorised delegate

_________________________________ ←

Signature of delegate

Name of delegate (print)

Position of delegate (**print**)

ON: [**insert date**] ______/______/_________ ←

ANNEXURE A – PROJECT DOCUMENT

ANNEXURE B – ADDITIONAL TERMS

Additional Terms

A1. Interpretation and further definitions

A1.1 In these Additional Terms, unless the context otherwise requires, reference to a clause is a reference to a clause of the Primary Terms and reference to an additional term is to a clause of these Additional Terms.

A2. Application

A2.1 These Additional Terms will only take effect in accordance with clause 2.

A3. Collaborating Countries and Collaborating Institutions

A3.1 As applicable, international agreements that establish the overseas operating framework for the Project including such matters as protocols, customs assistance, in-country security, indemnities and intellectual property rights will be signed by the parties to the Project, including the Parties and any applicable Collaborating Institutions.

A3.2 In undertaking the Project, the Commissioned Organisation will engage with each Collaborating Institution (if any) via an agreement substantially on the terms set out in Schedule 1 to these Additional Terms (**Collaborating Institution Agreement**).

A3.3 Without limitation to clause 5, in performing the Services the Commissioned Organisation will cooperate fully with any Collaborating Institution for the purpose of ensuring timely completion of the Project.

A3.4 Notwithstanding clause 11.3, the ownership of Supplies procured within a Collaborating Country will vest in the government of that Collaborating Country on completion of the Project, and the Commissioned Organisation will take whatever action is necessary to effect that transfer.

A4. Project Committee

A4.1 ACIAR may establish a Project Committee that will include a representative of each of the Parties and, where relevant and appropriate (as determined by ACIAR), any Collaborating Institutions.

A4.2 The Project Committee will advise the Parties in relation to Project matters, and may call for specialised advice on any matter related to the Project.

A5. Payments

A5.1 The Commissioned Organisation may, subject to the following qualification and without reference to ACIAR, transfer Payments payable in respect of a particular item in the Budget for the Project to another item. The amount transferred may be the lesser of 10% of the total of the particular item in the Budget or $10,000 from which the Payments are being transferred.

A5.2 Notwithstanding additional term A5.1, the Commissioned Organisation will not transfer Payments payable in respect of a particular item in the Budget payable outside Australia to another item in the Budget payable outside Australia. However, any Collaborating Institution will be able to vary its component of the Budget in the same way described in additional term A5.1. Transfer of Payments between items in excess of the amount referred to in additional term A5.1 must not be made without the prior written approval of ACIAR.

A5.3 Where the Budget for the Project provides for the payment of any Payments by the Commissioned Organisation to a Collaborating Institution, the Commissioned Organisation will pay those Payments six-monthly in advance within seven days following receipt of Payments from ACIAR. Any Payments that are unexpended by the Collaborating Institution at the expiration of the Payment Period for which they were allocated will be carried over for expenditure in the following Payment Period and the advance made for the following Payment Period by the Commissioned Organisation to the Collaborating Institution will be reduced proportionately, unless ACIAR approves otherwise in writing.

A6. Dispute Resolution

A6.1 Subject to additional term A6.4, before resorting to external dispute resolution mechanisms, the Parties will attempt to settle by negotiation any dispute in relation to this Agreement including by referring the matter to personnel who may have authority to intervene and direct some form of resolution.

A6.2 If a dispute is not settled by the Parties within 10 working days of one Party first sending to the other Party written notice that they are in dispute, the dispute may be the subject of court proceedings or may be submitted to some alternative dispute resolution mechanism as may be agreed in writing between the Parties.

A6.3 Notwithstanding the existence of a dispute, each Party will continue to perform its obligations under this Agreement.

A6.4 A Party may commence court proceedings relating to any dispute arising from this Agreement at any time where that Party seeks urgent interlocutory relief.

A7. Personnel

A7.1 The Commissioned Organisation will obtain the prior written approval of ACIAR to the appointment of any specialist or scientist Personnel not identified in the Project Document to perform the Services, which approval will not be unreasonably withheld. If ACIAR requests, the Commissioned Organisation must promptly provide any relevant information relating to such specialist or scientist including:

(a) the full names and date of birth of the proposed person(s)

(b) a statement which describes the position to be held, the position selection criteria and details of the duration of the proposed appointment

(c) a copy of the curriculum vitae of each of the proposed persons which details relevant employment experience and educational qualifications, and

(d) any other information relating to the proposed appointment necessary for, or directly related to, the Services.

A8. Audit and access

Without limitation to clause 15:

(a) the Commonwealth through ACIAR or a representative may conduct audits relevant to the performance of the Commissioned Organisation's obligations under this Agreement. Audits may be conducted of:

(i) the Commissioned Organisation's operational practices and procedures as they relate to this Agreement, including security procedures

(ii) the Commissioned Organisation's compliance with its confidentiality, privacy and security obligations under this Agreement

(iii) records and documentation in the possession of the Commissioned Organisation relevant to the Services or this Agreement, and

(iv) any other matters determined by the Commonwealth to be relevant to the Services or this Agreement

(b) the Commonwealth through ACIAR or a representative may, at reasonable times and on giving reasonable notice to the Commissioned Organisation:

(i) access the premises of the Commissioned Organisation to the extent relevant to the performance of this Agreement

(ii) require the provision by the Commissioned Organisation, its Personnel, of records and information in a data format and storage medium accessible by the Commonwealth by use of the Commonwealth's existing computer hardware and software

(iii) inspect and copy documentation, books and records, however stored, in the custody or under the control of the Commissioned Organisation, its Personnel, and

(iv) require assistance in respect of any inquiry into or concerning the Services or this Agreement. For these purposes an inquiry includes any administrative or statutory review, audit or inquiry (whether within or external to the Commonwealth), and any inquiry conducted by Parliament or any Parliamentary committee

(c) the Commissioned Organisation must provide access to its computer hardware and software to the extent necessary for the Commonwealth to exercise its rights under this additional term A8, and provide the Commonwealth through ACIAR or its representative with any reasonable assistance requested by the Commonwealth to use that hardware and software

(d) the Commonwealth through ACIAR or a representative must use reasonable endeavours to ensure that:

(i) audits performed under clause A8, and

(ii) the exercise of the general rights granted by clause A8(b) by the Commonwealth,

do not unreasonably delay or disrupt in any material respect the Commissioned Organisation's performance of its obligations under this Agreement or its business.

(e) each Party must bear its own costs of any reviews and/or audits

(f) the rights of the Commonwealth through ACIAR or its representative under additional term A8 apply equally to the Auditor-General or a delegate of the Auditor-General, or the Privacy Commissioner or a delegate of the Privacy Commissioner, for the purpose of performing the Auditor-General's or Privacy Commissioner's statutory functions or powers

(g) the Commissioned Organisation must do all things necessary to comply with the Auditor-General's or his or her delegate's or the Privacy Commissioner's or his or her delegate's requirements, notified under additional term A8(f), provided such requirements are legally enforceable and within the power of the Auditor-General, the Privacy Commissioner, or his or her respective delegate

(h) the requirement for, and participation in, audits does not in any way reduce the Commissioned Organisation's responsibility to perform its obligations in accordance with this Agreement

(i) the Commissioned Organisation must ensure that any subcontract entered into for the purpose of this Agreement contains an equivalent clause granting the rights specified in this additional term A8

(j) nothing in this Agreement reduces, limits or restricts in any way any function, power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner. The rights of the Commonwealth under this Agreement are in addition to any other power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner, and

(k) this additional term A8 applies for the Term and for a period of seven years from the expiry or termination of this Agreement.

A9. Intellectual property

A9.1 The Commissioned Organisation and any relevant Collaborating Institution, as part of the entering into a Collaborating Institute Agreement, negotiate Intellectual Property arrangements between those parties (**IP Arrangements**) that cover matters such as:

(a) how Project IP may be used and disseminated by those parties in accordance with the terms of this Agreement including, if applicable, the CGIAR IA Principles

(b) the terms of any rights to Project IP between those parties, including securing such rights as are necessary for the Commissioned Organisation to grant ACIAR and any other parties rights to Project IP pursuant to this Agreement

(c) the terms of any licence of Background IP, including securing such rights as are necessary for the parties to undertake the Project and to grant ACIAR or any other party any rights to Project IP pursuant to this Agreement

(d) indemnity arrangements against liability arising from claims by third parties in connection with the breach of Intellectual Property Rights

(e) whether the Commissioned Organisation and any Collaborating Institution will seek to put in place any 'Limited Exclusivity Agreements' or 'Restricted Use Agreements' as defined in and in accordance with Articles 6.1 to 6.3 of the CGIAR IA Principles, and

(f) the allocation of costs relating to the application for and maintenance of the IP Rights between the Commissioned Organisation and any relevant Collaborating Institution,

provided that in no circumstances may the IP Arrangements provide for arrangements that would be inconsistent with any other term of this Agreement (including as found in the Project Document), or otherwise place the Commissioned Organisation in breach of this Agreement.

Schedule 1 to Additional Terms – Collaboration Services Agreement

Project	[Project Title], as further described in the Project Document.
Commissioned Organisation *Name:* *Address* *Representative*	 [**Name**] [Postal Address] Name [Name] Position [Position] Tel. No. [Telephone Number] Email [Email Address]
Collaborating Institution *Name:* *Address* *Representative*	 [**Name**] [Postal Address] Name [Name] Position [Position] Tel. No. [Telephone Number] Email [Email Address]
Background	ACIAR has, pursuant to an executed agreement (**Research Agreement**), engaged the Commissioned Organisation to undertake certain services, relevantly including certain project management and coordination services in relation to the Project. The Collaborating Institution has proposed to carry out certain ancillary services and activities in connection with the Project, as specified in the Project Document (**Collaboration Services**). The Commissioned Organisation has agreed to engage the Collaborating Institution, and the Collaborating Institution has agreed to be engaged, to provide the Collaboration Services under the terms and conditions of this Agreement.
IP Arrangements	[IP arrangement or N/A] [**Note for Commissioned Organisation** - As per Clause 6 (IP Rights), if the Commissioned Organisation or Collaborating Institution propose different IP Arrangements, they are to be detailed here for ACIAR review and approval.]
Special Conditions	[special conditions or N/A] [**Note to Drafters**: if ACIAR agrees to amend one of the terms and conditions on request of the Commissioned Organisation or Collaborating Institution, we would note that in this Special Conditions in the form of "*clause X is deleted and replaced with the following…..*" so that all agreements contain the same standard terms and conditions*]*

THE PARTIES AGREE AS FOLLOWS:

1. Definitions and Interpretation

1.1 **Definitions.** In this Agreement, unless a contrary intention appears, capitalised terms have the meaning provided in the table at the front of this Agreement (**Agreement Details**) and in the Research Agreement.

1.2 **Interpretation**. This Agreement will be interpreted in accordance with clause 1.2 of the Research Agreement, save that unless the contrary intention appears, references to:

(a) an Agreement will be to this agreement

(a) a Party will be to a party of this Agreement, and

(b) a clause will be to a clause of this Agreement.

2. Term

This Agreement will commence on the date it is signed by the last Party to sign and, subject to earlier termination in accordance with this Agreement, will end upon expiry of the Research Agreement or upon the scope of the Research Agreement being reduced such that the Collaboration Services no longer form part of the Project.

3. Payment

3.1 In consideration of performance of the Collaboration Services, and subject to having received amounts relevantly allocated to the Collaborating Institution in the Budget from ACIAR (**Collaboration Payments**), the Commissioned Organisation will provide the Collaborating Institution the Collaboration Payments, in advance and in accordance with the Budget.

3.2 The Collaborating Institution acknowledges it is responsible for payment of, and accounting to the Commissioned Organisation for, all expenditure of Collaboration Payments and all costs and expenses incurred in performing the Collaboration Services.

3.3 The Collaborating Institution may, subject to the following qualification and without reference to the Commissioned Organisation, transfer Collaboration Payments payable in respect of a particular item in the Budget for the Project to another item. The amount transferred must be the lesser of 10% of the total of the particular item in the Budget or $10,000 from which the Collaboration Payments are being transferred.

4. Enabling the Commissioned Organisation to comply with the Research Agreement

The Collaborating Institution acknowledges that the Commissioned Organisation is responsible to ACIAR for the conduct and progress of the Project under the terms of the Research Agreement. The Collaborating Institution agrees it will not, through any act or omission, place the Commissioned Organisation in breach of the Research Agreement. Without limitation, the Collaborating Institution will:

(a) provide its Collaboration Services as though legally bound by clause 5 of the Research Agreement

(b) promptly notify the Commissioned Organisation of any (actual or potential) delay of Collaboration Services to enable the Commissioned Organisation to comply with clause 7 of the Research Agreement

(c) not sub-contract the Collaboration Services unless the Commissioned Organization has obtained prior written approval from ACIAR in accordance with the Research Agreement

(d) provide the Commissioned Organisation details of the expenditure (and non-expenditure) of Collaboration Payments to enable the Commissioned Organisation to provide Acquittal Reports in compliance with clause 9.4 of the Research Agreement

(e) at the cost of the Collaborating Institution, replace Personnel of the Collaborating Institution where ACIAR has directed that such Personnel be replaced pursuant to the Research Agreement

(f) in respect of any travel of Collaborating Institution Personnel, provide the Commissioned Organisation with:

 (i) a 'Travel Advice Note' for the Commissioned Organisation to provide to ACIAR in accordance with clause 12.1(c) of the Research Agreement, and

 (ii) a travel report for the Commissioned Organization to provide to ACIAR in accordance with clauses 12.1(d) and 15.3 of the Research Agreement

(g) provide all reasonable assistance enabling the Commissioned Organisation to prepare and provide reports pursuant to clause 15.1 of the Research Agreement

(h) maintain the confidentiality of any Confidential Information of ACIAR as though legally bound by clause 14 of the Research Agreement

(i) not engage in conduct that is detrimental to the reputation of ACIAR or the Commonwealth

(j) maintain, and provide the Commissioned Organisation and ACIAR with access to, Records and Scientific Records relating to the Collaboration Services, to enable the Commissioned Organization to comply with clauses 15.7 and 15.8 of the Research Agreement

(k) enable ACIAR and/or its nominees to conduct audits in accordance with additional term A8

(l) cooperate with any review(s) of the Project conduct by or at the behest of ACIAR in accordance with clause 15.9 and 15.10 of the Research Agreement, and

(m) comply with laws and policies as though legally bound by clause 19 of the Research Agreement.

5. Project Supplies

5.1 Subject to clause 5.2, the Collaborating Institution will be responsible for obtaining and maintaining equipment and supplies necessary to provide the Collaboration Services (**Collaboration Supplies**).

5.2 Where specified in the Project Document:

(a) the Collaborating Institution may apply Collaboration Payments to procure certain Collaboration Supplies, and

(b) the Commissioned Organisation may arrange the supply of certain Collaboration Supplies, which will thereafter be maintained and (if necessary) replaced by the Collaborating Institution,

and Collaboration Supplies obtained or procured under clause 5.2(a) or 5.2(b) will vest in the Collaborating Country in which they are located upon completion of the Project.

6. IP Rights

Subject to consistency with the terms of the Research Agreement, the Commissioned Organisation and the Collaborating Institute acknowledge and agree that arrangements in respect of IP Rights, including Project IP, follow the IP Arrangements. If the IP Arrangements are not consistent with the terms of the Research Agreement, the Parties will negotiate revision of the IP Arrangements in good faith so that the revised IP Arrangements are consistent with the terms of the Research Agreement.

7. Travel

For all travel of Collaborating Institution Personnel pursuant to this Agreement:

(a) the Collaborating Institution is responsible for arranging and paying for the travel and allowances of its Personnel, which may be paid from the Collaboration Payments if allocated for in the Budget and provided that:

(i) all air travel is to be purchased in economy/excursion class or at lower fares and the applicable fare be purchased for the most direct and economical routing (the Collaborating Institution may reroute or upgrade at its expense), and

(ii) any per diem paid from the Collaboration Payments to the Personnel while on travel must not exceed the schedule of maximum per diems in effect at ACIAR, and

(b) the Collaborating Institution is solely responsible for the security and safety of its Personnel and must make its own enquiries in relation to travel advice.

8. Personnel

As between the Parties, the Collaborating Institution will be solely responsible for the remuneration and the work, health and safety of its Personnel; and must ensure that such personnel comply with the Collaborating Institution's obligations under this Agreement (including in relation to the ownership of IP Rights and obligations of confidentiality).

9. Confidentiality

Confidentiality arrangements between the Parties will be governed in accordance with the terms of clause 14 of the Research Agreement, as if that clause was incorporated into this Agreement.

10. Insurance

Unless otherwise agreed, the Collaborating Institution will obtain insurances corresponding to those required of the Commissioned Organisation under clause 17 of the Research Agreement, and will provide the Commissioned Organisation with a copy of any insurance policy (or related certificates of currency) effected in accordance with this clause 10 and of all receipts for payments of premiums.

11. Indemnity

11.1 The Collaborating Institution will indemnify the Commissioned Organisation and the Personnel of the Commissioned Organisation (**Those Indemnified**) from and against any loss (including legal costs and expenses on a solicitor/own client basis), or liability, incurred or suffered by any of Those Indemnified arising from any claim, suit, demand, action or proceeding by any person where such loss or liability was caused by any breach of a term or condition of this Agreement or wilful misconduct or unlawful or negligent act or omission of Those Indemnified in connection with the Collaboration Services.

11.2 The Collaborating Institution's liability to indemnify Those Indemnified under clause 11.1 will be reduced proportionally to the extent that any unlawful or negligent act or omission of Those Indemnified contributed to the loss or liability.

12. Termination

12.1 Without prejudice to any other rights the Commissioned Organisation may have under this Agreement or at law, the Commissioned Organisation may terminate or reduce this Agreement by providing the Collaborating Institution written notice:

(a) if the Research Agreement is terminated or reduced

(b) if the Collaborating Institution breaches any term of this Agreement where that breach is not capable of remedy

(c) if the Collaborating Institution undergoes a change in Control or is subject to an Adverse Event, or

(d) if the Collaborating Institution breaches any term of this Agreement where the breach is capable of remedy and the breach is not remedied within 14 days of receipt of notice in writing from the Commissioned Organisation.

12.2 If notice is given to the Collaborating Institution to terminate this Agreement under clause 12.1(b) to 12.1(d), the Commissioned Organisation may, in addition to terminating this Agreement:

(a) recover any Collaboration Payments provided to the Collaborating Institution on any account or for Collaboration Services that have not been fulfilled or performed

(b) be regarded as discharged from any further obligations under this Agreement, and

(c) pursue any additional or alternative remedies provided by law.

13. Taxes

13.1 Subject to clauses 13.2 to 13.3, the Collaborating Institution must pay all:

(a) stamp duty (including penalties and interest) assessed or payable in respect of this Agreement and in providing the Collaboration Services, and

(b) all taxes, duties and government charges imposed or levied in Australia or overseas in connection with the performance of this Agreement.

GST

13.2 In clause 13.3:

(a) subject to clause 13.2(b), a word or expression defined in the *A New Tax System (Goods and Services Tax Act) 1999* (Cth) (**GST Act**) has the meaning given to it in the GST Act, and

(b) where a taxable supply takes place outside Australia in a territory that imposes a goods and services tax, value added tax, or similar, then references in clause to GST, GST Liability, and GST Law will refer to the applicable tax, tax liability and legislation in that territory and clause 13.3 will be read and construed accordingly.

13.3 Unless otherwise specified in the Budget, amounts that ACIAR is required to pay under this Agreement are calculated on a GST-exclusive basis. Where the Commissioned Organisation becomes liable to remit any amount of GST in respect of any Supply it makes to ACIAR in accordance with this Agreement (**GST Liability**), the amount otherwise payable by ACIAR under this Agreement will be increased by the amount of the GST Liability, or any lesser amount required by law. The increased amount will be payable by ACIAR in the same manner and at the same time as other amounts payable under this Agreement; and where required, the Commissioned Organisation will provide a tax invoice that may enable ACIAR, if permitted by the, to claim a credit or refund, a notional credit refund, of GST.

14. Notices

All notices, requests, demands and other communications under this Agreement will be in writing directed to the representative specified in the Agreement Details (which may be updated by providing a notice to the other Party in accordance with this clause 14) and will be deemed to have been given: (i) immediately if delivered by hand, (ii) on the seventh day following postage if delivered by express post; and (iii) on the next business day in the location of the recipient's address if sent by email.

15. Waiver

A waiver by either Party in respect of any breach of a condition or provision of this Agreement must be made in writing and will not be deemed to be a waiver in respect of any continuing or subsequent breach of that provision, or breach of any other provision. The failure of either Party to enforce any of the provisions of this Agreement at any time will in no way be interpreted as a waiver of such provisions.

16. Negation of Employment, Partnership and Agency

A Party will not by virtue of this Agreement be or for any purpose be deemed to be an officer, employee, partner or agent of the other Party, or as having power or authority to bind or represent the other Party, and will not represent itself, and will ensure that its Personnel do not represent themselves, as such.

17. Applicable Law

This Agreement will be governed by and construed in accordance with the laws of the State of Victoria. Each Party submits to the jurisdiction of the courts of Victoria and any court competent to hear appeals from those courts.

18. Consent

Except as expressly provided in this Agreement, a Party may conditionally or unconditionally in its absolute discretion give or withhold any consent or approval under this Agreement.

19. Variation to this Agreement

This Agreement may only be amended by a written instrument signed by the Parties.

20. Survival

Without limitation to the express provisions of this Agreement or those clauses of this Agreement which are intended or capable of having effect following the expiry or termination of this Agreement, the following clauses will survive the expiry or termination of this Agreement: clauses 1, 3.2, 4, 5.2, 8, 9, 10 ,11, 12.2, 13, 17, and this clause 20.

Signed for and on behalf of the **Commissioned Organisation** by its duly authorised delegate

______________________________ ←

Signature of delegate

____

Name of delegate (**print**)

____

Position of delegate (**print**)

ON: [**insert date**] ______/______/_________ ←

Signed for and on behalf of the **Collaborating Institution** by its duly authorised delegate

______________________________ ←

Signature of delegate

____

Name of delegate (**print**)

____

Position of delegate (**print**)

ON: [**insert date**] ______/______/_________ ←

Australian Government

Australian Centre for
International Agricultural Research

Full Project Proposal

ACIAR Program(s) area	Fisheries
Project Title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Project Number	FIS/2023/133
prepared by	Project Leader to complete
ACIAR Research Program Manager	Dr Chris Cvitanovic

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organisation, collaborating organisation(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavors to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Summary Information

Version # and date of this document	Project Leader to enter
Project number	FIS/2023/133
Full project title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Budget ($)	ACIAR to enter Project budget
Commissioned Organisation	Charles Sturt University
Project Leader	Dr Lee Baumgartner
Country 1 Coordinator	Project Leader to enter
Country 2 Coordinator	Project Leader to enter
Proposed start date	1/07/2024
Proposed end date	30/06/2029

The guidelines in italics in each section of this template will assist you to develop your Full Project Proposal. Please delete guideline text before submitting your Proposal. Your text should be in plain Arial 11 point.

The Full Project Proposal is used to:

- *provide the detailed plan needed for assessment by external reviewers,*
- *provide the basis for final ACIAR assessment and contracting of the project, and*
- *guide implementation of the project and monitoring and review during and after the project.*

ACIAR projects vary significantly in size and scope so there is no total page limit in the Full Project Proposal. However, the Proposal should not contain anything that isn't relevant to one of the three purposes outlined above.

The document should be prepared using Arial, 11-point font.

The structure of the Full Project Proposal differs from the Preliminary Project Proposal, by the addition of several new Sections.

Provide a list of all the abbreviations and acronyms used in the project proposal here – but please limit your use of both.

Contents

1. Project Justification

This section should explain why the proposed research will be a valuable part of Australia's Official Development Assistance.

1.1 Project Aim

A single sentence summary of what the project is intended to achieve. This Project Aim needs to make sense on its own as it will be used in other documents such as the Project Factsheet on the ACIAR website and in partner country agreements.

1.2 Development Issue and Research Opportunity

What is the development issue this project seeks to address? Briefly describe the context of the development issue, including what we already know about this issue and how it's been addressed to date. What is the opportunity for further research to address the development issue? Provide a concise explanation of the research opportunity, including what is new research and what is ongoing research on an existing topic. Support these statements with relevant references. It may be helpful to consider why a research project is needed to address the development issue rather than a development project.

1.3 Partner country and Australian research and development priorities

Explain how this project addresses national priorities and/or development priorities in the partner country/countries (and in Australia for projects with an Australian research component). Cite references to support these claims. What further evidence can you provide to demonstrate this problem is a priority for the partner country or countries and for Australia? If the project is to be commissioned through a CGIAR centre, you should also indicate how it will relate to relevant OneCGIAR initiatives.

1.4 Relationship to other ACIAR investments and other donor activities

How will this work complement other Programs and Projects? Provide a description of the relationships that this project would have to other relevant programs and projects (if any), including national programs, other ACIAR projects and any other related activities in the partner country/countries. For other ACIAR projects, focus on those projects that have a *strong link to the proposed research and indicate how the new research will complement or add to previous or current activities.*

2. Project Theory of Change

The purpose of this section is to present a detailed articulation of the project theory of change and the constitutive strategies (Research, Gender & Social Inclusion, Capacity Building, and Knowledge Exchange) that will guide project implementation. It also includes a detailed outline of project Activities and Approaches, and associated Outputs. Project teams should focus on demonstrating coherence between activities, outputs, cross-cutting strategies and intended short, medium and long-term development outcomes.

2.1 Overview

Please provide a clear Theory of Change, including:

- *A set of clear, expected end of project outcomes. These outcomes should articulate the project's expected contribution to the research program theory outcomes identified in the design brief. They should be as specific as possible, identifying the nature and extent of change that you anticipate the project will have during the funding period.*
- *A description of the main 'impact pathways' in the theory of change. This should be a description of the chain of results that will lead to the end of project outcome. This description should start with the research/activities that will be undertaken and explain what we expect these activities to lead to, and how this will contribute to the end of project outcomes. This should involve identifying a range of intermediate outcomes that can be used as progress markers between the activities and end of project outcomes. These are the outcomes that will be the focus of your monitoring plan and annual reporting.*
- *Key assumptions. At this stage, we are asking you to identify those assumptions that underpin the project theory of change. The project team will need to reflect and report on what they have learned about these assumptions annually. These assumptions can be identified at two levels:*

    1) *The context and development theory assumptions made in the design brief – e.g. that the arrangements of the prevailing market system are such that farmers could see benefit from investing in project promoted practices; that project interventions accurately diagnose and align with the aspirations of small holders for their farming systems.*

    2) *The causal assumptions relating to the internal logic of your theory of change – e.g. that a combination of structured training and supervised work-based*

application of new skills will result in the capacity to independently undertake improved laboratory practices; that iterative engagement with policy makers from the project design stage will improve the likelihood of engagement with, and uptake of, research findings.

It may be useful to include an anticipated time-horizon for ACIAR involvement and initial thinking about an exit strategy and/or avenue for scale-out of knowledge.

2.2 Research Strategy

This section should present key information about how the project will be implemented to address research questions and deliver project outcomes.

2.2.1 Research questions

Provide a set of clearly worded research questions that will guide and be answered by the research activities. Each research question should be supplemented by brief explanatory text, which outlines the links to research focus and key project outputs.

2.2.2 Addressing research questions

Summarise the proposed approaches (i.e. research methods) for conducting the research. ACIAR will use this information as a key part of determining the case for investment, including whether the proposed level of funding represents value for money. Provide a description of the disciplinary methods that will be used, approaches to inter-, multi-, or trans-disciplinarity (where appropriate). Where experiments, trials or surveys are to be used, provide an indication of scale.

2.3 Gender & Social Inclusion Strategy

Describe how the research will contribute to increased gender equity and social inclusion, and how this will be tackled in the project design and implementation. Describe the approaches to be used to: (i) increase gender equity and social inclusion as a result of the research; (ii) address gender equality and social inclusion beyond the project life; and (iii) engage the private sector and/or relevant community groups and partners.

ACIAR has Gender Guidelines (https://www.aciar.gov.au/Gender-Guidelines), which are designed to assist researchers to ensure proposals present project outcomes, research activities, methods, capacity building activities and outputs that can effectively address women's empowerment and improve understanding of gendered social relations.

ACIAR requires proposals to undertake research to include consideration of opportunities to (i) increase gender equity as a result of the research; (ii) address gender inequality subsequent to the research; and (iii) engage the private sector and/or relevant community *groups and partners. This includes a requirement for research teams to include, at a minimum, 40 per cent of female or gender-diverse team members.*

2.4 Capacity Building Strategy

Outline current thinking concerning the capacity building modality (individual skills & competencies and/or organisational strengthening and/or influencing institutional environment) that will be utilised to deliver this project. You may wish to consider outlining how the project will:

- *accurately diagnose the nature of the skills and/or capacity problem we are seeking to address and the institutional environment in which the project will operate*
- *cultivate ownership of, and commitment to, the capacity building agenda with partners*
- *assess the appropriateness of proposed skills and/or capacity building approaches*

One of ACIAR's overarching development objectives is 'Building scientific and policy capability within our partner countries'. Many ACIAR projects, therefore, include elements of research capacity building. ACIAR has prepared project development guidance for capacity building planning and reporting to support ACIAR project leaders and project team members.

Postgraduate research students can play an important role in ACIAR research projects. Improving the integration of postgraduate students on ACIAR projects can benefit the students themselves, research teams, and partner countries. ACIAR has prepared guidance on the integration of PhD and Masters students in ACIAR projects. This aims to support ACIAR project leaders and project team members to clearly articulate a student's role whilst setting out the risks.

2.5 Knowledge Exchange Strategy

This section should present key information about how the knowledge exchange strategy will be implemented during the project to deliver anticipated end of project outcomes.

Who (excluding the project team) do you anticipate being the key stakeholders and end-users of the knowledge generated through this project, and what strategies or activities will be used to engage them?

Please consider and outline:

- *At what point will key stakeholders and users of knowledge generated by the project be engaged?*

- *What activities or strategies will be employed to engage them for the purposes of knowledge exchange?*

- *How will the knowledge generated be positioned for use by users, and for what intended result?*

This strategy only needs to be indicative and can be revised, in consultation with ACIAR, as the project moves forward. Also note that the ACIAR ICCON (In-Country Communications Officer Network) exists to provide in-country outreach support and help create overarching visibility of in-country projects. Projects are encouraged to engage with the relevant In-Country Communications Officer, but you cannot rely on the ICCON or ACIAR Outreach budget for proposed project level activities.

2.6 Research activities, approaches, and outputs

Provide a detailed account of the activities that will be conducted to deliver the project. For each activity what will be done, by whom, when and what will be produced as a result?

Summarise the proposed approaches (i.e. research methods) for conducting the research using the following table. ACIAR will use this information as a key part of determining the case for investment, including whether the proposed level of funding represents value for money. Provide a description of the disciplinary methods that will be used.

You may wish to structure this section under the Research Questions identified above, or around the intended project outcomes identified in your theory of change..

Include any scientific publications that you anticipate being produced as specific project outputs. Publications such as technical reports, proceedings and monographs may be submitted to the ACIAR Scientific Publications Committee for approval and funding at a later date.

No.	Activity		Output(s)	Milestone date of output(s)
1.1	Example text		Example text	Example date
	Approach	Example text		
	Risks/Assumptions	Example text		
	Application of outputs	Example text		
1.2	Example text		Example text	Example date
	Approach	Example text		
	Risks/Assumptions	Example text		
	Application of outputs	Example text		
1.3	Example text		Example text	Example date
	Approach	Example text		
	Risks/Assumptions	Example text		
	Application of outputs	Example text		

3. Project Management

3.1 Project performance and monitoring plan

ACIAR expects all projects to develop and implement an outcome-oriented project performance monitoring plan (PPMP). At a minimum, this monitoring plan should demonstrate how a project intends to monitor and report on the activities and intended outcomes identified in the project theory of change, with particular reference to the implementation of the project research, gender, capacity-building, and knowledge exchange strategies. Reporting against this PPMP will be used as the basis for:

- *Completing annual reports*
- *Informing mid-term and final project reports*
- *Evidencing the initial contribution of the project to longer-term development outcomes (in ex-post outcome and impact evaluations).*

For further information on ACIAR's expectations in relation to project performance monitoring plans, please refer to the Project Performance Monitoring Plan Guidance Note.

3.2 Avoiding harm

If there is the possibility of negative environmental, animal welfare or socio-economic impacts because of this project's activities, provide a specific risk assessment and plan for mitigation or management of risks. This should involve detail of any specific governance requirements such as ethics approvals.

Note that ACIAR needs to ensure that its research investments comply with:

- *Section 28 of the Environment Protection and Biodiversity Conservation Act 1999 which states that a Commonwealth agency must not take inside or outside the Australian jurisdiction an action that has, will have or is likely to have a significant impact on the environment inside or outside the Australian jurisdiction.*
- *The Australian Code for the Responsible Conduct of Research (2018)*
- *The Australian Code for The Care and Use of Animals for Scientific Purposes 8th edition (2013)*
- *The National Statement on Ethical Conduct in Human Research (2007)—Updated 2018*

3.3 Data management plan

ACIAR seeks to ensure that data collected through our projects meet the requirements for FAIR (Findable, Accessible, Interoperable, Re-usable) data. Please describe the data management plan which will be implemented in this project, and how it will respond to each of those FAIR data elements.

3.4 Intellectual property and other regulatory compliance

Please describe any Intellectual property management regulatory compliance requirements that are relevant to this project. Outline how these will be managed over the course of this project.

The Mid Term Review will include a review of the use of Background IP in the project to date and any Project IP that is in development and likely to lead to IP that is protectable. The Mid Term Review team will be tasked with recommending to ACIAR whether additional actions, beyond that defined in the Standard Conditions, are required in order to clearly define ownership and / or public access to Project IP, that has been funded by Australian taxpayers' money.

4. Resourcing

Note that the budget is provided in a separate document to this Full Project Proposal.

The budget template provides space for explanatory text. This could include explanation of the proposed funding distribution between partners, in-kind contributions, the magnitude of the travel budget, an explanation of the need for capital items and allocations for outreach activities, monitoring and evaluation activities and accessing gender expertise etc.

4.1 Project team and partnerships

Please copy the following Table from 'All personnel' worksheet in the budget template and remember to update if you make further changes in the budget.

Name	Gender	Organisation	Discipline	Roles and responsibilities in project	% Time on Project	ACIAR Funding of time input %

Provide a description of each of the project team, including the commissioned organisation and partner organisations that will implement this project.

This might include the leadership structure for the project team, including who will be responsible from both the Australian/CGIAR team and the in-country partner(s) for implementation of the activities and the way the different researchers will work together. Where a component of the planned activities requires specialist skills (for example: soil science, value chain analysis, genetics or molecular biology, product development) indicate which team members will lead this component and be accountable for delivery.

In doing so, consider relevant aspects including the balance between the Australian/CGIAR and the in-country organisations and individuals, as well as diversity and balance with respect to female and male participation (including women's active participation in all aspects of project governance, leadership and implementation) and early/mid/late career researchers.

Describe the role of each partner organization, at the level that it relates to the planned project, and the comparative advantage that it brings to the project team. Describe any governance or advisory structure involving stakeholders that will be used to support project implementation and to ensure that the project's activities have the appropriate level of 'ownership' within the key in-country partner organizations.

4.2 Collaboration

Please outline how the relationships identified in Section 1.4 will be translated into collaboration and communication between this project team and (1) other relevant ACIAR work, (2) relevant external work in progress (e.g. DFAT), and/or (3) potential development scaling actors.

4.3 Budget

Provide a brief narrative to explain the logic behind the development of the figures contained in the budget spreadsheets. This could include information about the proposed funding distribution between partners, in-kind contributions, the magnitude of the travel budget, and an explanation of the need for capital items. Explain how much funding will be allocated to communications, project findings dissemination and monitoring and evaluation activities.

4.4 Additional resourcing requirements

List other resources that are required to deliver the project and how those resources will be accessed / managed by the project team. These might include equipment, operating conditions, permits etc.

5. References

Provide a bibliography of the references cited in the Full Project Proposal.

Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to [redacted].

FOI Act s. 47f

Administrative details

Project ID	FIS/2023/133
Project title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Assessment provider	Name of person completing this IP pro forma, usually the Australian Project Leader
If not Australian project leader, provide title	
Date of assessment	

Categories of intellectual property and brief description

Plant or animal germplasm exchange

Does the project involve:	Yes	No
provision of germplasm by Australia to a partner country?		
provision of germplasm from a partner country to Australia?		
provision of germplasm from or to an IARC or another organisation and a project participant?		
use of germplasm from a third party		
material subject to plant breeders/variety rights in Australia or another country?		

If "yes" to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	Details of plant or animal germplasm exchange

Proprietary materials, techniques and information

Does the project involve provision (from one party to another) of:	Yes	No
research materials or reagents (e.g. enzymes, molecular markers, promoters)?		
proprietary techniques or procedures?		
data		
proprietary computer software?		

"Data" means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

Country	Details of proprietary materials, techniques and information

Other agreements

Is any aspect of the project work subject to, or dependent upon:	Yes	No
other materials-transfer agreements entered into by any project participant?		
confidentiality agreements entered into by any project participant?		

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

Country	Details of other agreements

Project, background and third-party Intellectual Property

This includes but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Project IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Project IP (IP that is expected to be developed during the project)

The following material is to be developed as part of the Project:

Type of material	Description (name of document, subject or other identifying information)
[this table contains examples of the types of material that could be considered Project/SRA IP. The contents must be replaced with actual materials created by the Project/SRA.] *Publications/ Reports*	*For example:* • *Technical report on…* • *Journal publication on…* • *Scientific Report on…* • *Literature review on…* • *Conference presentation and policy advice focused on legal and governance frameworks for…* • *High impact primary research article* • *Academic Publication in…*
Framework/Guidelines	*For example:* • *Set of guidelines on…* • *Detailed, revised research framework and TOC* • *Framework for assessment of [insert description*
Education Materials	*For example:* • *Educational materials on the importance of…* • *Best-practice manual*

	• *Posters, factsheets and educational materials in local language(s)*
Communication Materials	*For example:* • *Technical information packs and manuals* • *Policy briefs* • *Fact/Information sheets* • *Info-graphics* • *Project website* • *Animation videos* • *Best practice documents* • *Website* • *DVD's* • *Extension materials and market information*
Training Materials	*For example:* • *Country-specific manuals for farmers* • *Handicraft skills training and product development* • *Sales support materials*
Strategies	*For example* • *Strategies for the ongoing protection of…*
Plans	*For example:* • *National plan of action/policy brief* • *Community implementation and monitoring plans for selected interventions* • *[insert description] management plans*
Analysis	*For example:* • *Market research diagnostics* • *Cost-benefit analysis to identify…* • *Qualitative factor analysis* • *Internal analysis and working paper on…* • *Working paper on the current policy environment and potential for integration of…* • *Theories of action/change for policy engagements in Indonesia*
Pathways	*For example:* • *Pathways for scaling out e.g. strategies, methods, materials including …*
New germplasm potentially protectable under plant variety rights	
Inventions potentially protectable under patent laws	*For example:* • *Reagents* • *Vaccines* • *Chemicals* • *Strains of biological organisms* • *Machines and designs* • *Data reduced to a material form*
Software and Apps	• *Proprietary software only*
Other	*For example:* • *Other Project Outputs as specified in section [insert reference] of this Full Project Proposal*

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Project IP should be provided to ACIAR prior to project commencement.

	Yes	**No**
Is there Background IP?		
If "yes", are there any restrictions on the project's ability to use the Background IP?		
would there be any restriction on ACIAR or the overseas collaborator claiming their rights to IP for the project based on the Background IP (refer ACIAR Standard Conditions)?		

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

country	**Details of background IP**

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

	Yes	**No**
Is there any relevant Third Party IP that is essential to the project?		
If "yes", would there be any restriction on ACIAR claiming its rights to IP for the project (refer ACIAR Standard Conditions)?		

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

Country	**Details of third party IP**

Other contracts, licences or legal arrangements

	Yes	**No**
Are there any other contracts, licences or other legal arrangements that relate to the project?		

If "yes", for each applicable country provide brief details.

Country	**Details of other contracts, licences or legal arrangements**

Appendix B: Project Variations

Variations to the project after commissioning should be documented in this section

Variation 1.

Variation Date	Purpose	
Example date	Brief explanation of purpose for variation	
Changes (omissions, substitutions, inclusions)	i.	Page 8, line 16-18. - **Omitted line**: "*…example…*" - **Substituted line**: "…example…"
	ii.	Page 9, line 12. - **Included line: "…example…"**
	iii.	
	iv.	
	v.	
	vi.	
	vii.	
	viii.	
	ix.	

Australian Government

Australian Centre for
International Agricultural Research

Research Agreement

between the

Commonwealth of Australia

represented by the

Australian Centre for International Agricultural Research

and the

Commissioned Organisation

Agreement Details

Project Title	FIS/2023/133 Optimising fish passage at hydropower sites in the Mekong
ACIAR *Name:* *Australian Business No.* *Postal Address* *Physical Address*	The Commonwealth of Australia represented by the Australian Centre for International Agricultural Research 34 864 955 427 GPO Box 1571, Canberra ACT 2601, AUSTRALIA ACIAR House, 38 Thynne Street, Fern Hill Park, Bruce ACT 2617
ACIAR Contract Manager	Name Ingrid van Putten Position Research Program Manager Tel. [redacted] Email [redacted]
Commissioned Organisation *Name* *Registered Business No.* *Postal Address* *Physical Address* *Australian Entity*	Charles Sturt University 83 878 708 551 Locked Bag 588, Wagga Wagga, NSW 2678 Boorooma Street, North Wagga, NSW 2650 Yes ☒ No ☐ ***NOTE****: selection of whether the Commissioned Organisation is an Australian Entity will affect the application of clauses under this Agreement as further detailed in clause 3.*
Commissioned Organisation Contract Manager	Name Dr Lee Baumgartner Position Executive Director Tel. [redacted] Email [redacted]
Term *Commencement Date* *Completion Date*	1 July 2024 or from the date of the last signature (whichever is the later) 30 June 2029
Financial Limitation	[redacted]
Withheld Sum	[redacted]
Project Leader	As detailed in the Project Document.
Key Personnel	The Project Leader and other Personnel of the Commissioned Organisation: either identified as 'Key Personnel' in the Project Document or listed immediately below.
Subcontractors	(see table below)

Organisation	Name	Role
KarlTek	Karl Pomorin	Advice and management of PIT tag data
Fishway Consulting Services	Martin Mallen-Cooper	Advisory board member
Consultant	Jody Swirepik	Advisory board member
Consultant	Daniel Deng	Advisory board member
Snowy Hydro	Lizzie Pope	Advisory board member
Alinea International	Mia Urbano, Ana Illic, Primatina Wulandari	Manage GEDSI and MEL reporting

Requirement for Personnel to sign confidentiality deeds	Yes ☐ No ☒ ***NOTE****: If the requirement applies, ACIAR may require the Commissioned Organisation's Personnel to sign deeds of confidentiality under clause 14.1(d).*
Reports *Annual Report(s)* *Final Report*	Annual reports are to be provided each Financial Year of the Term by the following 31 March, other than for the final Financial Year of the Project (where a Final Report is required instead). A final report is to be provided within 60 days of completion of the Project.

FOI Act s. 47f

FOI Act s. 47f

FOI Act s. 47g

Other Report(s)	NA
Reviews *Final Review* *Mid-Term Review*	 To be conducted 8-12 months before completion of the Project. To be held within the first 12-36 months of the Term.
Special Conditions	N/A
CGIAR IA Principles Apply?	Yes ☐ No ☒ ***NOTE:*** *If CGIAR IA Principles apply, payment arrangements will be in accordance with clause 9.2 and intellectual property arrangements will be in accordance with clause 13.5.*
Complex Activity ***Collaborating Country*** ***Collaborating Institution***	Yes ☒ No ☐ ***NOTE:*** *If this Agreement relates to a Complex Activity, the Additional Terms will form part of this Agreement in accordance with clause 2.* Lao PDR **Living Aquatic Resources Research Centre – National Agriculture and Forestry Research Institute** **National University of Laos** **Department of Livestock and Fisheries** **Xayaburi Power Company Limited**

Table of Contents

Research Agreement between ACIAR and the Commissioned Organisation

BACKGROUND

ACIAR has requested that certain services be carried out pursuant to the Project, and the Commissioned Organisation has agreed to provide the Services on the terms of this Agreement.

THE PARTIES AGREE AS FOLLOWS:

1. Interpretation

1.1 **Definitions.** In this Agreement, unless a contrary intention appears, capitalised terms have the meaning provided in the Agreement Details and:

Acquittal Report has the meaning provided in clause 9.4.

Additional Terms means the additional terms that are included as Annexure B, if the Agreement Details specifies this Agreement as relating to a Complex Activity.

Adverse Event occurs, in respect of a Party, if

(a) the Party is the subject of winding up or liquidation proceedings, whether voluntary or compulsory, otherwise than for the purpose of and followed by, a reconstruction, amalgamation or reorganisation

(b) if the Party has become insolvent, bankrupt or is subject to the appointment of a receiver, manager or an inspector to investigate its affairs, enters into any arrangement or composition with its creditors generally, or is unable to pay its debts as and when they become due, or

(c) if execution is levied upon all or any part of the assets of the Defaulting Party, provided that no breach occurs if the execution is contested in good faith or if within 5 Business Days after it is levied payment is made in full to the judgment creditor in question of all amounts owing to the judgment creditor.

Agreement means this agreement, and includes the Background, the Agreement Details and the documents set out in clause 1.3 (as applicable).

Agreement Details means the details set out in the table at the front of this Agreement.

Approved Subcontractor means a third party to be engaged by the Commissioned Organisation for provision of sub-contracted Services that has been approved in writing by ACIAR, but does not include a Collaborating Institution.

Background IP means IP Rights that are in existence prior to the date of this Agreement, or are brought into existence independently of this Agreement, and which are used in, or is otherwise required for the use of, the Project IP.

Budget means the budget set out in Annexure B of the Project Document.

Commonwealth means the Commonwealth of Australia.

Confidential Information means information of a Party (**Disclosing Party**) that is by its nature confidential and:

(a) is designated by the Disclosing Party as confidential, or

(b) that another Party (**Receiving Party**) knows or ought to know is confidential,

but does not include information which:

(c) is or becomes public knowledge other than by:

(i) breach of this Agreement, or

(ii) any other unlawful means

(d) is in the possession of a Receiving Party without restriction in relation to disclosure before receipt from the Disclosing Party, or

(e) has been independently developed or acquired by the Receiving Party,

and the burden of establishing any exceptions referred to in subclauses (c) to (e) above is on the Receiving Party.

Control	means, in relation to a body corporate, the ability of any person directly or indirectly to exercise effective control over the body corporate (including the ability to determine the outcome of decisions about the financial and operating and other policies of that body corporate) by virtue of the holding of voting shares, units or other interests in that body corporate or by any other means.
Deliverables	means the deliverables of the Project as specified in the Project Document.
Due Date	means the date that a Deliverable is due for submission to ACIAR, as specified in the Project Document.
Exploit	means, in respect of IP Rights: (a) 'exploit' as defined in the *Patents Act 1990* (Cth), and (b) to the extent that any IP Rights relates to works subject to copyright, to reproduce, modify, publish, adapt and communicate the works to the public.
Financial Year	means the period from 1 July to 30 June of the following year.
IP Rights	means statutory and other proprietary rights in respect of patents, designs, plant breeders' rights, trade marks, circuit layouts, copyright, confidential information, know-how and all other intellectual property rights as defined in Article 2 of the *Convention Establishing the World Intellectual Property Organisation of July 1967*.
International Arrangements	means arrangements that establish the operating framework for the Project including such matters as: intergovernmental arrangements, sub-contracts with Approved Sub-Contractors, contracts between the Commissioned Organisation and any Collaborating Institutions, the arrangements covering matters such as customs assistance, in-country security, indemnities and intellectual property rights.
Moral Rights	means the right of attribution of authorship, the right not to have authorship falsely attributed and the right of integrity of authorship granted to authors under the *Copyright Act 1968* (Cth).
Parties	means ACIAR and the Commissioned Organisation (and their respective successors and permitted assigns), and **Party** means either one of them.
Payment Period	means, unless otherwise specified in the Project Document, the periods: 1 January to 30 June, or 1 July to 31 December, except that the period will be reduced in length relevantly if the Commencement Date or Completion Date falls within the period.

Payments	means the payments ACIAR will make available to the Commissioned Organisation in consideration of receipt of the Services as specified in the Budget, to be made available by ACIAR in accordance with the terms of this Agreement, and **Payment** means any one of those payments.
Personnel	means, in respect of a party, the: employees, officers, agents, students and sub-contractors of that party and, in respect of the Commissioned Organisation, includes the Key Personnel.
Primary Terms	has the meaning provided in clause 1.3.
Project Document	means the document set out in Annexure A to this Agreement, as amended from time to time in accordance with this Agreement.
Project IP	means IP Rights created by or on behalf of the Commissioned Organisation as a result of performing the Services or otherwise in the course of expending the Payments.
Services	means the services (including Deliverables) that the Commissioned Organisation is required to provide under this Agreement.

1.2 **Interpretation.** Unless a contrary intention appears, in this Agreement:

(a) words imputing a gender include any other gender

(b) a business day means a day which is not a Saturday or Sunday or a public holiday in the place where a notice is to be received or a particular activity is to be performed, and if a day on or by which an obligation must be performed or an event must occur is not a business day, the obligation must be performed or the event must occur on or by the next business day

(c) the singular includes the plural and vice versa

(d) another grammatical form of a defined word or expression has a corresponding meaning

(e) a reference to a statute or other law includes regulations and other instruments under it and consolidations, amendments, re-enactments or replacements of any of them

(f) a reference to a document includes the document as novated, altered, supplemented or replaced from time to time

(g) a reference to a person includes a natural person, partnership, body corporate, association, governmental or local authority or agency or other entity, and includes and includes the person's permitted successors, substitutes (including persons taking by novation) and assigns

(h) 'including', 'includes', 'such as' and 'in particular' do not limit the generality of the words which precede them or to which they refer

(i) 'month' means a calendar month and 'year' means a calendar year

(j) any agreement, representation, warranty or indemnity by two or more parties (including where two or more persons are included in the same defined term) binds them jointly and severally

(k) any agreement, representation, warranty or indemnity in favour of two or more parties (including where two or more persons are included in the same defined term) is for the benefit of them jointly and severally

(l) a rule of construction does not apply to the disadvantage of a Party because the Party was responsible for the preparation of this Agreement

(m) paragraph headings are inserted for convenient reference only and have no effect in limiting or extending the language of provisions to which they refer

(n) all references to dollars are to Australian dollars, unless otherwise specified, and

(o) a reference to a clause is a reference to a clause of these Primary Terms, and a reference to a Schedule, or Annexure is a reference to a schedule or annexure of this Agreement.

1.3 **Order of Priority.** In the event and to the extent of any inconsistency, the components of this Agreement will be interpreted in the following order of priority:

(a) the Special Conditions (if any)

(b) where applicable under clause 2, the Additional Terms

(c) these clauses 1 to 21 (**Primary Terms**), and

(d) the Project Document.

2. Additional Terms

Where the Agreement Details identify this Agreement as a Complex Activity, this Agreement includes the Additional Terms. Where the Agreement Details do not identify this Agreement as a Complex Activity, the Additional Terms do not form part of this Agreement.

3. Country Specific Clauses

The Parties acknowledge and agree that:

(a) if the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details, clauses 15.6, 19.9, and 19.20 will apply to this Agreement and clause 19.10 will have no effect, and

(b) if the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details, clause 19.10 will apply to this Agreement and clauses 15.6, 19.9, and 19.20 will have no effect.

4. Term

4.1 Subject to clause 4.3, the term of this Agreement will commence on the Commencement Date and, subject to extension under clause 4.2 or earlier termination under clause 16, will end on the Completion Date (**Term**).

4.2 The Term may be extended upon the mutual agreement of the Parties, including in circumstances where ACIAR has granted an extension of time under clause 7.2.

4.3 If the International Arrangements enabling the Project have not been established to the satisfaction of ACIAR prior to the Commencement Date, the term of this Agreement shall commence upon ACIAR being satisfied (in its absolute discretion) that such International Arrangements have been established.

5. Services

The Commissioned Organisation will perform the Services:

(a) in a proper and professional manner exercising all appropriate care, diligence and attention, and in accordance with ethical scientific practice

(b) in furtherance of the objectives of the Project

(c) so as to provide any Deliverables and reports by the Due Dates and otherwise as required under this Agreement (including as specified in the Project Document)

(d) without limitation to clause 10, using Personnel of the requisite scientific calibre

(e) at the times and in the manner specified in this Agreement (including as specified in the Budget and the Project Document more generally) or otherwise agreed by the Parties, and

(f) in accordance with:

(i) applicable law, and

(ii) the reasonable directions of ACIAR.

6. Project Leader

In addition to any tasks designated for the Project Leader in the Project Document, the Project Leader will be responsible for coordinating all Services to be provided by the Commissioned Organisation and will liaise with ACIAR regularly regarding Project progress.

7. Delays

7.1 Notwithstanding clauses 9.4(a)(iv) and 9.5(c), upon becoming aware of any (actual or potential) delay in provision of Services the Commissioned Organisation will immediately notify ACIAR in writing of: the relevant background circumstances, the likely length of delay, and the steps the Commissioned Organisation has and will take to minimise the length and effect of the delay (**Delay Notice**).

7.2 Following receipt of a Delay Notice, ACIAR will determine, acting reasonably, whether to grant an extension of time to perform all or part of any remaining Services.

8. Subcontracting

8.1 The Commissioned Organisation will not subcontract performance of Services other than to Approved Subcontractors. For the purposes of this clause 8.1, the subcontractors specified in the Project Document and the Subcontractors listed in the Agreement Details constitute Approved Subcontractors.

8.2 The Commissioned Organisation remains responsible for performance of the Services by its subcontractors, including Approved Subcontractors.

9. Payment

9.1 In consideration of performance of the Services, ACIAR will make the Payments to the Commissioned Organisation, in advance and in accordance with the Budget.

9.2 If the Agreement Details specify that the CGIAR IA Principles apply, then the Parties acknowledge that Payments shall be made pursuant to clause 9.1 according to the following process:

(a) all Payments shall be made to the Commissioned Organisation via the International Bank for Reconstruction and Development (**IBRD**) as the Trustee of the CGIAR Fund for this Agreement

(b) in respect of each of the Payments, ACIAR will seek an invoice from IBRD, and

(c) following receipt of an invoice from IBRD, ACIAR will make the relevant Payments to IBRD with instructions to disburse those Payments to the Commissioned Organisation.

9.3 The Commissioned Organisation acknowledges it is responsible for payment of, and accounting to ACIAR for, all expenditure of Payments and all costs and expenses incurred in performing the Services.

9.4 Within 30 days of the end of each Payment Period or receiving a Withheld Payment under clause 9.5(e), the Commissioned Organisation will provide ACIAR (in a format as specified by ACIAR from time to time) a report including the following details:

(a) for the relevant Payment Period and detailed on an item-by-item basis, an accurate account of:

(i) Payments received

(ii) Payments expended, including details of how Payments have been expended

(iii) Payments not expended, and

(iv) if the amount of Payments not expended exceeds 20% of Payments made available for the relevant Payment Period, the reasons for any delay in spending or committing Payments, and

(b) sign-off by the Project Leader, and certification of the accuracy of details provided in acquittal report by an authorised officer of the Commissioned Organisation, together an **Acquittal Report.**

9.5 Notwithstanding clauses 9.1 and 9.2:

(a) Payments are subject to appropriation being made by the Parliament of the Commonwealth for those Payments

(b) ACIAR will only advance Payments for the next Payment Period following:

(i) receipt of a satisfactory Acquittal Report for the previous Payment Period, and

(ii) if the Commissioned Organisation is required to provide ACIAR reports under clause 15.1 during earlier Payment Periods, satisfactory provision of such reports.

(c) in respect of any previously advanced Payments (or part thereof) not expended during earlier Payment Periods (**Unspent Payments**), ACIAR may reduce the Payment for the next or a future Payment Period, and the Financial Limitation, by all or part of the amount of the Unspent Payments.

(d) unless otherwise agreed in writing by ACIAR:

(i) Payments will not exceed the Financial Limitation

(ii) ACIAR will not be liable for expenses incurred other than as provided for in the Budget, for any services other than Services, or for any services performed (including purported Services) or expenses incurred after the Completion Date, and

(iii) the Commissioned Organisation must return any Payments not properly earned or expended within 30 days of ACIAR accepting the final Acquittal Report.

(e) ACIAR will withhold the Withheld Sum from the final Payment pending acceptance of a satisfactory Final Report, following which:

(i) ACIAR will provide the Commissioned Organisation the Withheld Sum within thirty (30) days of ACIAR accepting the Final Report, and

(ii) the Commissioned Organisation must provide ACIAR a final Acquittal Report for the Project within thirty (30) days of receipt of the Withheld Sum.

10. Personnel and Personal Property

10.1 The Commissioned Organisation will provide adequate and competent Personnel to perform the Services.

10.2 The Commissioned Organisation will notify ACIAR immediately if any Key Personnel become unavailable to continue performance of Services or otherwise progress the Project.

10.3 ACIAR may require the Commissioned Organisation to, at the cost of the Commissioned Organisation, promptly replace Personnel with replacement Personnel approved by ACIAR if:

(a) the circumstance set out in clause 10.2 arises, or

(b) ACIAR has any reasonable grounds to require removal of Personnel from the Project, including in circumstances where Personnel perform Services in another country and, while not citizens of that country, become involved in the political affairs of that country.

10.4 As between the Parties, the Commissioned Organisation will be solely responsible for the remuneration and the work, health and safety of its Personnel, and must ensure that such Personnel comply with the Commissioned Organisation's obligations under this Agreement (including in relation to the ownership of IP Rights and obligations of confidentiality).

10.5 The Commissioned Organisation is responsible for its personal property (and the property of any of its Personnel involved in performing the Services, including any Key Personnel) and for any loss of property or damage caused to it.

11. Project Supplies

11.1 The Commissioned Organisation will arrange the procurement and delivery of all equipment and supplies required for the Project, including those specified in the Project Document (**Supplies**), and may apply Payments to do so where specified in the Project Document.

11.2 The Commissioned Organisation will: exercise administrative control over, manage the security, maintain and keep in good repair, and (where applicable) repair or replace, the Supplies.

11.3 Ownership of Supplies will vest in the Commissioned Organisation from the date of purchase.

12. Travel

12.1 For all travel of Commissioned Organisation Personnel pursuant to this Agreement:

(a) the Commissioned Organisation is responsible for arranging and paying for the travel and allowances of the Personnel, which may be paid from the Payments if allocated for in the Budget, and provided that all air travel is purchased in economy/excursion class or lower fares and for the most direct and economical routing (the Commissioned Organisation may reroute or upgrade at its expense)

(b) without limitation to clause 10.4, the Commissioned Organisation is solely responsible for the security and safety of its Personnel and must make its own enquiries in relation to travel advice. ACIAR has no responsibility or liability for any injury, death, loss or damage suffered or expenses incurred relating to travel undertaken by Commissioned Organisation Personnel

(c) the Commissioned Organisation will provide prior written notice to ACIAR, including a travel schedule and details of its Personnel undertaking the travel (and of any accompanying dependants), in the form of a 'Travel Advice Note' as available on the ACIAR website accessible at http://aciar.gov.au/travel, and

(d) the Commissioned Organisation will provide a travel report in accordance with clause 15.3.

13. IP Rights and moral rights

IP Rights

13.1 ACIAR and the Commissioned Organisation will have regard to the provisions of and fulfil all relevant obligations under international arrangements to which Australia is a signatory relating to intellectual property and biological resources including:

(a) the *International Treaty on Plant Genetic Resources*

(b) the FAO trustee arrangements with international agricultural research centres

(c) the *Convention on Biological Diversity*

(d) the *Agreement on Trade Related Aspects of Intellectual Property Rights*, and

(e) and the provisions of the *International Union for the Protection of New Varieties of Plant.*

Transfer and exchange of germplasm by the Commissioned Organisation and/or sub-contractors will be subject to materials transfer and acquisition agreements and in accordance with the Convention on Biological Diversity. This clause 13.1 will be interpreted such that the relevant obligation is that which was in effect at the time of the action in question.

13.2 ACIAR and the Commissioned Organisation agree, in respect of any Project IP, that:

(a) in a Collaborating Country, the Project IP shall vest upon creation in the Collaborating Institute that is located within the relevant Collaborating Country, and if there is more than one Collaborating Institute located in that Collaborating Country, those Collaborating Institutes shall own the Project IP in that Collaborating Country as joint owners;

(b) in Australia, the Project IP shall vest upon creation in the Commissioned Organisation (and clause 13.3 shall apply);

(c) in respect of all countries and territories outside Australia and any Collaborating Countries, in accordance with the cooperative nature of the Project and recognising that it will be desirable to use or exploit advances or discoveries which may be made in the course of the Project and under this Agreement, ACIAR and the Commissioned Organisation will discuss and will jointly determine:

(i) the equitable apportionment of ownership of any Project IP arising from the Project

(ii) the management, control and payment of costs in respect of any steps to obtain and maintain registration of IP Rights in respect of Project IP

(iii) the equitable apportionment of profits, royalties or licence fees relating to such Project IP

(iv) the equitable licensing of such Project IP

(v) the equitable licensing of any Background IP of a Party as necessary to enjoy the full benefits of the Project and the Project IP, and

(vi) where it is within their power, the equitable licensing of such other IP Rights (including third party IP Rights) as is necessary to enjoy the full benefits of the Project and the Project IP

and clause 13.4 shall apply.

13.3 Unless otherwise agreed pursuant to clause 13.2(c), where ownership of the Project IP vests in the Commissioned Organisation, the Commissioned Organisation grants to ACIAR a permanent, irrevocable, royalty free, world-wide, non-exclusive licence (including a right to sublicense) to exploit, use, reproduce, modify, publish, adapt and communicate to the public the Project IP.

13.4 In fulfilling their obligations under the clause 13.2(c), ACIAR and the Commissioned Organisation will have regard to relevant considerations including:

(a) their respective intellectual and other contributions

(b) their respective contributions of Background IP, material, research effort and proprietary work

(c) the facilities and funding provided by the Parties, and

such other relevant considerations as they may mutually determine.

13.5 If the Agreement Details specify that CGIAR IA Principles apply:

(a) clauses 13.2 to 13.4 will not apply

(b) the Parties agree that all Intellectual Assets, as defined in the CGIAR Principles on the Management of Intellectual Assets (**CGIAR IA Principles**) and Project IP will be dealt with in accordance with CGIAR IA Principles and that all Project IP will be used for the public good

(c) the Commissioned Organisation acknowledges that:

(i) as a member of the Consortium of International Agricultural Research Centres, the Commissioned Organisation must ensure that all agreements and contracts it enters (including any confidentiality, partnership, collaboration, development, licensing, distribution, material transfer agreements), comply with the CGIAR IA Principles

(ii) ACIAR supports the vision and objectives of the CGIAR, and supports the dissemination of the results of research as a public good, and

(iii) accordingly, Project IP will be managed in a manner consistent with CGIAR IA Principles

(d) ACIAR, the Commissioned Organisation will consider whether to register/ apply for (or allow third parties to register/apply for) patents and/or plant variety protection (**IP Applications**) over the Intellectual Assets. In accordance with CGIAR IA Principles, the Parties agree that no such IP Applications will be made unless they are necessary for the further improvement of such Intellectual Assets or for the public good. The Parties acknowledge that all IP Rights will be exercised consistently with Articles 6.1 to 6.3 of the

CGIAR IA Principles

(e) ACIAR and the Commissioned Organisation will grant or will secure the grant to each other of a permanent, irrevocable, royalty free, worldwide, non-exclusive licence (including a right to sublicense its rights to third parties) to Exploit the Project IP. Where Parties propose to sublicence its rights under this clause 13.5(e), they will ensure that any sublicence will be on the same or substantially the same terms and conditions as the licence such party has from the other.

13.6 The Commissioned Organisation will promptly notify ACIAR of the details of any Project IP. Any notification will be treated as Confidential Information by ACIAR.

13.7 Unless otherwise expressly agreed in writing by the Parties, this Agreement does not affect the ownership of Background IP.

13.8 The Commissioned Organisation warrants to ACIAR that to its actual knowledge and belief, following all diligent and reasonable enquiries, at the date that ACIAR first consents to use, or otherwise uses, Background IP supplied by the Commissioned Organisation pursuant to this Agreement (as applicable):

(a) it is the owner of, or is otherwise entitled to use, the Background IP

(b) it is entitled to grant any licences to such Background IP made pursuant to this Agreement, and

(c) the exercise by ACIAR of its rights in such Background IP granted pursuant to this Agreement will not infringe the IP Rights of any third party.

13.9 Where the Commissioned Organisation intends to publish any article or paper of an academic, scientific or technical nature in regard to the Services or this Agreement, or to place any advertisement requesting applications from persons to perform any part of the Services, any such publication or advertisement must acknowledge the funding and other support provided by ACIAR in regard to this Agreement and must comply with ACIAR Branding Guidelines available on the ACIAR website https://www.aciar.gov.au/branding-guidelines.

13.10 The Commissioned Organisation may report details of this Agreement in non-specialist media provided:

(a) it acknowledges the funding and support provided under this Agreement by ACIAR, and

(b) if the subject of the proposed media report may be controversial, the Commissioned Organisation will, prior to submission for publication, request ACIAR's written consent.

Moral Rights

13.11 ACIAR and the Commissioned Organisation:

(a) acknowledge the existence of Moral Rights conferred on the authors of any Works which are created in carrying out this Agreement or which exist as part of the Background IP

(b) will immediately notify the other Party in writing:

(i) upon becoming aware of a possible infringement of Moral Rights of an author of any Works referred to in clause 13.11(a), and

(ii) upon becoming aware of a claim for infringement of Moral Rights being made against a Party by an author of any Works referred to in 13.11(a), and

(c) will, following notice under clause 13.11(a), meet to negotiate in good faith (involving, where possible, the author of the relevant Works) the appropriate steps to resolve the matter to the satisfaction of the Parties and the author.

14. Confidentiality of Information

14.1 Each Party will:

(a) keep Confidential Information of the other Party confidential and will not, without the other Party's prior written consent, disclose or permit the same to be disclosed to any third party

(b) use reasonable endeavours (including labels or verbal notification) to ensure that the receiving Party is aware of the confidential nature of Confidential Information at disclosure

(c) take reasonable steps to provide for the safe custody of Confidential Information of the other Party and to prevent unauthorised access to or use of such Confidential Information, and

(d) ensure that its Personnel comply with the obligations of confidentiality imposed upon it by this clause 14, including in the case of the Commissioned Organisation (if specified in the Agreement Details and where required by ACIAR thereafter), by ensuring that its Personnel to execute deeds of confidentiality in favour of ACIAR consistent with this clause 14.

14.2 The obligations on the Parties under this clause 14 will not be taken to have been breached to the extent that a Party:

(a) discloses Confidential Information of the other Party to its:

(i) Personnel, and

(ii) legal, financial or other professional advisers,

who have a need to know for the purposes of this Agreement (and only to the extent that each has a need to know), provided the disclosure is made subject to an obligation of confidentiality in accordance with clause 14.1(d), or

(b) discloses Confidential Information of the other Party to the extent required to be disclosed:

(i) by law including under court subpoena, parliamentary order, under the *Freedom for Information Act 1982* (Cth) (or equivalent legislation) or as part of discovery during legal proceedings

(ii) to any government agency, authority, department or minister, or to any parliamentary committee, or

(iii) by the rules of a stock exchange,

provided that to the extent reasonably possible, prior written notice of such required disclosure is given to the disclosing Party to enable it to seek to challenge the disclosure of its Confidential Information.

14.3 At any time upon written request, a Party must return all documents in any form which embody Confidential Information of the other Party, provided that a Party may retain one copy of such Confidential Information as necessary to meet its reasonable record-keeping requirements subject to an obligation to keep such copy confidential in accordance with this clause 14.

14.4 Each Party's obligations under this clause 14 survive expiration or earlier termination of this Agreement and continue until the Confidential Information disclosed to it lawfully becomes part of the public domain.

15. Reports, Records, Review and Evaluation

Reports

15.1 The Commissioned Organisation must provide ACIAR the Reports at the times specified in the Agreement Details, and any other reports as reasonably requested by ACIAR (such as interim final reports, project factsheets, and other ad hoc reports).

15.2 Where a self-assessment of the potential for significant environmental impacts under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) has been produced and accepted pursuant to this Agreement, the Commissioned Organisation will provide ACIAR with a report by 14 July each year on the implementation and effectiveness of the risk management procedures identified in the self-assessment.

15.3 Within 30 days of completion of any travel referred to in clause 12.1, the Commissioned Organisation will provide ACIAR a trip report including the travel itinerary and all information reasonably required by ACIAR to enable ACIAR to monitor the Project.

15.4 Each report provided under this clause 15 must be accurate, complete and detailed to enable ACIAR to confirm the true status of the Project, and (where applicable) prepared in accordance with the 'Guidelines for Annual Reports' available on the ACIAR website www.aciar.gov.au (**Guidelines**).

Access to documents

15.5 In clause 15.6, 'document' and 'Commonwealth Contract' have the same meaning as in the *Freedom of Information Act 1982* (Cth).

15.6 If:

(a) the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details

(b) this Agreement (or a subcontract of this Agreement) is a Commonwealth Contract, and

(c) the Commonwealth has received a request for access to a document created by, or in the possession of, the Commissioned Organisation (or any of its Personnel) that relates to the performance of this Agreement (and not to the entry into of this Agreement),

the Commonwealth may at any time by written notice require the Commissioned Organisation to provide the document to the Commonwealth, and the Commissioned Organisation must, at no additional cost to the Commonwealth, promptly comply with the notice.

Records

15.7 The Commissioned Organisation must, at its cost, for the period commencing on the Commencement Date and ending seven years after expiry or termination of this Agreement (**Bookkeeping Period**), keep (and ensure its Personnel keep) adequate books and records, in accordance with international accounting standards, in sufficient detail to enable the determination of how Payments have been expended, and the determination of any other amounts paid or payable under this Agreement (**Records**).

15.8 The Commissioned Organisation must, at its cost, keep (and ensure that its Approved Subcontractors keep) accurate hardcopy or digital scientific records relating to the Project – such records will include detailed, witnessed laboratory notebooks (which may be kept in digital or hardcopy format) sufficient to document any discoveries or inventions made in the course of the Project (**Scientific Records**).

Reviews

15.9 In addition to the Reviews that ACIAR may undertake as specified in the Agreement Details, ACIAR may at any time during the Term, undertake (through its Personnel or its appointed nominee(s)) to review and evaluate this Agreement and the exercise of rights and obligations relating to it (including in respect of the performance of Services). To facilitate any such review, the Commissioned Organisation will at its cost promptly provide any financial, technical or such other information (including Records and Scientific Records) as is required by ACIAR, provide ACIAR with access to Personnel participating in the Project to enable interview and general cooperation, and will at all reasonable times permit persons authorised by ACIAR to have access to the premises upon which the Services are being, or have been, performed.

15.10 ACIAR may at any time during the Bookkeeping Period, direct that the Records be examined by an independent accountant nominated by ACIAR and will permit the accountant to take copies or extracts from the Records. The Commissioned Organisation will give the accountant all assistance, access and facilities necessary to enable the accountant to verify the Records and will supply such other information as may be necessary or proper to verify how Payments have been expended.

Post Project Updates

15.11 Upon request at any time in the ten (10) years following completion of the Project, the Commissioned Organisation will use all reasonable endeavours to provide ACIAR updates in respect of the current outcomes and impact of the Project, having regard to Project objectives (**Post Project Update**). Each Post Project Update will (as all reasonable endeavours enable) include:

(a) details of Project impacts (including scientific impacts, capacity-building impacts, community impacts and environmental impacts)

(b) details of steps take to obtain the full benefit of Project outcomes

(c) where applicable, details of how Project outcomes could be better used to benefit communities, and

(d) learnings as to what future projects may be conducted to benefit communities in respect of the Project outcomes and topics related to the Project.

15.12 The Commissioned Organisation may charge ACIAR a fee for complying with clause 15.11, provided that:

(a) such fee is reasonable and commensurate with the effort involved in complying with clause 15.11, and

(b) the Commissioned Organisation has provided written notice to ACIAR of the amount of such fee (the notified amount calculated to comply with clause 15.12(a)) prior to commencing activities in compliance with clause 15.11.

Accessing Premises

15.13 In accessing the premises of the other Party (**Host**), a Party (**Visitor**) will:

(a) give reasonable written notice to the Host, such notice identifying the representatives of the Visitor to attend the Host's premises

(b) ensure that its representatives comply with all policies of the Host with respect to their attendance (including policies relating to health and safety, security, and standards of conduct) and otherwise comply with all reasonable directions, and

(c) procure that its representatives will (if required) sign a confidentiality agreement in favour of the Host to protect the confidentiality of any Confidential Information of the Host.

16. Termination and Reduction

Termination due to circumstances outside the control of the Parties

16.1 Should acts of God, fire, storm, flood, earthquake, explosion, accident, acts of a public enemy or terrorism, war, political upheaval, rebellion, insurrection, sabotage, epidemic, quarantine restrictions, industrial dispute, withdrawal of necessary support for the Project by a host nation government listed in the International Arrangements, transportation embargo or failure or delay in transportation render the completion of the Project impossible or unfeasible, either Party may terminate this Agreement upon providing the other with three months' written notice.

Termination

16.2 ACIAR may terminate or sever part of this Agreement without cause at any time by giving written notice to the Commissioned Organisation which must, on receipt, immediately cease all work and take appropriate action to mitigate any loss and prevent further costs being incurred with respect to the Services.

16.3 Without prejudice to any other rights ACIAR may have under this Agreement or at law, ACIAR may terminate or sever part of this Agreement for default by providing the Commissioned Organisation written notice if:

(a) the Commissioned Organisation breaches any term of this Agreement where that breach is not capable of remedy

(b) the Commissioned Organisation undergoes a change in Control or is subject to an Adverse Event

(c) the Commissioned Organisation or its Personnel engage in conduct that, in the reasonable opinion of ACIAR, is detrimental to the reputation of ACIAR or the Commonwealth, or

(d) if the Commissioned Organisation breaches any term of this Agreement where the breach is capable of remedy and the breach is not remedied within 14 days of receipt of notice in writing from ACIAR.

Effect of termination (or partial termination)

16.4 If this Agreement is terminated pursuant to clause 16.1, ACIAR may recover (and the Commissioned Organisation agrees to return) any Payments provided to the Commissioned Organisation that have not been expended as at the date the Commissioned Organisation was notified of termination.

16.5 Where this Agreement is terminated, wholly or in part, under clause 16.2, ACIAR must pay invoices in respect of:

(a) all reasonable amounts due in accordance with clause 16.2 for Services performed by the Commissioned Organisation in accordance with the terms of this Agreement up until the date of termination, and

(b) the equivalent of any liabilities or expenses of the Commissioned Organisation relating to the terminated Services which are substantiated, and which are properly incurred by the Commissioned Organisation, to the extent that those liabilities or expenses cannot be mitigated, but no other amount,

provided that in no event will ACIAR be required to pay any loss of prospective profits.

16.6 For the purposes of clauses 16.2 and 16.3, ACIAR may elect to sever part of this Agreement (**Partial Termination**) by notifying the Commissioned Organisation that it no longer requires the Commissioned Organisation to provide a particular Service, in which case:

(a) the Commissioned Organisation will cease to provide that Service

(b) ACIAR will no longer be obliged to provide any Payments in respect of that Service (and any Payments made available on account of the future performance of that Service will be returned to ACIAR), and

(c) this Agreement will be construed, and its provisions will be enforceable by and against the Parties, as if references to the Services the subject of that Partial Termination, and Payments made (or to be made) available in respect of those Services, were severed from the Contract.

16.7 If ACIAR notifies the Commissioned Organisation of termination of this Agreement under clause 16.3, ACIAR may, in addition to terminating this Agreement:

(a) recover any Payments provided to the Commissioned Organisation for Services or other obligations that have not been fulfilled or performed

(b) be regarded as discharged from any further obligations under this Agreement, and

(c) pursue any additional or alternative remedies provided by law.

17. Insurance

17.1 The Commissioned Organisation will, for so long as any obligations remain in connection with this Agreement, effect and maintain with reputable and substantial underwriters the following insurance:

(a) workers' compensation for an amount required by any relevant legislation

(b) in relation to Services performed in Australia, public liability insurance for an amount of not less than $20,000,000 per claim and $20,000,000 in aggregate

(c) in relation to Services performed outside Australia, adequate insurance against claims by third parties resulting from acts or omissions of the Commissioned Organisation in carrying out the Services, and

(d) adequate travel and medical insurance for any domestic and international travel undertaken on behalf of this Agreement by its Personnel.

17.2 Within 14 days of a written request from ACIAR, the Commissioned Organisation must provide ACIAR with a copy of any insurance policy (or related certificates of currency) effected in accordance with this clause 17 and of all receipts for payments of premiums.

17.3 The requirement of clause 17.1(c) will not apply in relation to work performed in a particular country if ACIAR has agreed in writing that such insurance is not available in relation to the performance of the Services in that country.

17.4 The Commissioned Organisation will ensure that any Approved Subcontractor maintains appropriate insurances.

17.5 Notwithstanding the above, the Commissioned Organisation may undertake self-insurance arrangements with ACIAR's prior written approval.

18. Indemnity

18.1 The Commissioned Organisation indemnifies ACIAR and the Personnel of ACIAR (**Those Indemnified**) from and against any loss (including legal costs and expenses on a solicitor/own client basis), or liability, incurred or suffered by any of Those Indemnified arising from any claim, suit, demand, action or proceeding by any person where such loss or liability was caused by any breach of a term or condition of this Agreement or wilful misconduct or unlawful or negligent act or omission of the Commissioned Organisation and the Personnel of the Commissioned Organisation in connection with the Services.

18.2 The Commissioned Organisation's liability to indemnify Those Indemnified under clause 18.1 will be reduced proportionally to the extent that any unlawful or negligent act or omission of Those Indemnified contributed to the loss or liability.

18.3 Neither party shall be liable to the other Party for any special, indirect or consequential loss or damages arising under or pursuant to this Agreement (including without limitation for loss of profits or an anticipated saving or benefit).

19. Compliance with laws and policies

Modern Slavery

19.1 In these additional terms 19.1 to 19.3:

(a) **Guiding Principles on Business and Human Rights** means the United Nations' Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework available at https://www.ohchr.org/documents/publications/ guidingprinciplesbusinesshr_en.pdf.

(b) **Modern Slavery** has the same meaning as it has in the *Modern Slavery Act 2018* (Cth).

19.2 The Commissioned Organisation must take reasonable steps to identify, assess and address risks of Modern Slavery practices in the operations and supply chains used in the provision of the Services, having regard to the Guiding Principles on Business and Human Rights.

19.3 If at any time the Commissioned Organisation becomes aware of Modern Slavery practices in the operations and supply chains used in the performance of this Agreement, the Commissioned Organisation must as soon as reasonably practicable take all reasonable action to address or remove these practices, including where relevant by addressing any practices of other entities in its supply chains.

Prohibited dealings

19.4 The Commissioned Organisation must ensure that it and any individuals, persons, entities or organisations involved in the Project, including its Personnel, are not:

(a) directly or indirectly engaged in preparing, planning, assisting or fostering a terrorist act

(b) listed terrorist organisations for the purposes of the *Criminal Code Act 1995* (Cth) (details of listed terrorist organisations are available at https://www.nationalsecurity.gov.au/Listedterroristorganisations/Pages/default.aspx)

(c) subject to sanctions or similar measures under the Charter of the United Nations Act 1945 (Cth) or the Autonomous Sanctions Act 2011 (Cth) (details of individuals and entities are available at: https://dfat.gov.au/international-relations/security/sanctions/Pages/consolidated-list.aspx)

(d) listed on the 'World Bank's Listing of Ineligible Firms and Individuals' posted at https://www.worldbank.org/en/projects-operations/procurement/debarred-firms

(e) owned, controlled by, acting on behalf of, or at the direction of individuals, persons, entities or organisations referred to in clauses 19.4(a) to 19.4(d) above, or

(f) providing direct or indirect support, resources or assets (including any grant monies) to individuals, persons, entities or organisations referred to clauses 19.4(a) to 19.4(d).

19.5 Where the Commissioned Organisation becomes aware that there are reasonable grounds to suspect it or any of its Personnel has or may have contravened any part of clause 19.4, the Commissioned Organisation must:

(a) notify ACIAR and confirm that information in writing as soon as possible, which must be no later than within 24 hours

(b) immediately take all reasonable action to mitigate the risks, and

(c) take any other action required by ACIAR.

Security Requirements

19.6 The Commissioned Organisation must perform its obligations to the highest professional standards and comply with the security requirements for the protection of official information: as detailed in the Commonwealth Protective Security Policy Framework available at: https://www.protectivesecurity.gov.au/ as amended from time to time; and as advised by ACIAR from time to time during the term of this Agreement.

Public Interest Disclosure

19.7 Public officials (including service providers under a Commonwealth contract) who suspect wrongdoing within the Commonwealth public sector can raise their concerns under the *Public Interest Disclosure Act* 2013 (Cth). Prior to making a disclosure, refer to information available at: http://www.ombudsman.gov.au/about/making-a-disclosure/information-for-disclosers.

19.8 All Public Interest Disclosure matters (relating to this procurement) should be referred to:

Name/Position:	**Chief Financial Officer**
Address:	Chief Financial Officer ACIAR House GPO Box 1571, Canberra, ACT 2601
Telephone:	[redacted]

FOI Act s. 47f

Compliance with relevant legislation and policies

19.9 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must:

(a) observe the same standards and obligations that are imposed on Commonwealth personnel under the *Work Health Safety Act 2011* (Cth) or where relevant any state or territory law and regulations applicable to work health and safety

(b) comply with the obligations imposed under the *Lobbying Code of Conduct* (Cth), if applicable

(c) comply with all relevant legislation of the Commonwealth, or of any State, Territory or local authority under any agreement entered into with the Commonwealth including:

(i) the *Crimes Act 1914* (Cth)

(ii) the *Disability Discrimination Act 1992* (Cth)

(iii) the *Racial Discrimination Act 1975* (Cth)

(iv) the *Sex Discrimination Act 1984* (Cth)

(v) the *Age Discrimination Act 2004* (Cth) and the *Age Discrimination (Consequential Provisions) Act 2004* (Cth)

(d) comply with all applicable workers compensation laws, and

(e) comply with such other Commonwealth and agency policies relevant to the performance or provision of the Services and notified in writing to the Commissioned Organisation.

19.10 If the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must comply with all laws and standards corresponding or equivalent to those listed in clause 19.9 in the country or territory in which the Commissioned Organisation is based or in which Services are performed (as applicable).

Child safety

19.11 If any part of the Project involves the Commissioned Organisation employing or engaging Personnel in a manner that requires the Personnel by local law to have a working with children check (or equivalent) to undertake the Project or any part of the Project, the Commissioned Organisation agrees:

(a) to comply with all local law relating to the employment or engagement of people who work or volunteer with children in relation to the Project, including mandatory reporting and working with children checks (or equivalent), and

(b) if requested, provide the Commonwealth at the Commissioned Organisation's cost, an annual statement of compliance with this clause 19.11, in such form as may be specified by the Commonwealth.

Privacy

19.12 In clauses 19.13 to 19.16, capitalised terms have the meaning provided in the *Privacy Act 1988* (Cth) (**Act**).

19.13 The Commissioned Organisation acknowledges that ACIAR will store, use and disclose Personal Information in accordance with its privacy policy located at www.aciar.gov.au/privacy-policy and the Commissioned Organisation is responsible for obtaining all necessary consents to enable ACIAR to do so in respect of Personal Information provided to ACIAR by or through the Commissioned Organisation pursuant to this Agreement.

19.14 The Commissioned Organisation must in undertaking this Agreement comply with all applicable privacy laws including, to the extent that the Australian *Privacy Act 1988* (Cth) applies to any of its activities under this Agreement by:

(a) complying with the Australian Privacy Principles and with any registered, applicable APP Code or Registered CR Code, and

(b) cooperating with any reasonable request or direction of ACIAR in relation to an inquiry, audit or other exercise of powers or functions, by the Information Commissioner under that Act.

19.15 Where the Act applies:

(a) if the Commissioned Organisation becomes aware that there are reasonable grounds to suspect that there may have been an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its performance of the Services, the Commissioned Organisation agrees to:

(i) notify ACIAR in writing as soon as possible, which must be no later than within three (3) days of becoming aware, and

(ii) unless otherwise directed by ACIAR, carry out an assessment in accordance with the requirements of the Act, and

(b) if the Commissioned Organisation is aware that there are reasonable grounds to believe there has been, or where ACIAR notifies the Commissioned Organisation that there has been, an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its provision of the Services, the Commissioned Organisation must:

(i) take all reasonable action to mitigate the risk of the Eligible Data Breach causing serious harm to any of the individuals to whom the Personal Information relates

(ii) unless otherwise directed by ACIAR, take all other action necessary to comply with the requirements of the Act, and

(iii) take any other action as reasonably directed by ACIAR.

19.16 Where privacy or data breach laws of another territory apply, the specific obligations of the Commissioned Organisation under clause 19.15 shall be modified only as necessary to ensure compliance with the privacy or data breach laws of that territory.

Fraud and Anti-Corruption

19.17 The Commissioned Organisation warrants that neither it nor its Personnel will make or cause to be made, receive or seek to receive any offer, gift or payment or benefit of any kind, which could be construed as an illegal or corrupt act, either directly or indirectly to any individual or organisation in relation to the execution of this Agreement.

19.18 Without limitation to any other clause of this Agreement, the Commissioned Organisation must comply with ACIAR's Fraud Policy Statement and guidance on reporting any allegations or concerns regarding fraud within the Project which is available at: https://www.aciar.gov.au/Standard-Contract-Conditions-and-Intellectual-Property-Policy.

19.19 On request, the Commissioned Organisation will provide for ACIAR's review and acceptance a fraud control plan that details actions the Commissioned Organisation will undertake in order to identify, report and manage instances of actual or potential fraud. The fraud control plan will specify what audit procedures and audit frequency will be applied.

19.20 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting its obligations under this clause 19, the Commissioned Organisation must comply with the requirements of the Commonwealth Fraud Control Framework or any replacement guidelines, in force from time to time, available at http://www.ag.gov.au/Integrity/counter-fraud/fraud-australia/Documents/CommonwealthFraudControlFramework2017.DOCX

Conflict of interest

19.21 The Commissioned Organisation warrants that, to the best of its knowledge after making diligent inquiry, at the date of signing this Agreement no conflict of interest exists or is likely to arise in the performance of its obligations under this Agreement.

19.22 If, during the performance of the Services a conflict of interest arises, or appears likely to arise, the Commissioned Organisation must:

(a) notify ACIAR immediately in writing

(b) make full disclosure of all relevant information relating to the conflict, and

(c) take such steps as ACIAR requires to resolve or otherwise deal with the conflict.

20. Taxes & Invoices

Stamp Duty and other taxes

20.1 Subject to clauses 20.2 and 20.3, the Commissioned Organisation must pay all:

(a) stamp duty (including penalties and interest) assessed or payable in respect of this Agreement and the undertaking of the Project, and

(b) all taxes, duties and government charges imposed or levied in Australia or overseas in connection with the performance of this Agreement.

GST

20.2 In clause 20.3:

(a) subject to clause 20.2(b), a word or expression defined in the *A New Tax System (Goods and Services Tax Act) 1999* (Cth) (**GST Act**) has the meaning given to it in the GST Act, and

(b) where a taxable supply takes place outside Australia in a territory that imposes a goods and services tax, value added tax, or similar, then references in this clause to GST, GST

Liability, and GST Law will refer to the applicable tax, tax liability and legislation in that territory and clause 20.3 will be read and construed accordingly.

20.3 Unless otherwise specified in the Budget, amounts that ACIAR is required to pay under this Agreement are calculated on a GST-exclusive basis. Where the Commissioned Organisation becomes liable to remit any amount of GST in respect of any Supply it makes to ACIAR in accordance with this Agreement (**GST Liability**), the amount otherwise payable by ACIAR under this Agreement will be increased by the amount of the GST Liability, or any lesser amount required by law. The increased amount will be payable by ACIAR in the same manner and at the same time as other amounts payable under this Agreement; and where required, the Commissioned Organisation will provide a tax invoice that may enable ACIAR, if permitted by the GST Act, to claim a credit or refund, a notional credit refund, of GST.

21. Miscellaneous

Warranties

21.1 The Commissioned Organisation warrants that it has all necessary permissions and is entitled to undertake the Services and that it is not subject to any agreement, policy, arrangement or otherwise, which is inconsistent with or would otherwise restrict its ability to undertake the Services and vest or licence IP Rights under clause 13.

Approvals and consents

21.2 Except where this Agreement expressly states otherwise, a Party may, in its discretion, give conditionally or unconditionally or withhold any approval or consent under this Agreement.

Entire agreement

21.3 This Agreement contains the whole of the agreement between the Parties with respect to its subject matter and supersedes any and all other representations or statements by a Party whether oral or in writing and whether made prior or subsequent to the date of this Agreement.

Notices

21.4 All notices, requests, demands and other communications under this Agreement will be in writing directed to the representative specified in the Agreement Details (which may be updated by providing a notice to the other Party in accordance with this clause 21.4) and will be deemed to have been given: (i) immediately if delivered by hand, (ii) on the seventh day following postage if delivered by express post; and (iii) on the next business day in the location of the recipient's address if sent by email.

Negation of Employment, Partnership and Agency

21.5 The Commissioned Organisation will not by virtue of this Agreement be, or for any purpose be deemed to be, an officer, employee, partner or agent of ACIAR or the Commonwealth, or as having power or authority to bind or represent ACIAR or the Commonwealth, and will not represent itself, and will ensure that its Personnel do not represent themselves, as such.

Applicable Law

21.6 This Agreement will be governed by and construed in accordance with the laws of the State of Victoria. The Commissioned Organisation submits to the jurisdiction of the courts of Victoria and any court competent to hear appeals from those courts.

Waiver

21.7 A waiver by either Party in respect of any breach of a condition or provision of this Agreement must be made in writing and will not be deemed to be a waiver in respect of any continuing or subsequent breach of that provision, or breach of any other provision. The failure of either Party to enforce any of the provisions of this Agreement at any time will in no way be interpreted as a waiver of such provisions.

Authority and consents

21.8 Any and all rights, powers, authorities and discretions expressed in this Agreement or in the specifications to be conferred upon or vested in ACIAR may be exercised by any person designated for that purpose by the Commonwealth minister responsible for ACIAR.

21.9 Except as expressly provided in this Agreement, ACIAR may conditionally or unconditionally in its absolute discretion give or withhold any consent or approval under this Agreement.

Assignment

21.10 The Commissioned Organisation must not assign or attempt to assign or otherwise transfer or encumber any right or obligation arising out of this Agreement except with the written consent of ACIAR.

Variation to this Agreement

21.11 This Agreement may only be amended by a written instrument signed by the Parties.

No Merger

21.12 The rights and obligations of the Parties under this Agreement do not merge on completion of any transaction contemplated by this Agreement.

Further acts

21.13 A Party, at its own expense and within a reasonable time of being requested by the other Party to do so, must do all things and execute all documents that are reasonably necessary to give full effect to this Agreement and the transactions contemplated by it.

Severance

21.14 A term or part of a term of this Agreement that is illegal or unenforceable may be severed from this Agreement and the remaining terms or parts of the term of this Agreement will continue in force.

Costs and Expenses

21.15 Each Party will bear its own costs and expenses in relation to the negotiation, preparation, execution, delivery and completion of this Agreement and any related documentation.

Counterparts

21.16 This Agreement may be executed in counterparts. All executed counterparts constitute one document. Counterparts may be exchanged and relied on in facsimile or digital scanned form.

Survival

21.17 Without limitation to the express provisions of this Agreement or those clauses of this Agreement which are intended or capable of having effect following the expiry or termination of this Agreement, the following clauses will survive the expiry or termination of this Agreement: clauses 1 to 3, 10.4, 10.5, 13 to 15, 16.4, 16.5, 16.7,17, 18, 20, 21.3, 21.5, 21.6, 21.7, 21.10, 21.12, 21.14, 21.16 and this clause 21.17.

EXECUTED as an Agreement

Signed for and on behalf of the **Commonwealth of Australia** as represented by the **Australian Centre for International Agricultural Research ABN 34 864 955 427** by its duly authorised delegate

←

Signature of delegate

Prof Wendy J. Umberger

Name of delegate (print)

Chief Executive Officer

Position of delegate **(print)**

ON: **[insert date]** 10 / 09 / 2024 ←

Executed by **Charles Sturt University** by its duly authorised delegate

←

Signature of delegate

Professor Mark Evans

Name of delegate (print)

Deputy Vice-Chancellor (Research)

Position of delegate **(print)**

ON: **[insert date]** 21 / 06 / 2024 ←

A8 apply equally to the Auditor-General or a delegate of the Auditor-General, or the Privacy Commissioner or a delegate of the Privacy Commissioner, for the purpose of performing the Auditor-General's or Privacy Commissioner's statutory functions or powers

(h) the Commissioned Organisation must do all things necessary to comply with the Auditor-General's or his or her delegate's or the Privacy Commissioner's or his or her delegate's requirements, notified under additional term A8(g), provided such requirements are legally enforceable and within the power of the Auditor-General, the Privacy Commissioner, or his or her respective delegate

(i) the requirement for, and participation in, audits does not in any way reduce the Commissioned Organisation's responsibility to perform its obligations in accordance with this Agreement

(j) the Commissioned Organisation must ensure that any subcontract entered into for the purpose of this Agreement contains an equivalent clause granting the rights specified in this additional term A8

(k) nothing in this Agreement reduces, limits or restricts in any way any function, power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner. The rights of the Commonwealth under this Agreement are in addition to any other power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner, and

(l) this additional term A8 applies for the Term and for a period of seven years from the expiry or termination of this Agreement.

A9. Intellectual property

A9.1 Without limitation to additional term A3.2(a), the Commissioned Organisation and any relevant Collaborating Institution, as part of the entering into a Collaborating Institute Agreement, negotiate Intellectual Property arrangements between those parties (**IP Arrangements**) that cover matters such as:

(a) how Project IP may be used and disseminated by those parties in accordance with the terms of this Agreement including, if applicable, the CGIAR IA Principles

(b) the terms of any rights to Project IP between those parties, including securing such rights as are necessary for the Commissioned Organisation to grant ACIAR and any other parties rights to Project IP pursuant to this Agreement

(c) the terms of any licence of Background IP, including securing such rights as are necessary for the parties to undertake the Project and to grant ACIAR or any other party any rights to Project IP pursuant to this Agreement

(d) indemnity arrangements against liability arising from claims by third parties in connection with the breach of Intellectual Property Rights

(e) whether the Commissioned Organisation and any Collaborating Institution will seek to put in place any 'Limited Exclusivity Agreements' or 'Restricted Use Agreements' as defined in and in accordance with Articles 6.1 to 6.3 of the CGIAR IA Principles, and

(f) the allocation of costs relating to the application for and maintenance of the IP Rights between the Commissioned Organisation and any relevant Collaborating Institution,

provided that in no circumstances may the IP Arrangements provide for arrangements that would be inconsistent with any other term of this Agreement (including as found in the Project Document), or otherwise place the Commissioned Organisation in breach of this Agreement.

details of the duration of the proposed appointment

(c) a copy of the curriculum vitae of each of the proposed persons which details relevant employment experience and educational qualifications, and

(d) any other information relating to the proposed appointment necessary for, or directly related to, the Services.

A8. Audit and access

Without limitation to clause 15:

(a) the Commonwealth through ACIAR or a representative may conduct audits relevant to the performance of the Commissioned Organisation's obligations under this Agreement. Audits may be conducted of:

(i) the Commissioned Organisation's operational practices and procedures as they relate to this Agreement, including security procedures

(ii) the Commissioned Organisation's compliance with its confidentiality, privacy and security obligations under this Agreement

(iii) records and documentation in the possession of the Commissioned Organisation relevant to the Services or this Agreement, and

(iv) any other matters determined by the Commonwealth to be relevant to the Services or this Agreement

(b) the Commonwealth through ACIAR or a representative may, at reasonable times and on giving reasonable notice to the Commissioned Organisation:

(i) access the premises of the Commissioned Organisation to the extent relevant to the performance of this Agreement

(ii) require the provision by the Commissioned Organisation, its Personnel, of records and information in a data format and storage medium accessible by the Commonwealth by use of the Commonwealth's existing computer hardware and software

(iii) inspect and copy documentation, books and records, however stored, in the custody or under the control of the Commissioned Organisation, its Personnel, and

(iv) require assistance in respect of any inquiry into or concerning the Services or this Agreement. For these purposes an inquiry includes any administrative or statutory review, audit or inquiry (whether within or external to the Commonwealth), and any inquiry conducted by Parliament or any Parliamentary committee

(c) the Commissioned Organisation must provide access to its computer hardware and software to the extent necessary for the Commonwealth to exercise its rights under this additional term A8, and provide the Commonwealth through ACIAR or its representative with any reasonable assistance requested by the Commonwealth to use that hardware and software

(d) the parties confirm that the rights of the Commonwealth set out in Additional Terms A8(b) and A8(c) may only be exercised for the purposes established in additional term A8(a)

(e) the Commonwealth through ACIAR or a representative must use reasonable endeavours to ensure that:

(i) audits performed under clause A8, and

(ii) the exercise of the general rights granted by clause A8(b) by the Commonwealth,

do not unreasonably delay or disrupt in any material respect the Commissioned Organisation's performance of its obligations under this Agreement or its business.

(f) each Party must bear its own costs of any reviews and/or audits

(g) the rights of the Commonwealth through ACIAR or its representative under additional term

A3.6 Notwithstanding clause 11.3, the ownership of Supplies procured within a Collaborating Country will vest in the government of that Collaborating Country on completion of the Project, and the Commissioned Organisation will take whatever action is necessary to effect that transfer.

A4. Project Committee

A4.1 ACIAR may establish a Project Committee that will include a representative of each of the Parties and, where relevant and appropriate (as determined by ACIAR), any Collaborating Institutions.

A4.2 The Project Committee will advise the Parties in relation to Project matters, and may call for specialised advice on any matter related to the Project.

A5. Payments

A5.1 The Commissioned Organisation may, subject to the following qualification and without reference to ACIAR, transfer Payments payable in respect of a particular item in the Budget for the Project to another item. The amount transferred may be the lesser of 10% of the total of the particular item in the Budget or $10,000 from which the Payments are being transferred.

A5.2 Notwithstanding additional term A5.1, the Commissioned Organisation will not transfer Payments payable in respect of a particular item in the Budget payable outside Australia to another item in the Budget payable outside Australia. However, any Collaborating Institution will be able to vary its component of the Budget in the same way described in additional term A5.1. Transfer of Payments between items in excess of the amount referred to in additional term A5.1 must not be made without the prior written approval of ACIAR.

A5.3 Where the Budget for the Project provides for the payment of any Payments by the Commissioned Organisation to a Collaborating Institution, the Commissioned Organisation will pay those Payments six-monthly in advance within seven days following receipt of Payments from ACIAR. Any Payments that are unexpended by the Collaborating Institution at the expiration of the Payment Period for which they were allocated will be carried over for expenditure in the following Payment Period and the advance made for the following Payment Period by the Commissioned Organisation to the Collaborating Institution will be reduced proportionately, unless ACIAR approves otherwise in writing.

A6. Dispute Resolution

A6.1 Subject to additional term A6.4, before resorting to external dispute resolution mechanisms, the Parties will attempt to settle by negotiation any dispute in relation to this Agreement including by referring the matter to personnel who may have authority to intervene and direct some form of resolution.

A6.2 If a dispute is not settled by the Parties within 10 working days of one Party first sending to the other Party written notice that they are in dispute, the dispute may be the subject of court proceedings or may be submitted to some alternative dispute resolution mechanism as may be agreed in writing between the Parties.

A6.3 Notwithstanding the existence of a dispute, each Party will continue to perform its obligations under this Agreement.

A6.4 A Party may commence court proceedings relating to any dispute arising from this Agreement at any time where that Party seeks urgent interlocutory relief.

A7. Personnel

A7.1 The Commissioned Organisation will obtain the prior written approval of ACIAR to the appointment of any specialist or scientist Personnel not identified in the Project Document to perform the Services, which approval will not be unreasonably withheld. If ACIAR requests, the Commissioned Organisation must promptly provide any relevant information relating to such specialist or scientist including:

(a) the full names and date of birth of the proposed person(s)

(b) a statement which describes the position to be held, the position selection criteria and

Additional Terms

A1. Interpretation and further definitions

A1.1 In these Additional Terms, unless the context otherwise requires, reference to a clause is a reference to a clause of the Primary Terms and reference to an additional term is to a clause of these Additional Terms.

A2. Application

A2.1 These Additional Terms will only take effect in accordance with clause 2.

A3. Collaborating Countries and Collaborating Institutions

A3.1 As applicable, international agreements that establish the overseas operating framework for the Project including such matters as protocols, customs assistance, in-country security, indemnities and intellectual property rights will be signed by the parties to the Project, including the Parties and any applicable Collaborating Institutions.

A3.2 In undertaking the Project, the Commissioned Organisation will engage with each Collaborating Institution (if any) via an agreement:

(a) as negotiated and agreed with each Collaborating Institution, provided that in no circumstances may an agreement with a Collaborating Institution provide for arrangements that would be inconsistent with any other term of this Agreement (including as found in the Project Document), or otherwise place the Commissioned Organisation in breach of this Agreement, or

(b) substantially on the terms set out in Schedule 1 to these Additional Terms,

(**Collaborating Institution Agreement**).

A3.3 The Commissioned Organisation warrants that, as of the date of signing this Agreement, each Collaborating Institution has received a draft copy of a proposed Collaborating Institution Agreement and that the terms of a proposed Collaborating Institution Agreement have either:

(a) been agreed and executed by the Commissioned Organisation and each Collaborating Institution, or

(b) been in substance approved by each of the Commissioned Organisation and each Collaborating Institution, and

the Commissioned Organisation shall provide ACIAR with a copy of each executed Collaborating Institution Agreement as soon as practical following the later of:

(c) execution of this Agreement, or

(d) execution of the relevant Collaborating Institution Agreement.

A3.4 The Commissioned Organisation acknowledges that ACIAR may:

(a) delay the provision of any Payments until the Commissioned Organisation has provided ACIAR with copies of all applicable Collaborating Institution Agreements, and

(b) terminate this Agreement with immediate effect upon providing the Commissioned Organisation written notice if the Commissioned Organisation has not provided ACIAR with all applicable Collaborating Institution Agreements within one (1) calendar month of the date this Agreement is signed by the last Party to sign, and clause 16.7 shall apply.

A3.5 Without limitation to clause 5, in performing the Services the Commissioned Organisation will cooperate fully with any Collaborating Institution for the purpose of ensuring timely completion of the Project.

ANNEXURE B – ADDITIONAL TERMS

ANNEXURE A – PROJECT DOCUMENT

Australian Government

Australian Centre for International Agricultural Research

Full Project Proposal

ACIAR Program(s) area	Fisheries
Project Title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Project Number	FIS/2023/133
prepared by	Lee Baumgartner and Nathan Ning
ACIAR Research Program Manager	Dr Chris Cvitanovic

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organisation, collaborating organisation(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavors to keep this information as up to date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Summary Information

Version # and date of this document	August 2023
Project number	FIS/2023/133
Full project title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Budget ($)	$5,700,000
Commissioned Organisation	Charles Sturt University
Project Leader	Dr Lee Baumgartner
Country 1 Coordinator	Dr Oudom Phonekhampheng (NUOL)
Country 2 Coordinator	Dr Michael Raeder (XPCL)
Proposed start date	1/07/2024
Proposed end date	30/06/2029

Contents

1. Project justification

1.1 Project aim

This project aims to minimise the potentially harmful impacts of hydropower dams on the productive fisheries, and the people who depend upon them, in the Lower Mekong Basin.

1.2 Development issue and research opportunity

Development issue

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively and severely impacted if all planned large-scale mainstem hydropower dams are completed without appropriate consideration for the impacts on fish migration and people who depend upon migratory fish. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The dams have divided public opinion. The Mekong region fishery has been estimated to be worth US$4-7 billion annually (Nam et al. 2018), but dams are expected to reduce, by more than half, this important source of food and income for many people (ICEM 2010).

Hydropower development (HPD) on the Mekong River is expected to aggravate food insecurity and poverty in the region (MRC, 2018). Thailand is expected to suffer the most economically and ecologically, and full dam development will decrease GDP growth for LMB countries by US$29 billion (MRC, 2018). Native fish stocks will be particularly impacted, with more than 900,000 tonnes of fish biomass, worth US$4.3 billion (Figure 1), predicted to disappear by 2040 because of dams. Thailand (55%) would have the highest rate of fish loss, followed by Lao PDR (50%), Cambodia (35%) and Vietnam (30%).

Social impacts are also expected, such as livelihood and food insecurity reductions, and will largely affect riparian communities. Environmental issues of reduced water quality decreased fish quantity and unstable water flow will exacerbate these losses (Soukhaphon et al. 2022). Loss of livelihood is expected to be cumulative and become increasingly significant as more dams are constructed along the Mekong River. Issues of food and livelihood security are also faced by those relocated and not provided appropriate compensation. Dam proponents suggest that these impacts can be minimised through the application of technical solutions, such as fish passes (Baumgartner et al. 2018; Baumgartner et al. 2012).

The first LMB mainstream dam, at Xayaburi, in Lao PDR was completed in late 2018 (Figure 1). Xayaburi Dam blocks the entire width of the river with a dam wall more than 30 m high, presenting an impassable barrier to all fish species (Orr et al. 2012). Significant investment (US$380M) to provide for fish passage was incorporated into the final designs to minimise impacts on fisheries. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical world. However, at the time of construction, there were no data available globally to inform the likely success, or otherwise, of such an investment in a river system with a highly diverse fish community like the Mekong. The success of this structure was the focus of FIS/2017/017.

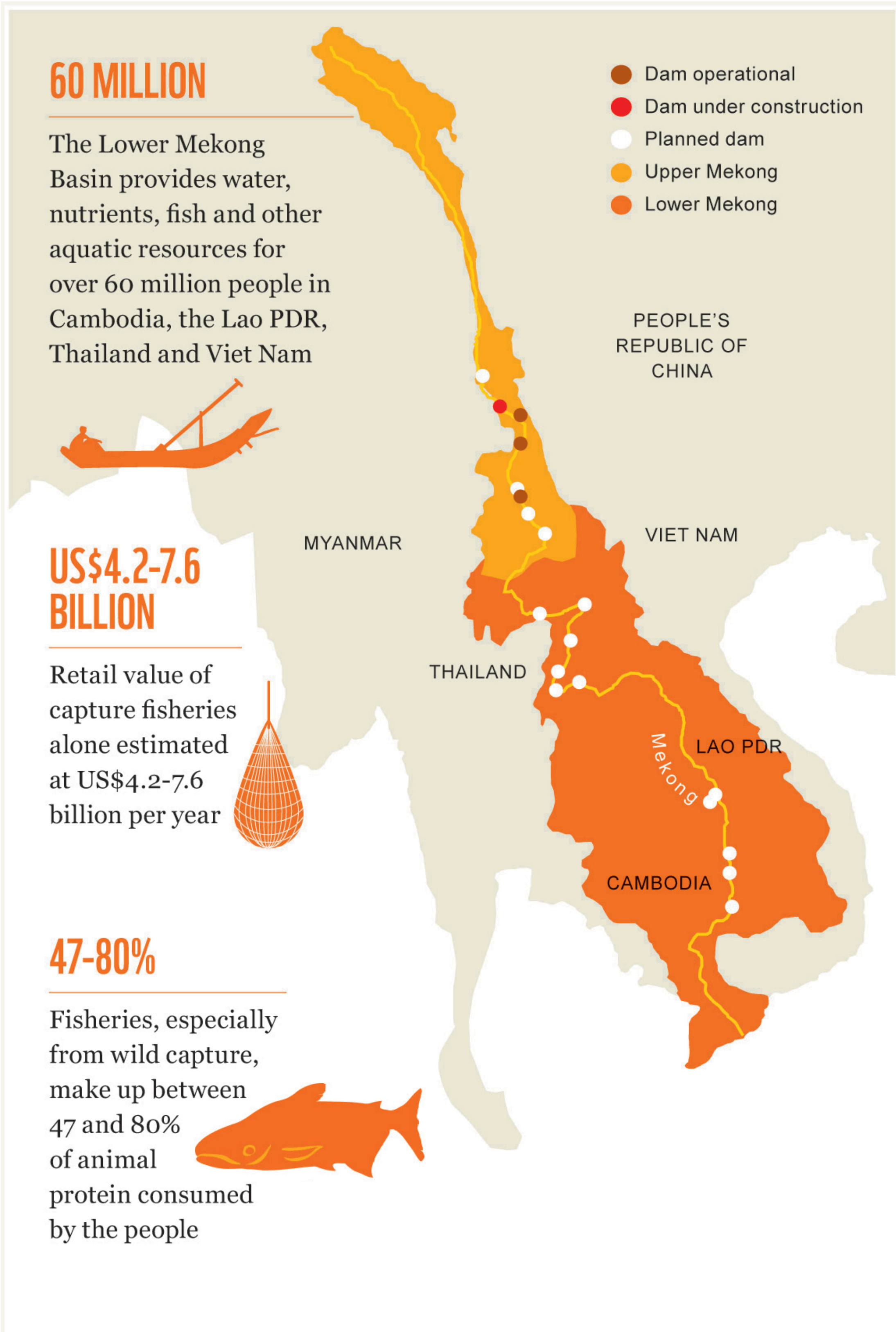

Figure 1. Infographic of hydropower development in the Mekong and the link to fish-dependent livelihoods (source: WWF Freshwater Program).

What do we already know?

ACIAR/DFAT and Charles Sturt University partnered with the dam proponents to answer the question of whether the upstream fish passage facilities were effective in passing a large proportion of fish numbers and species. A structured research program was initiated (FIS/2017/017), which focused on the effectiveness of the upstream fish pass within a limited line of inquiry (focused largely on the fish pass effectiveness for fish migrating upstream). Nevertheless, initial results are very promising, demonstrating that large numbers of many species are moving upstream with a >80% efficiency (unpublished data, FIS/2017/017).

This initial work was, deliberately, technically focused. The monitoring technology needed to measure fish pass effectiveness had never been used before in SE Asia, nor at a dam of this size. So, the methods needed to be validated (methods included microchipping and electrofishing). Secondly, efficiency trials had never been completed for such a diverse tropical ecosystem. Methods were therefore needed to be refined for a significant number of Mekong fish. Thirdly, the study represented the first time that fisher-independent data had been generated in the Lower Mekong Basin. Therefore, the mechanisms to analyse and interpret such data needed to be developed. These were all achieved as part of FIS/2017/017, which concludes in June 2024. The project has significantly advanced knowledge generation to inform the development agenda. However, several knowledge gaps remain.

What is the current stage of the development cycle?

The Mekong River Commission (MRC) coordinates a ‘prior consultation’ process under the Procedures for Notification, Prior Consultation and Agreement (PNPCA). This represents an opportunity for MRC Member Countries and other stakeholders to discuss and review benefits and risks of any water-use project proposed for the mainstream, which may have potential significant cross-border impacts on the Mekong River flow regimes, water quality and other environmental and socio-economic conditions (Table 1). This is a highly public, open and transparent process, by which developers submit their plans for hydropower projects and these then become subject to national and international scrutiny. The MRC has concluded prior consultations for five hydropower projects: Xayaburi, Don Sahong, Pak Beng, Pak Lay and Luang Prabang, and is carrying out the consultations for the Sanakham project (Table 1; Figure 1). The outcomes of these PNPCA processes were that the proposed fisheries mitigation strategies, as submitted, were likely to be insufficient and that the developers needed to work harder to identify sustainable solutions.

Xayaburi, Don Sahong and Luang Prabang altered their plans because of the PNPCA and proposed solutions that were otherwise untested in the region. Other developers (for Pak Lay and Pak Beng) are now actively working to amend their submissions in response to PNPCA feedback. The Mekong River Commission are subsequently seeking evidence and data to support these re-designs. The main point here is that there are few new hydropower plants currently under construction; most are in the design, or redesign phase. Those that are already operating have a significant opportunity to influence those about to be designed, or those that are being re-designed (Table 1).

Therefore, there is an extremely limited, but time bound, opportunity to influence the design of future dams provided that (a) evidence and learnings from existing sites, in terms of fisheries productivity and livelihood protection, can be disseminated; (b) dam proponents agree to share and incorporate data into new designs; and (c) the need to protect fisheries and livelihoods is accepted and actioned by developers.

Table 1. Expected completion dates for hydropower dams in the Lower Mekong.

Hydropower project	PNPCA date	Expected commissioning year	Installed capacity (MW)	Mean annual energy (GWh)	Height (m)	Crest length (m)	Max reservoir area (km²)
Ban Kum	TBD	Beyond 2030	1,872	8,434	53	780	132.5
Latsua	TBD	2029	800	3,504	22	1,300	13
Luang Prabang	2019	2030	1,200	6,500	57.5	318	72.4
Pak Beng	2018	2029	912	4,846	85	943	87
Pak Lay	2018	2030	1,320	4,252	35	630	108
Sanakham	2020	2028	700	5,015	25	1,144	81
Santhong-Pakchom	TBD	Planned. COD Unknown.	1,079	5,052	55	1,200	80.3
Stung Treng	TBD	Planned. COD unknown.	980	4,870	22	10,884	211

Knowledge gaps in the 'sustainable hydropower' research for development framework

There is insufficient evidence available, in the public domain, or otherwise, for developers to adequately address PNPCA concerns. There remains significant debate as to what the 'minimum' requirement would be to define a hydropower project as 'sustainable' and there is virtually no data/evidence available, from existing sites, which demonstrate 'best practice standards'. The Mekong River Commission recently released the 'MRC Hydropower Mitigation Guidelines' (MRC 2020), which steps through the key considerations for developers. However, the document lacks local evidence and examples in the guidance are largely from other regions (North and South America). In fact, the only data that currently exists regarding mitigating fish migration outcomes in the LMB has been solely generated by FIS/2017/017 at Xayaburi Dam. Nonetheless, that project was limited in scope and identified several key knowledge gaps that require further investigation, and dissemination, in a 'research for development' sense. Indeed, that work, once disseminated will necessitate an update to the MRC document.

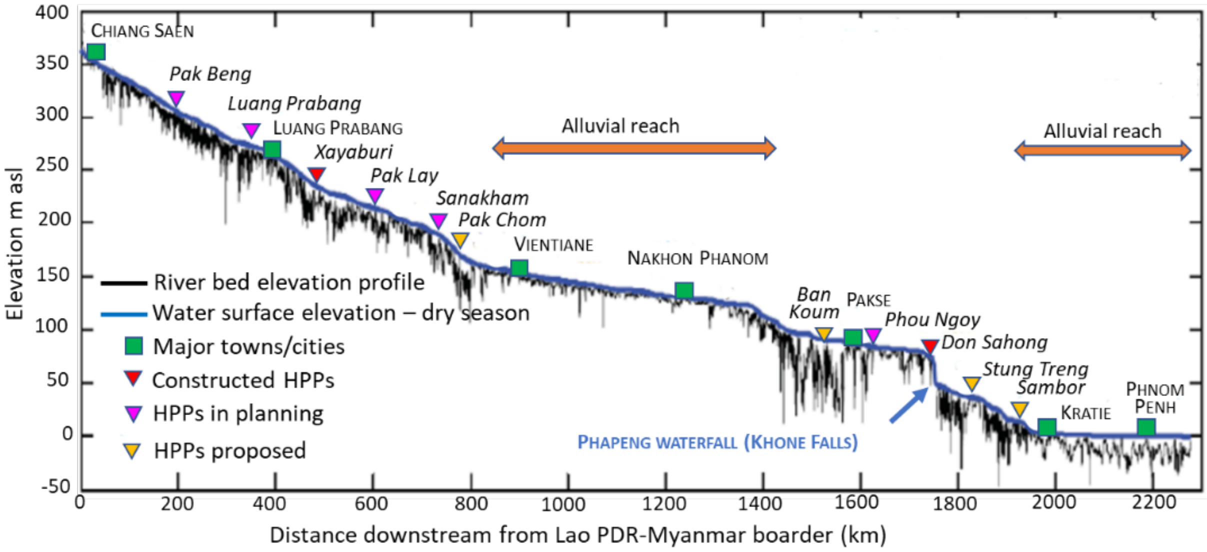

Figure 2. Cross section of hydropower construction along the Mekong.

Progress so far

Following FIS/2017/017 a knowledge gap workshop was held, comprising of a team with developers, the Lao government, and Charles Sturt University academics. The workshop participants identified scalability of existing results, and any knowledge gaps that remained, to influence the policy and activities of other hydropower planners and developers in the region.

The co-design workshop revealed that:

- The Charles Sturt team is presently the only research group with established relationships, and an active program of work, at all existing mainstem hydropower dams (Don Sahong, Xayaburi and Luang Prabang).
- The team has long-standing (since 2007) and functional links with the Lao government (Ministry of Energy and Mines, Ministry of Agriculture and Forestry and National University of Laos). Additionally, the team actively works with major river development initiatives in association with the Mekong River Commission, the Asian Development Bank and the World Bank.
- The existing project (FIS/2017/017) successfully demonstrated new technology and established trust among partners.
- The existing project only focused on upstream fish pass effectiveness using a single technology at a single site.
- In a 'research for development' sense, there is still a need to understand:
  (a) whether the downstream fish pass's are facilitating bi-directional fish movement and if upstream migrating fish are delayed (Knowledge Gap (KG) 1).
  (b) if there have been changes in river fisheries structure/yield following construction (KG1).
  (c) factors influencing migratory fish in the region, why fish are migrating, where they are migrating to, and if the dam facilities are assisting (KG1).
  (d) the long-term benefits of the existing facilities at Xayaburi (KG1).
  (e) whether livelihoods of people dependent upon fish have changed (or are unchanged from pre-dam conditions) (KG2).

(f) how best to disseminate and translate the results of the program of ACIAR/DFAT work into improved policy and decision-making outcomes (KG3).

(g) whether the learnings from Xayaburi can be directly applied to other sites, such as the next hydropower plant (Luang Prabang) and others in Table 1 (KG4).

Consolidating the workshop outcomes into the new activity yielded four focus areas linked to the requirements of the ACIAR project design brief:

KG 1: Fish pass facility effectiveness. The FIS/2017/017 assessment of the fish passage facilities at Xayaburi focused entirely on the fish ladder itself and only on upstream migration. This was urgently needed and filled an important knowledge gap. However, this alone is insufficient to demonstrate that a hydropower project has mitigated its environmental impacts. For instance, there is a need to understand if migratory fish are delayed 'outside' the fish pass and cannot enter the fish pass at all. Fish also need to migrate downstream, but there have been no studies on downstream passage efficiency at any hydropower project site along the Mekong. There is, therefore, an urgent need to document whether fish can pass both upstream and downstream at Xayaburi. There is also a need to determine if fish approaching the dam are delayed, or unable to locate the fish pass entrance at all. These questions are equally relevant to the next dam scheduled for construction, Luang Prabang, and there remains significant international demand for this evidence to be generated. The data then needs to be transferred to other sites.

KG 2: Social benefits arising from fish pass construction. The degree to which the level of investment ($US300m in fish pass facilities) has brought about positive benefits to the lives of fishers, and those in the fisheries value chain, remains unknown. During the construction process, some villagers were resettled, and some fishers were transitioned to other industries. Some fishers also persisted with fishing and, presumably, all households still have a dependency on fish as a major source of protein and micronutrients. There is a need to demonstrate whether the investment in fish pass construction has effectively sustained opportunities for locals to keep fishing. If so, this evidence needs to be disseminated to other sites.

KG 3: 'Who is who' in the sustainable hydropower space: The information on fish pass success and livelihoods (viz. KG1 and KG2) needs to be disseminated among developers and decision makers to ensure uptake and translation of results (into policy and practice). However, there is a poor understanding of the network of stakeholders involved in the overall hydropower development process across the LMB. This lack of cohesion, and a general lack of data sharing, has been propagated by some developers as a reason to proceed with sub-optimal mitigation strategies incorporated into dam planning (i.e. until the knowledge is generated, projects are proceeding). Consequently, while the dissemination pathways and key actors are unknown, it will be difficult to ensure this evidence and data are disseminated.

KG 4: Designing effective dissemination pathways. Given that the dissemination pathways and various actors remain unknown, the best mode of dissemination, to maximise policy and practice change, also remains unknown. Therefore, the information generated (in point 1 and 2 above) on social and fisheries outcomes needs to be disseminated (to the actors defined in point three) in the most appropriate format (to be determined here in point 4).

These knowledge gaps form the central concepts needed to close out an adaptive management theory of change. In this instance, an intervention has been designed and data has been gathered on its performance. Future interventions now need to be improved based on this information. So far, only limited information on KG1 has been generated by FIS/2017/017. KG2, KG3 and KG4 require urgent resolution to influence the next dams, which are scheduled for construction over the next seven years. Filling these essential knowledge gaps, and disseminating the data, remain the most significant barriers to the sustainable hydropower movement in the Lower Mekong Basin.

Novelty and timeliness of this research

There are presently no other efforts underway to address these research priorities in the Mekong region. All learnings from this research are novel, and crucial for providing a standard for dam construction and fish pass monitoring at other dam sites in the LMB. Plans to construct eight other mainstem dams on the Lower Mekong are at various stages of development. The next dam, Luang Prabang, will be operational in seven years. Additional sites at Pak Beng and Pak Lay will follow and are presently progressing through concept design review. Each dam will add cumulative impacts on fish migratory ecology (Halls and Kshatriya 2009), but there is little to no practical understanding or anticipation of these compounded impacts in the region; in fact, our team is the custodian of the only practical dataset, which is in significant demand by consent authorities and donor agencies and could realistically influence this agenda.

There remain critical knowledge gaps – across ecological management, policy influence and technical interventions – to achieve outcomes at a whole-of-region scale. Continuing the existing research program (from the ACIAR-DFAT co-funded FIS/2017/017 project) is required to assess the quantum and species mix of fish that are passing at fully operational hydropower sites, both up- and downstream. Furthermore, there is an increasing and immediate requirement to disseminate the data to a broader audience and to communicate the human/social issues. These are urgently needed if sustainable practices are to be incorporated into future hydroelectric power development programs.

There is a time-limited opportunity to develop critical knowledge, which can be translated into actions at these new sites. The research outcomes from this proposal could positively influence development at the remaining sites, by building on a solid foundation of industry-relevant research, and an effective policy influence framework for decision makers.

1.3 Partner country and Australian research and development priorities

Country/regional priorities and commitments

Protecting migratory fish from hydropower infrastructure impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to international conservation advocacy groups. The overarching need for this work is largely driven by the 1995 Mekong Agreement, which explicitly requires Lower Mekong Basin countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). It is also driven by the commitment of the XPLC to set the standard for fish pass infrastructure design and fish pass monitoring in the region.

For hydropower dams in Lao PDR, the Lao government (through the Ministry of Natural Resources and Environment - MONRE, and the Ministry of Energy and Mines - MEM) enter into 30-year concession agreements with power companies. During this period, the company owns and operates the site, after which ownership transfers to the Government of Lao PDR.

Dam proponents are required, via approval processes managed by MEM, to take substantial steps to minimise environmental impacts at the dam site, including providing successful passage for fish species. MEM is currently the only agency with an outward facing discussion with all proponents of mainstem hydropower dams. Their role in approving dam projects includes reviewing the design of the fish pass component. MEM officials recognise their engineers are not equipped to do this work and have sought to engage with FIS/2017/017, requesting that their staff are trained in sustainable fish pass techniques. The new project will bring MEM into the centre of its strategic partnership engagements, given their influence in effecting change in dam design in PDR of Laos. At a recent co-design process with the project team and stakeholders, MEM officials identified that gaining access to critical skills and data is needed to make more informed choices when decision-makers are given consent for future projects.

Australian Aid and/or Foreign Affairs Agenda

DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (DFAT 2017; DFAT 2020a; DFAT 2020b).

This activity is therefore directly related to DFAT's strategic outcome ‘Agriculture, Fisheries and Water’. Hydropower development is the most significant water management issue in the Lower Mekong Basin. The Xayaburi Dam, being the first site, remains of particular interest and significance internationally.

This project is directly related to Australian Aid’s strategic outcome ‘Agriculture, Fisheries and Water’. There are also important links with ‘Education and Health’ and ‘Gender Equality and Empowering Women and Girls’, and alignment with ‘Building Resilience’ and ‘Acquiring Critical Infrastructure’ in the fisheries field.

The use of research and innovation to achieve strategic objectives underpins ‘Agriculture, Fisheries and Water’. The two objectives our activity most closely aligns with are:

a) Increasing incomes of poor people: using strategic applied policy research to improve water policy to prevent a major decline in income for those directly employed in fishing-related market chains; and

b) Enhancing food, nutrition and water security: empowering government agencies and private industries to understand, and develop strategies to mitigate, potential development impacts.

Protecting migratory fish from dam impacts is a priority for all SE Asian countries and is recognised by many foreign aid agencies. Our team members work with ACIAR on fishery-related research in Lao PDR (through active projects FIS/2006/183, FIS/2009/041, FIS/2012/100). Likewise, the recently completed CGIAR Challenge Program on Water and Food commissioned several projects on hydropower sustainability. In addition, USAID have an active program, which has identified fisheries sustainability as a priority area for SE Asian countries.

Until the mid-2010s, these programs were largely unilateral, focusing on individual countries, rather than taking a regional collaborative approach as will be the case in this project. USAID recently committed $US600,000 towards an initiative to extend fish passage outcomes (from ACIAR investments FIS/2006/183, FIS/2009/041, FIS/2012/100) to Vietnam, Cambodia and Myanmar. It was agreed that USAID funding would be used to progress initiatives in Cambodia and Vietnam until 2020. ACIAR funding (this proposal) is anticipated to be used to progress initiatives in Lao PDR, Indonesia, Cambodia and Myanmar. However, as momentum and outcomes grow from this program, so do the demands on project team members' time and expertise.

Relevance to ACIAR 10-year strategy

Food security and poverty reduction

SE Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural people are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities.

Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in SE Asia because hard research data does not exist. This project will identify and bridge information gaps, drawing upon data from fishway projects across the region shaping more effective management strategies. Indeed, the knowledge generated from this project will be crucial for sustainably managing SE Asian fisheries in the face of increasing human development and changing climatic conditions.

Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. River development has negatively impacted inland fisheries. This project aims to redress this imbalance and broker win-win scientific solutions so modern river development projects support the sustainable production of fish, rice and energy.

Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. Research has found that women can occupy half of the harvest and post-harvest workforce, and selling fish can provide extra income and offset household needs, and provide extra nutrition with by-catch for the immediate family. This project will document this participation and champion the need to recognise the important role of women and girls in fisheries value chains benefitted by fishway construction (see Section 2.5).

Value chains and private sector engagement

Hydropower modernisation is generally the domain of developers under development bank, or investor, supervision and generally contracting local companies for construction, though local village coordination and then accepting final ownership. The sector is increasingly receptive to considering fish passage during planning and construction activities and is looking to external and private sector experts for assistance. But often solutions that are developed are sub-optimal and based on experiences from outside the LMB. The private sector also plays a key role in shaping government regional decisions and policies. This project will bring both private, developmental and governmental sectors together to recognise the value of fisheries resources and to determine how to maximise those resource returns in sympathy with future growth across the hydropower sector.

Building capacity (individual and institutional)[1]

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner with regional governments, multilateral development banks, regional agencies, and capacity building experts to equip these organisations with capacity to address fish migration challenges beyond the lifespan of the project.

1.4 Relationship to other ACIAR investments and other donor activities

Existing/previous ACIAR work on hydropower sustainability

This research follows on and extends a body of ACIAR research that has developed and tested techniques to assess the performance of the fish pass at Xayaburi – and, to an extent, other future mainstem dams in the LMB (ACIAR FIS/2017-016 and FIS/2017/017). It also addresses DFAT's Mekong Australia Partnership – Water Energy Climate (MAP-WEC) goal of strengthening the environmental resilience of countries in the Mekong subregion (Cambodia, Laos, Myanmar, Thailand, and Vietnam). FIS/2017/017 engaged with both technical and policy influence change pathways. The project progressed despite COVID-19, but there remains a significant challenge in providing a rigorous validation of the technical aspects of Mekong hydropower fish passes. There also remains a significant challenge to build local capacity in the design of fish pass infrastructure for environmentally sustainable hydropower and influencing decision making to adopt best practice sustainable fish pass technologies. Furthermore, significant research for development challenges remain, as the team in conjunction with management agencies in the Mekong need to find effective processes for translating research findings into improved decision-making, dam design and management practices.

We learnt in FIS/2017/017 that there is a significant political challenge in influencing change. We recognised that the Mekong River Commission guidelines are not the final adoption point for sustainable technology; in the first instance this is the Government of Laos. Second, the project only focused on upstream fish pass investigations. There remain significant gaps in terms of downstream migration, and, more broadly at the ecosystem scale. Third, the team has not yet explored social dimensions (whether the dam is influencing re-settled and other communities' fisheries-based livelihoods and food/nutrition security). Fourth, the most appropriate dissemination and influencing mechanisms, for each key next user, are yet to be understood.

Further, this project adds to (1) SSS/2020/142, which explores the policy impact in Lao PDR and the transition from research to practice, and (2) the (almost finalised) impact evaluation work conducted by ACIAR on the 'Research-Policy Interface: Lessons from Lao PDR'.

[1] relates to components to be funded by ACIAR's Capacity Building section under FIS/2018/153.

Activities of other actors/donors

Substantial investments have been made by ACIAR, DFAT and XPCL in researching the required infrastructure to build effective fish passage systems and in developing new technologies to assess fish pass rates when the hydropower facility is operating. Now further research is needed to scale up and scale out the ecological learnings from the Xayaburi Dam site; as well as to better understand the cumulative impacts of the Xayaburi and Laung Prabang damsites on the livelihoods of local communities; and to translate the research outcomes from the Xayaburi and Laung Prabang dam sites into policy. The main additional actors to be brought into this initiative are (a) Lao Ministry of Energy and Mines (as a central partner as opposed to a reference group member like they were in FIS/2017/017), and (b) other hydropower developers who are proposing mainstem dams. The Mekong River Commission is also charged with developing a regional 'Sustainable Hydropower Guidance' document and data generated by the team will be highly relevant to future iterations of that document.

A significant feature of the proposed activity will be to 'map' actors which have been 'missing' from our collaboration network (KG 3). Critical to this process will be building on our existing collaborations with the Mekong River Commission and making strategic connections to dam developers relevant to other projects. The Mekong River Commission has already indicated that they are very motivated to see the outcomes of FIS/2017/017 translated and transferred to other projects. So, there can be an immediate suite of information transfer which can take place whilst other knowledge gaps are advanced.

2. Project Theory of Change (i.e. program logic)

2.1 Overview

Adaptive management is the most appropriate theory of change mechanism applying to 'sustainable hydropower' in the LMB. In this context, adaptive management is described as (Bunnefield, 2015):

"a structured, iterative process for making decisions in 'response to changes in context and new information that promotes intentional learning and minimizes the obstacles to modifying programs."

Relevant to the agenda 'Sustainable Hydropower', adaptive management is fundamentally dependent upon the injection of empirical knowledge and learning at critical phases of the project or programme cycle (Figure's 3 and 4). This would most notably occur during the design and planning phase (to ensure that plans reflect the environment in which they are located, that objectives are relevant and realistic, and that the proposed interventions are feasible and appropriate) and then subsequently during implementation to ensure that experience and lessons are captured and fed back into the next hydropower project, informing adjustments to implementation as required. With respect to fish pass criteria, results determined from FIS/2017/017 could now be, theoretically, directly applied to improve the criteria for fish pass design at the next dam, Luang Prabang then the following one at Pak Beng; and so forth. In essence this is occurring, but is also straightforward, because the Luang Prabang dam is owned by the same developer (Xayaburi Power Company Limited). The challenge is establishing dialogue with the other developers and transferring research findings to them in a manner which influences practice change. In this context, we define long term 'practice change' as when a developer proposes a dam which contains a mitigation strategy that is most likely to pass fish, both upstream and downstream, with minimal (or no) impact on fish-dependent livelihoods. We suggest that the ability to do so requires:

(a) technical solutions which are based on robust evidence in the local context.
(b) knowledge of the solutions and how to apply them.
(c) a willingness to adopt, and invest in, the solutions.
(d) a commitment to monitor, evaluate, learn, and apply improved solutions to future situations.

Our Theory of Change (TOC) approach outlines a specific process and approach to incorporate learning and information into new and ongoing hydropower development activities. In adaptive management frameworks, the TOC needs to be seen as dynamic, allowing stakeholders to review and adapt whenever there is new evidence, or when there are changes in the context that affect assumptions or hypothesized pathways of change. The hydropower agenda in the LMB is dynamic. It is influenced by changes in institutional leadership, investors, developers, ministerial portfolios, government priority setting, and international technology advancements among many factors. Therefore, should a theory of change have been developed in 1995, when the Mekong Agreement was signed, it would have needed revision, over the past 30 years, in response to changing regional and international priorities, technological changes and environmental changes (such as climate change). The TOC presented here reflects our current understanding of the sustainable hydropower development agenda, but should be reviewed annually as the project progresses or whenever political, economic, social, technological, legal or environmental factors significantly change.

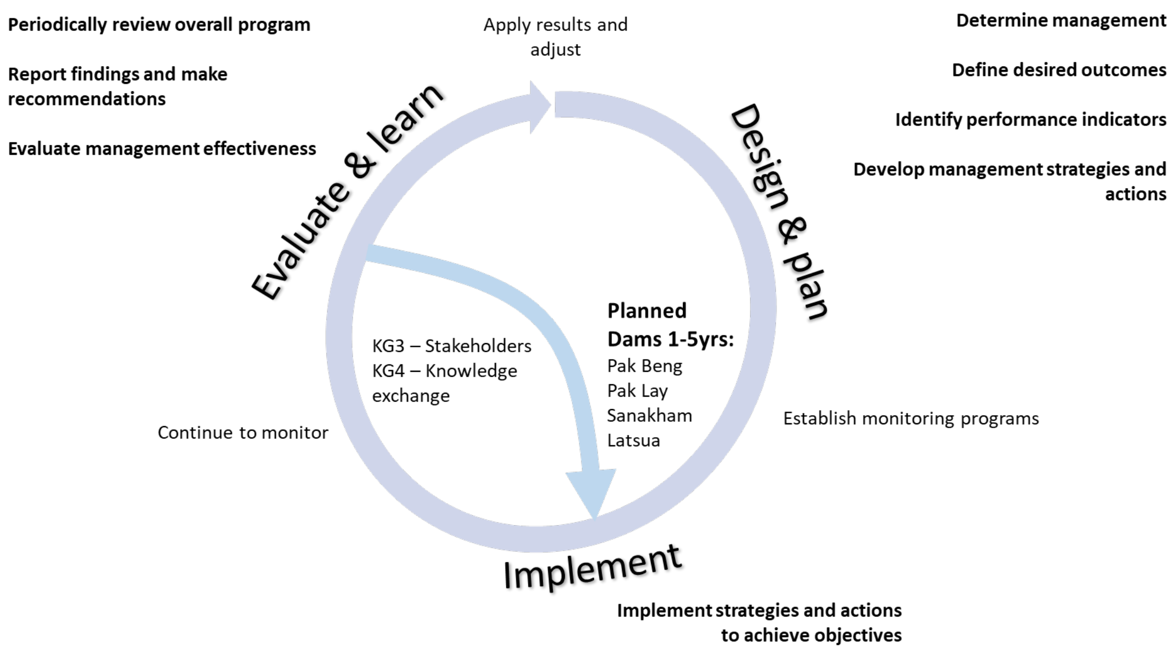

Figure 3. Theoretical adaptive management framework pathways relevant to sustainable hydropower in the LMB.

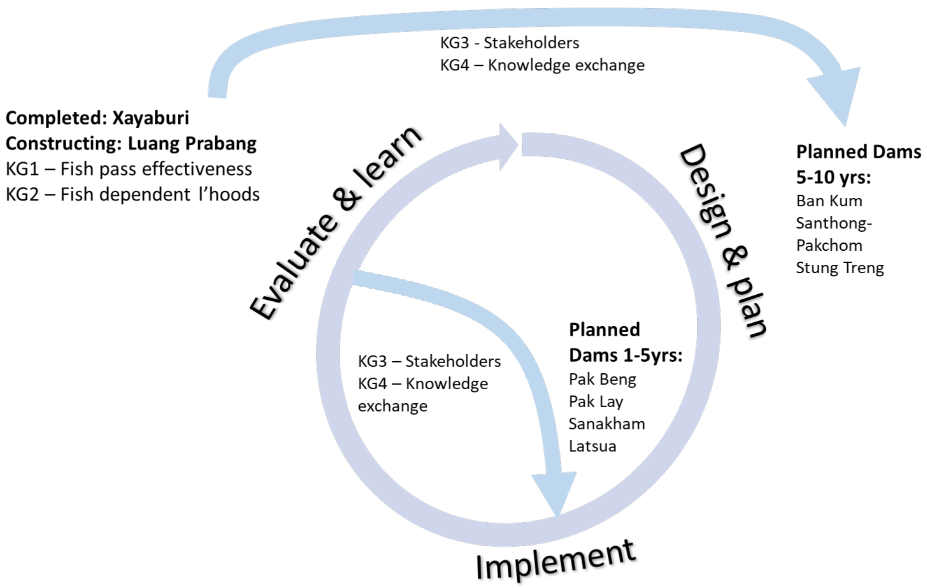

Figure 4. Theoretical adaptive management framework pathways considering the dams scheduled for design/construction commencement within the next five years (the term of this proposed project activity), with key knowledge gaps (KG's) shown as enablers into a 1-10 year impact pathway. Initially the focus will be on dams scheduled to commence in the next 1-5yrs; with knowledge brokering required for dams on the 5-10 year horizon.

End-of-Project-Outcomes

The overall goal of the ACIAR Fisheries Program is 'to improve fisheries ecosystem health under climate change. It takes a human rights-based approach to development and aims to improve the lives of aquatic resource-dependent rural people. It does this by investing in R4D that aims to improve the health of the aquatic ecosystems and resources that rural people depend upon' (ACIAR Research Design Brief). FIS/2023/133 will contribute to the overall goal of the ACIAR Fisheries Program by achieving three End-of-Project-Outcome's (EoPO's) (Figure's 7 and 8), which explicitly link identified knowledge gaps with hydropower project construction schedules in an adaptive management sense. The main focus here is research for development. This is time-bound as the ability to influence hydropower projects, until the sector enters the 'development' stage, is within the next five years.

Consistent with the goals of the ACIAR Fisheries program, our overarching development goal for this activity is: *'To ensure that hydropower does not negatively impact fish and fish-dependent livelihoods'*.

To achieve that objective, there are four primary EOPO's that the activity is targeting. The first two focus on expanding the evidence base on technical solution effectiveness to inform the sustainable hydropower agenda. The second two focus on transferring, and translating, that evidence base into improved policy, decision making and implementation.

- EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).
- EoPO 2: Social and economic dimensions of hydropower and fisheries interactions are better-defined.
- EoPO 3: High level stakeholders advocate for and support sharing information and participating in a process for evidence-based decision making.
- EoPO 4: Technical staff in relevant government agencies and hydropower companies have capacity to make informed decisions.

Links between the EoPO's

The technical fish passage (EoPO1) and socio-economic research (EoPO2) evidence will establish the evidence base that is needed to guide the design and planning for the remaining dams (but currently missing from the MRC PNPCA process). Absence of evidence is presently being propagated, by some developers, as a reason to proceed with sub-optimal technical solutions. EoPO3 is required to effectively 'map' the hydropower development stakeholder system to understand who key evidence needs to be disseminated to, in order to facilitate policy and practice change to influence the adaptive management cycle. EoPO4 seeks to design and evaluate the performance of dissemination/policy framework to ensure that the evidence base (EoPO 1 and 2) is disseminated to the identified stakeholders (EoPO4). There are functional and structural links between each of the EoPO's. The dissemination, policy adoption and capacity building frameworks will subsequently link to meet our overarching development objective of protecting fish-dependent livelihoods.

'Impact pathways' in the theory of change/program logic

The program logic will follow the sequence of undertaking 'Foundational' and subsequent 'Influencing Activities', to achieve 'Immediate' and successive 'Intermediate Outcomes' that eventually result in the 'EoPO's'. These are summarised in Figure 8.

EoPO 1

The Foundational Activity for EoPO 1 will involve documenting the effectiveness of the fish pass operations at Xayaburi and Luang Prabang. This Foundational Activity will underpin the Influencing Activity of generating empirical evidence to support the inclusion of fish passage in hydropower developments. The Immediate Outcome will be that hydropower companies and investment decision makers in central government both understand the business case for investing in fish friendly hydropower development. This should subsequently translate into the corresponding Intermediate Outcome. That is, hydropower companies and government investment decision maker criteria requiring hydropower developments to be fish friendly.

EoPO 2

The Foundational Activity for EoPO 2 involves making the 'human' case for investing in technical solutions. Specifically, research will be undertaken to understand socio-economic impacts of dam and fish pass operations at Xayaburi and Luang Prabang. Across the Mekong, fish remain the most important source of protein and micronutrients for over 60 million people (Hortle et al. 2017). It is widely accepted that dams will reduce this resource base unless suitable technical solutions are applied. Now that several dams are operational, with technical solutions applied, there is an opportunity to understand if the investment is generating the intended benefit to fish-related livelihoods (i.e. no net reduction). The Influencing Activity for EoPO 2 will involve generating empirical evidence to understand the community impacts of dam and fish pass operations at Xayaburi and Luang Prabang. A series of social surveys will be conducted in areas around constructed dams (with and without technical solutions) to triangulate information on livelihood benefits/disbenefits following construction. The Influencing Activity should lead to the Immediate Outcome of hydropower companies and investment decision makers in central government both understanding the business case for investing in socio-economically responsible hydropower development. This will involve building a solid evidence base on the state of livelihoods before and after construction. The Immediate Outcome is expected to subsequently translate into the Intermediate Outcome of hydropower company and government investment decision maker criteria requiring hydropower developments to be socio-economically responsible and inclusive. This outcome cannot be met without scientifically robust data on the effectiveness of existing solutions at mitigating impacts on fish, and will apply that data to improved fish-related outcomes at future dams. For instance, if livelihoods have declined following construction, and that is due to insufficient efficiency of technical solutions, then improved interventions need to be designed. If livelihoods are unaffected, that may indicate that the technical design of existing interventions is sufficient and should be replicated at other sites.

EoPO 3

The Foundational Activity for EoPO 3 will involve key informant interviews among owners, the Mekong River Commission and the Lao government to effectively ‘snowball’ a ranked path analysis (to track their power and influence), and then a social network analysis to understand the key influencers for each hydropower project. The Influencing Activity will be most prominent in the early stages when high-level stakeholders are engaged, although the success of achieving this outcome will depend upon their willingness to share information and engage in a process for evidence-based decision making. The Immediate Outcome will be that the various high-level stakeholders are willing to engage and share information. This will be a two-way process, with the project team sharing information on technical solution performance, and the stakeholders willing to share their networks. The Immediate Outcome should subsequently translate into the Intermediate Outcome of broader connections with key influencers across the social network. The further the network is explored, the better key influencers and decision makers will be understood. Once defined, appropriate dissemination pathways will then be designed, preferably, as a co-designed activity.

EoPO 4

Foundational Activities for EoPO 4 will involve developing a context-specific knowledge management system to ensure adoption of project outcomes beyond the life of the project, and disseminating (knowledge brokering) the improved knowledge on the effectiveness of technical solutions to industry and government. Influencing activities will involve targeted education and dissemination through seminars, workshops, face-to-face meetings, conferences or more formal masterclasses or courses to support fish friendly hydropower development based on value-for-money and social impact. It is important that these activities are targeted towards key stakeholders identified as part of our work addressing EoPO 3. This will lead to the Immediate Outcomes of increased individual and institutional capacity to apply technical solutions while also ensuring that outcomes from EoPO 1 and EoPO 2 are socialised and made publicly available. The subsequent Intermediate Outcome will be that individuals are capable of actively applying these outcomes to on-ground projects, and that developers and the MRC provide responsible and appropriate decision-making regarding hydropower sustainability.

The Foundational Activities, Influencing Activities, Immediate Outcomes and Intermediate Outcomes for each EoPO will be used as progress markers for these EoPO's.

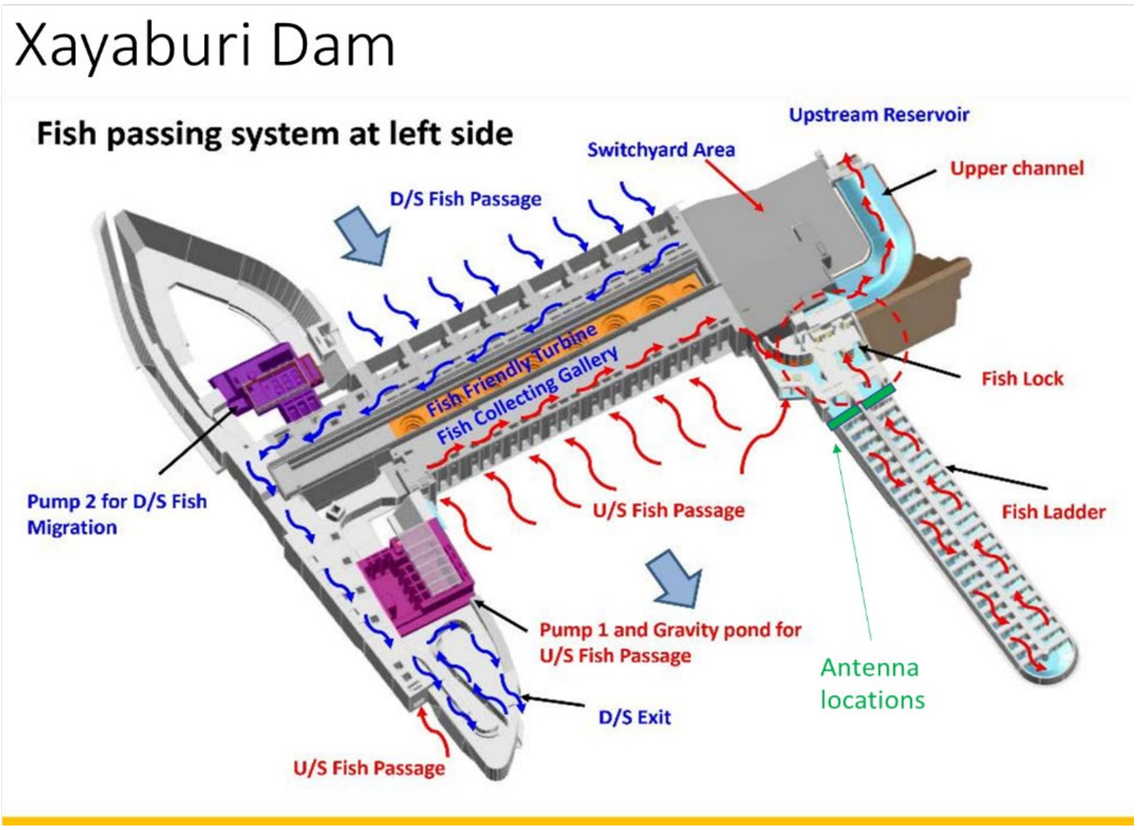

Figure 5. Schematic of the fish pass facilities at Xayaburi Dam (top) and an actual aerial photo of the site (bottom) (source: XPCL). In terms of technical data, FIS/2017/017 yielded excellent research data on the upstream fish pass. Matters of downstream migration, delay and turbine passage are still unresolved and are built into FIS/2023/133.

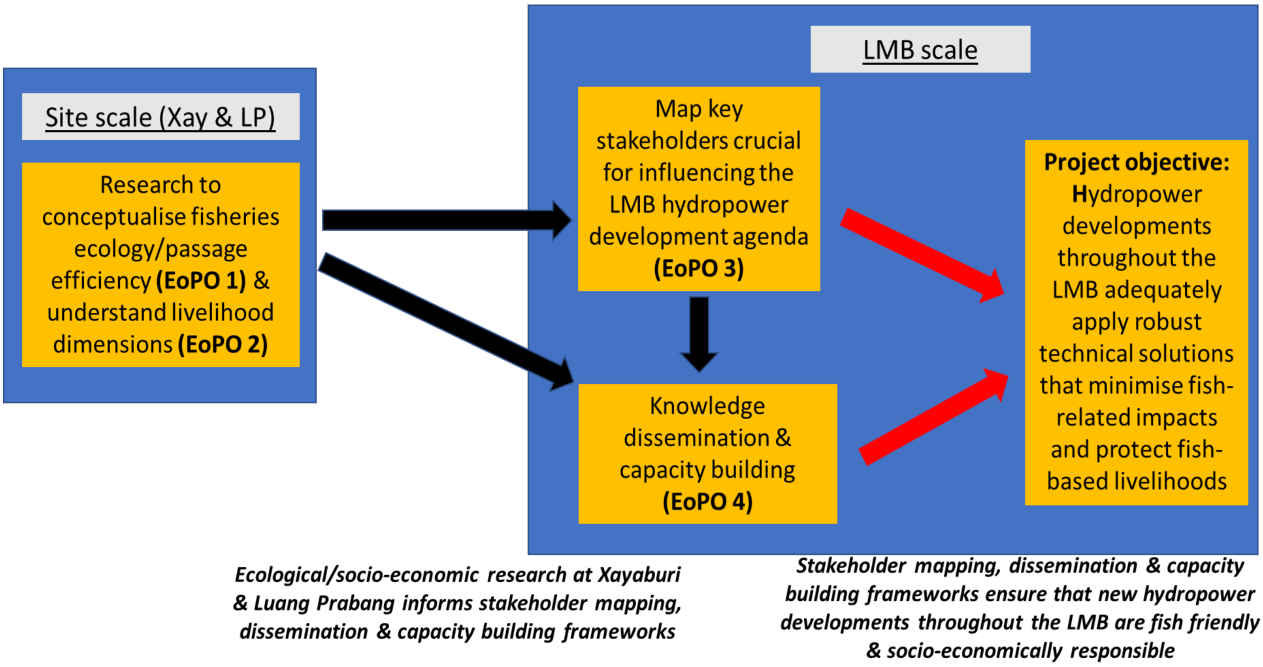

Figure 6. Functional links between EoPO's and the overall development outcome. The activities for EoPO 1 and EoPO 2 will be conducted at the site scale (at Xayaburi and Luang Prabang), but all four project outcomes will transpire at the LMB scale.

Table 2. Impact pathways and functional links to EoPO’s.

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).	Access to XPCL and other facilities Fisheries researchers	Activity 1.1. Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions Fish pass monitoring at Xayaburi Dam Acoustic fish tracking at Xayaburi Dam Downstream fish monitoring at Xayaburi Dam	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings)	Evidence base is developed Implemented the fish pass to enhance aquatic biodiversity and ecological sustainability Technical solutions have been internationally and independently assessed	Locally-developed data which is of relevance to other developers Addresses international requests for data Demonstration of sustainable hydropower development, aligning with government/regional goals
EoPO 2: Social and economic dimensions of hydropower and fisheries interactions are better-defined (linked to KG2).		Activity 2.1. Research to understand socio-economic impacts of dam & fish pass operations Activity 2.2.1 Gather social-based data on villages at/near hydropower projects Activity 2.2.2. GEDSI disaggregate social data to investigate inclusivity dimensions	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings)	Assess the socio-economic effects of hydropower dams on local communities Highlighting benefits and challenges to inform balanced policy decisions	Enable evidence-based policy formulation that improves lives and fish-dependent livelihoods in tandem with hydropower development

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 3: Stakeholders advocate for and support sharing information & participating in a process for evidence-based decision making (links KG1 and KG2 to KG3).	Social scientists Connections with developers Connections with MRC Connections with government Ability to travel Willingness to share information	Activity 3.1. Stakeholder mapping Activity 3.2. Key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers	Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	Identify key stakeholders for effective information dissemination Share insights with stakeholders to influence hydropower development agenda	Forge collaborative partnerships with stakeholders, shaping development strategies in line with governmental and regional priorities Developers are connected with researchers
EoPO 4: Technical staff in relevant government agencies & hydropower companies have capacity to make informed decisions (links KG1, KG2 and KG3 to KG4).	Educators Development of curriculum / masterclasses Travel budgets Operational costs	Activity 4.1.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 4.1.2. Deliver capacity building activities Activity 4.2.1. Targeted knowledge brokering activities and learning opportunities Activity 4.2.2. Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	Proposed and future hydropower projects have better technical solutions for fisheries sustainability Fisheries and fish-dependent livelihoods are not negatively impacted

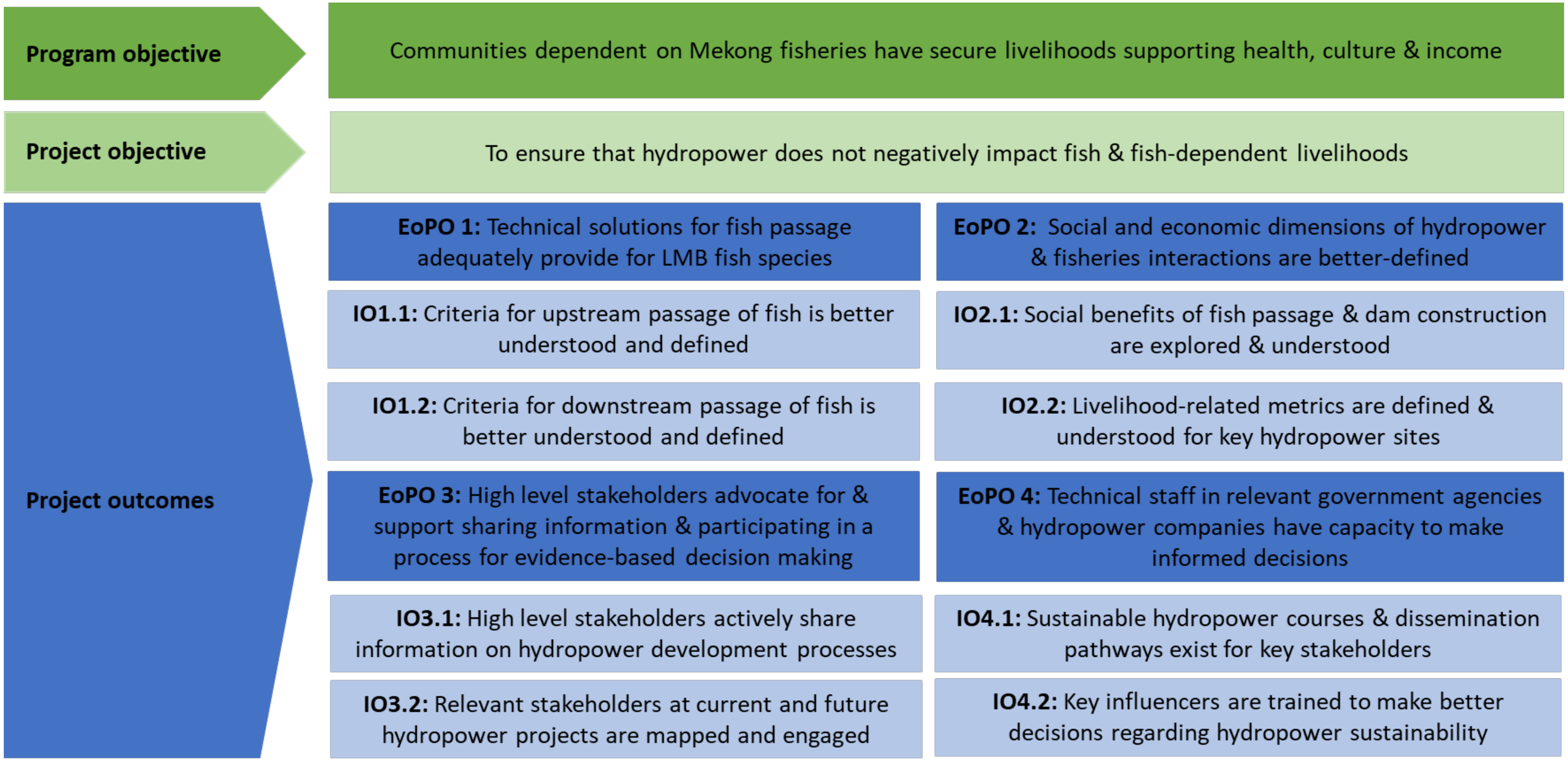

Figure 7. Conceptual overview of End-of-Project-Outcome's (EoPO's) and Intermediate Outcomes (IO's).

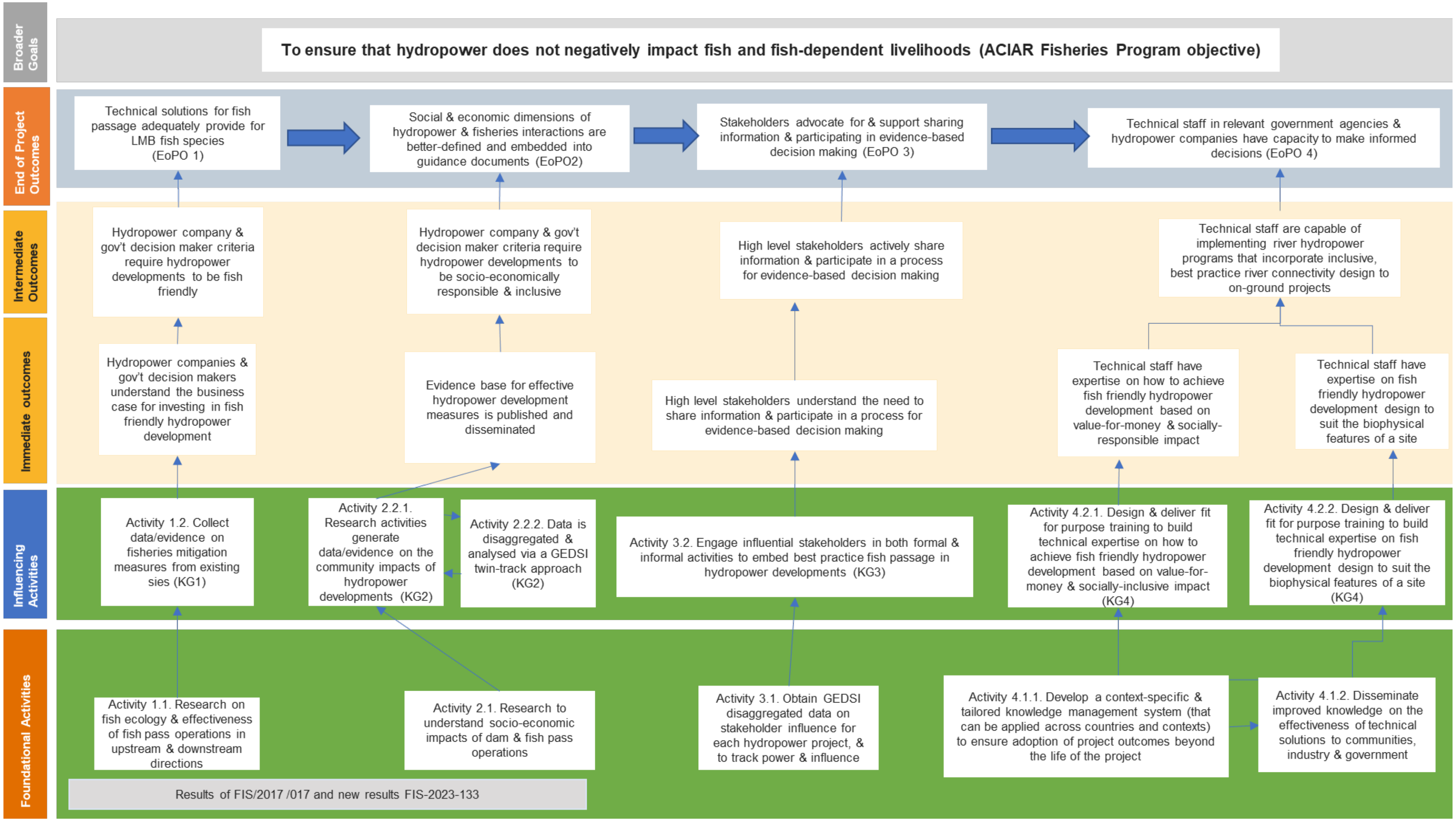

Figure 8. Program logic for FIS/2023/133, showing the impact pathways from the Foundational Acitivities to each End-of-Project-Outcome. Foundational Activities and Influencing Activities are detailed in section 2.6.

Key assumptions

Table 3. Key assumptions underpinning each activity.

EoPO	Activities	Assumptions
EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).	Activity 1.1. Research on fish pass operations in upstream & downstream directions Fish pass monitoring at Xayaburi Dam Acoustic fish tracking at Xayaburi Dam Downstream fish monitoring at Xayaburi Dam	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained
EoPO 2: Social & economic dimensions of hydropower & fisheries interactions are better-defined and embedded into guidance documents (linked to KG2).	Activity 2.1. Social surveys and interactions with local communities Activity 2.2.1 Gather social-based data on villages at/near hydropower projects Activity 2.2.2. GEDSI disaggregate social data to investigate inclusivity dimensions	Access to local villagers is possible Developers agree to surveys taking place Human ethics committee permission is obtained Lao government approves, and facilitates, access to villagers
EoPO 3: Stakeholders advocate for and support sharing information & participating in a process for evidence-based decision making (links KG1 and KG2 to KG3).	Activity 3.1. Stakeholder mapping Activity 3.2. Key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared
EoPO 4: Technical staff in relevant government agencies & hydropower companies have capacity to make informed decisions (links KG1, KG2 and KG3 to KG4).	Activity 4.1.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 4.1.2. Deliver capacity building Activity 4.2.1. Targeted knowledge brokering activities and learning Activity 4.2.2. Policy brief development Update to MRC guidance document Research dissemination think tanks / dissemination events	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments

Time horizon

The team anticipate this being a 10-year program of work; but with the most urgent need to influence developers between 2023 and 2029. We will apply a theory of change framework (Olsen, 2003; UNEP/GPA, 2006) that can guide project governance and management responses based on sound research and improved capacity, and provide a pathway for change, through the uptake of knowledge and technologies. This framework will set out four 'orders' of outcomes (over a 10-year period) in the fishway program responses to changing societal, economic and environmental conditions, leading to the ultimate long-term goal of sustainable forms of energy development.

The first order outcomes (1–4 years) will involve the creation of the enabling conditions for a fish passage governance/policy initiative by linking key stakeholders, performing key research, and policy advances. This will be completely evidence-based. The team will complete the technical investigations at Xayaburi, preliminary investigations at Luang Prabang, and develop a resource base for dissemination to other developers involved with Pak Beng, Pay Lay, Sanakham and Latsua.

The second order outcomes (2–6 years) will involve changed behaviour of resource users and key institutions based on uptake of research outcomes. We will be specifically targeting the hydropower dams, which have been through PNPCA but have been required to make changes to their designs to meet sustainability guidelines.

The third order outcomes (4–10 years) will involve an increasing adoption of fish-friendly practices, aimed at livelihood protection, at other sites in the Mekong. These will focus on the dams with a longer time horizon for design and construction (Ban Kum, Santhong-Pakchom and Stung Treng).

The fourth order outcomes (1–10 years) will lead to a more sustainable and resilient inland capture fishery, with fisheries and livelihood considerations being integrated into new and existing infrastructure projects; and any future projects that may be considered.

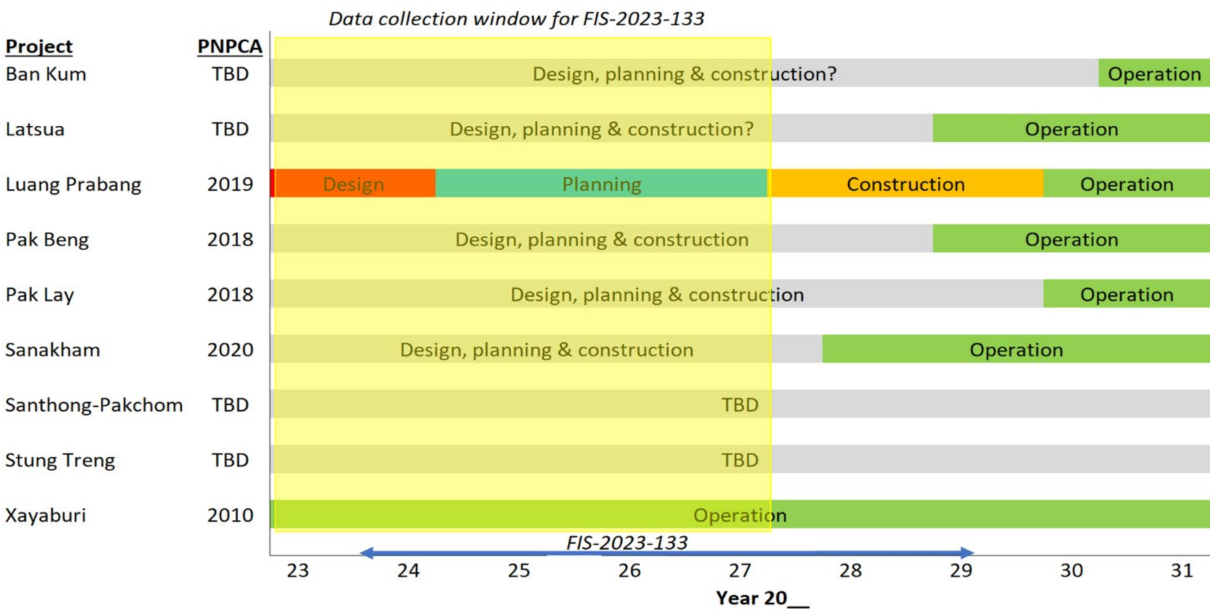

Figure 9. Construction timelines for the nine hydropower dams being built. There is a significant, time-bound opportunity to drive sustainable outcomes if research can be disseminated to the correct stakeholders.

2.2 Research strategy

2.2.1 Research questions

Question: How can improved knowledge on fisheries migration and on the Xayaburi fish pass efficiency be used to leverage improved outcomes at other planned dam sites on the Mekong River? (EoPO 1; KG 1).

Question: How can we better understand the cumulative effects of multiple dams on fisheries migratory ecology? (EoPO 1; KG 1).

Question: How has the Xayaburi site influenced local communities' fisheries livelihoods? (EoPO 2; KG 2).

Question: What are the most influential actors and mechanisms to translate the research outcomes from the Xayaburi and Luang Prabang dam sites into future dam policy? (EoPO 3; KG3).

Question: What is the most effective capacity building program to build in-country individual and institutional proficiency to make improved policy and decision making for hydropower? (EoPO 4; KG 4).

2.2.2 Addressing research questions

EoPO 1: Research to conceptualise the fish ecology and passage effectiveness (technical research)

Specific design parameters were incorporated into the Xayaburi Dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Figure 10). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Figure 10),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Figure 10),
(c) they then enter a large fish pass facility (left-bank facilities, Figure 10) and
(d) then proceed through a locking system into the weir pool (orange shading, Figure 10); or
(e) alternatively, they can move through the navigation lock.

It is important that fish can successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

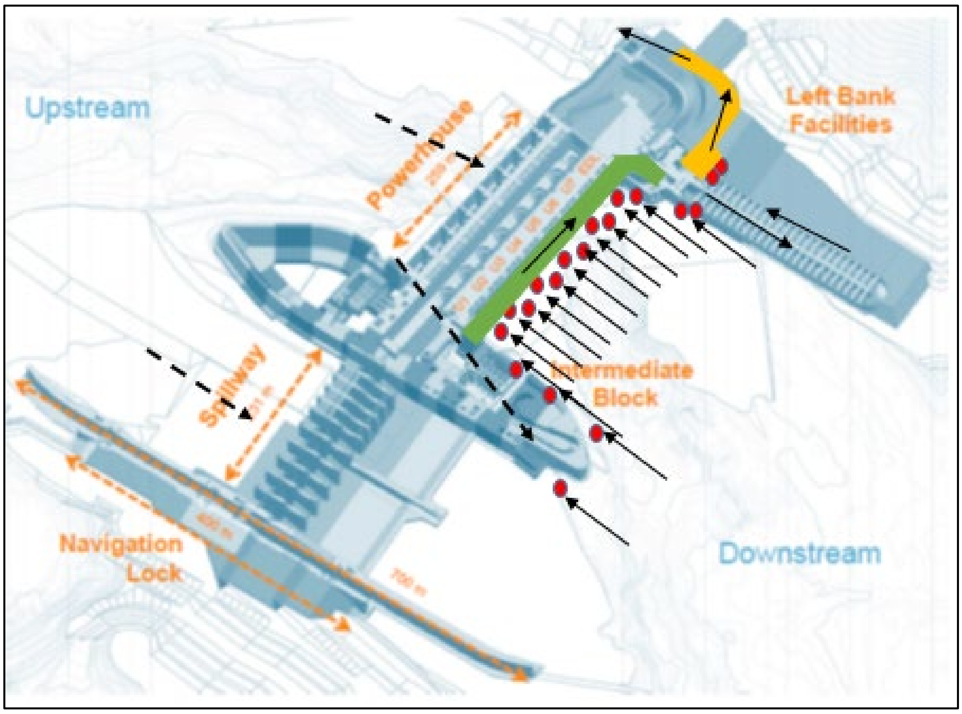

Figure 10. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green, and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

Terms of reference / research questions

A team of Australian, Lao and US fisheries scientists (fish experts) in collaboration with XPCL scoped several key research questions to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

Request from XPCL: FIS/2017/017

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was initially requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, was beyond the scope of the available budget so the ACIAR/DFAT team only focused on methods to assess upstream fish passage for FIS/2017/017.

Consequently, the initial research questions posed were:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

The result of this was that so far there has been no attempt to address the research questions regarding downstream passage, nor about what fish are approaching the dam. These questions are extremely important, both at Xayaburi and Luang Prabang, and the other dams under design and planning; and FIS/2023/133 will seek to progress.

PIT tag systems (extension of FIS/2017/017)

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations. Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23 mm or 12 mm long; half or full duplex), which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage, which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date, or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hours a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems were assessed as part of FIS/2017/017 and have proven to be an effective method for assessing upstream fish pass effectiveness. The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It now provides a complete system, which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a webpage. Ensuring a standard tagging system is installed at multiple sites will guarantee that fish tagged in other parts of the LMB, can be detected anywhere. The system is online, active and contributing usable data. The team are tracking 4,500 fish so far (but the target was 10,000 to provide statistically meaningful results). The team will continue the existing work and build a longitudinal dataset on fish migration and fish pass efficiency. This data will be directly transferrable to other sites and, if other developers adopt and install this technology, would be the main mechanism for monitoring fish movements once (if) the hydropower cascade is completed. It will provide the largest and most comprehensive transboundary dataset on fish migration in the entire Mekong.

Rationale

FIS/2017/017 provided: (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study, the project team were tasked with using PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations, which are all being applied to the work at Xayaburi. So, the team are starting from a strong knowledge and experience base. Our aim is to achieve an increase percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Undertake large-scale tagging to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, we will continue to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 2,000 fish annually (300 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate. We can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will migrate, shed tags or be harvested, there will be a need to tag new fish in every year to maintain a sufficient sized pool of tagged fish. The team will use a model that was developed for FIS/2017/017, to estimate the number of fish that need to be tagged every year to maintain target populations of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating efficiently.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fish pass operation and XPCL fish passage efficiency reporting requirements back to the government of Laos. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power. This will be achieved by further developing long-term PIT tagging requirement models for the key species.

Stage 5: Publication, reporting and reporting to other developers and the MRC. Including further development of the MRC hydropower guidance document.

Acoustic systems

Rationale

PIT systems will only be suitable for documenting upstream migration rates through the fish pass. Acoustic systems are more flexible than PIT systems in that their listening stations can detect tagged fish from much further away, and do not require a narrow channel to steer the fish past the detection (antenna) system. Nonetheless, they are more expensive than PIT systems, require more maintenance (e.g. they require a battery), and are constrained by the landscapes in which they can be deployed.

Activities

Acoustic systems will be used either instead of (or in conjunction with) PIT tag systems to determine: (a) what fish are approaching the dam (for both up-and downstream passage), (b) what influences which route is taken (spillway, fish collector or turbines), (c) whether there is migratory delay downstream of the structure, or (d) whether fish survive downstream migration in general.

Sensor Fish and turbine Injury

Rationale

Sensor Fish are robotic data logging fish that can assess the hydraulic conditions fish may potentially be exposed to while passing through hydropower turbines. A series of Sensor Fish instructional movies were developed as part of FIS/2017/017 by the team during the COVID-19 pandemic, and shared with the in-country project partners. The in-country staff were then later given face-to-face training on the use of Sensor Fish at Xayaburi Dam in October 2022, once XPCL eased their COVID-site access restrictions. The training was provided Dr Daniel Deng (a Pacific Northwest National Laboratory (PNNL) engineer who developed the Sensor Fish) and the CSU team. The in-country staff then assisted in undertaking actual trials with dummy Sensor Fish to apply their learnings.

Activities

Sensor Fish trials will be undertaken to further empirically quantify the hydraulic conditions associated with the hydropower turbines to add a range of approach conditions (fish swimming depth) to the initial trials. Turbine-specific pressure change results will be simulated in laboratory conditions, using a barotrauma chamber, to examine the impact of turbine-related pressure changes on fish survival. These comprehensive experiments will include several target Mekong species and at various life stages. The Sensor Fish data will also be used to model the impacts of turbine-related blade strike on fish survival. The information provided by the Sensor Fish will therefore enable us to validate the ‘fish-friendliness’ of the hydropower turbines and their associated hydraulic conditions. We will compare the measurements of the hydraulic situation to 'dose rate' information from actual Mekong River fish. Linking these together gives an overall indication of survival rates through turbines.

Furthermore, there are no data yet documented for fish using the other downstream passage routes including: the downstream fish passage channel, the spillway, and the navigation lock. We will use the Sensor Fish technology and actual fish to assess the stresses faced by fish in those routes, including barometric trauma, impact trauma and fluid shear stress, which are all important factors that potentially affect downstream migrating fish survival.

EoPO 2: Research to understand the social dimensions (social science mixed methods approach)

Rationale

This EoPO seeks to determine livelihood dimensions regarding dam construction. There is a strong desire for qualitative/quantitative data documenting that the investment in technical solutions (which will be studied in-depth as part of EoPO1) is justified by fish-dependent livelihood outcomes. However, is the intervention having the desired impact on social dimensions? For instance, are fishers no 'worse-off' because of the dam? Has the fishery changed? These social dimensions are very important to transfer to the public domain, and to other developers (and the MRC for inclusion into hydropower guidelines).

Approach

We will adopt an approach taken by the FishTech (FIS/2018/153) team which recently applied an exploratory mixed-method sequential design, bringing together qualitative and quantitative datasets (Creswell & Clark, 2011), to assess the impacts of Perjaya Dam on fisheries, and fish-dependent livelihoods in Indonesia.

Data collection will be divided into a two-stage process starting with interviewing key informants using semi-structured interviews, followed by a questionnaire survey with household respondents. Key informant interviews will aim to elicit key themes and understand changes, if any, in various metrics pre- and post-dam construction. Findings from the key informant interview data will be used to guide the development of the questionnaire survey, and to get local, national, and regional contexts on hydropower development and the importance of fisheries. We plan to interview people in resettled/unsettled regions upstream and downstream of hydropower sites. Female perspectives, and those of social minorities, will be purposively sought so that data can be disaggregated by gender and/or social status.

The purposive recruitment process will be undertaken with initial guidance from local government officers and/or village chiefs. Snowballing will then be applied, either during the interview process (Kirchherr & Charles, 2018), or where government and NGO staff may contact the potential key informant themselves, prior to connecting them with our researchers. All participants will be provided an information sheet, which will be verbally explained. The information generated by the interviews will relate to:

(a) the general conditions of changes (if any) in the river and fisheries;
(b) inland fisheries production;
(c) the value of fish caught;
(d) household income;
(e) and species captured, including various details regarding perceptions of the dam on fish migration.

All interviews will be either in English or Lao, depending on respondent's language preferences.

A questionnaire survey will be designed after data analysis of the key informant interviews once the first round of fieldwork has been completed. Based on our previous experience at Perjaya Dam (Indonesia), we expect the questionnaire may include sections relating to:

(a) the value of fish for fishers;
(b) where they fish;

(c) how they utilise fish;
(d) changes in fisheries because of the fishway and dam construction;
(e) any impacts (or otherwise) on fish migration;
(f) their opinion regarding fisheries governance and management.

Questionnaire participants will be recruited using random sampling, after stratification by location and time living and fishing in the area (fishing more than 30 years in their location). This time stratification will be followed to several locations (0–5 km upstream, 0–5 km downstream, 5–10 km upstream, 5–10 km downstream, 10–20 km upstream and 10–20 km downstream from the dam).

A list of households in these areas will be obtained from the local niban/government office in line with ethics approval. From the list, equal numbers of fishers fishing for more than 30 years, and less than 30 years will be randomly selected to participate in the survey utilizing random function '=RAND' available in Microsoft Excel. In total, we aim to survey a minimum of 60 respondents with more than 30 years of fishing experience and 60 respondents with less than 30 years of fishing experience as an aspirational baseline for these surveys. This random sampling allows for male and female, and both poor and rich fishers, with and without disabilities to be included in the study. For interviews occurring with family households, the questionnaire survey will be undertaken with both members of the couple where possible to allow for both women's and men's input into the data.

Additional quantitative strategies will also be considered we will seek to partner with staff within the National University of Laos from the Faculty of Social Science and the School of Economics. We will make use of an existing LaoX survey data to quantify differences before and after construction. This is extremely important to form a "before" baseline. In addition, we will consult the LSIS (Lao Social Survey Indicator) dataset to perform before and after comparisons of livelihood status. There will be a significant challenge to disentangle impacts of the dam from other indicators of social change occurring in Lao PDR. To address this the team will use a multiple-lines-of-evidence approach with a triangulation strategy.

EoPO 3: Knowledge exchange and policy adoption (social science knowledge brokering and social network approach)

<u>*Rationale*</u>

Hydropower development involves managing a network of diverse stakeholders. As a construction project takes place in a non-linear, complex and interactive environment, efficient inter-organizational links are vital for delivering projects successfully and meeting stakeholder expectations. Essentially, cooperation with stakeholders and efficient inter-organizational linking can help owner improve social capital that arises from their stakeholder networks. The ability for a hydropower project to be designed, implemented and operated in a way which minimises environmental impact is the sum-total of the knowledge, capacity and willingness of all stakeholders to work towards that goal.

<u>*Approach*</u>

Most direction in establishing hydropower projects starts with the owners. Owners need to establish cooperation with stakeholders for a project to succeed. The owner generally would interact with (adapted from Wang et al. 2018):

- A designer which plays a role similar to that of the architect/engineer
- An owner representative who acts as agent of owner in conveying the owner's orders to contractors, and as certifier for issuing certificates regarding project cost, quality and time
- Contractors who execute and complete the works to meet the requirements of specified standards

- Suppliers who provide the owner with equipment and materials
- Local residents, who are those people who are influenced by the development
- The government, who deals with the issues regarding approval for the project, use of lands, environmental protection and relocation of migrants
- Power grid corporations, who become buyers of the electricity generated by the hydropower
- Consulting companies, which may be used to help the owners with deciding on key strategies and solving technical problems in developing hydropower projects.

In the LMB, there is a complex transboundary environment where the owners also need to manage neighbouring governments and their needs. This is generally facilitated by the Mekong River Commission through the PNPCA process. Thus, to access the social network responsible for influencing the design, construction and operation of a project; the owner and the MRC are critical, influential, stakeholders along with the Lao government as the consent authority.

Whilst the general network of stakeholders in a project is known, what is unknown, is whether these stakeholders differ among remaining projects and which actors in this complex network of stakeholders yield the biggest influence over the design and construction of mitigation measures for environmental impacts, with respect to fisheries mitigation strategies. We propose a path analysis and social network analysis to identify the role played by each stakeholder, and their overall influence, on the decision-making process.

An et al. (2022) identified that the stakeholders identified by Wang et al. (2018) can be grouped five types of influencers within hydropower projects with respect to decision making (coordinators, consultants, gatekeepers, representatives and liaison officers). Defining the sphere of influence (or power) is important when identifying their role in design and planning.

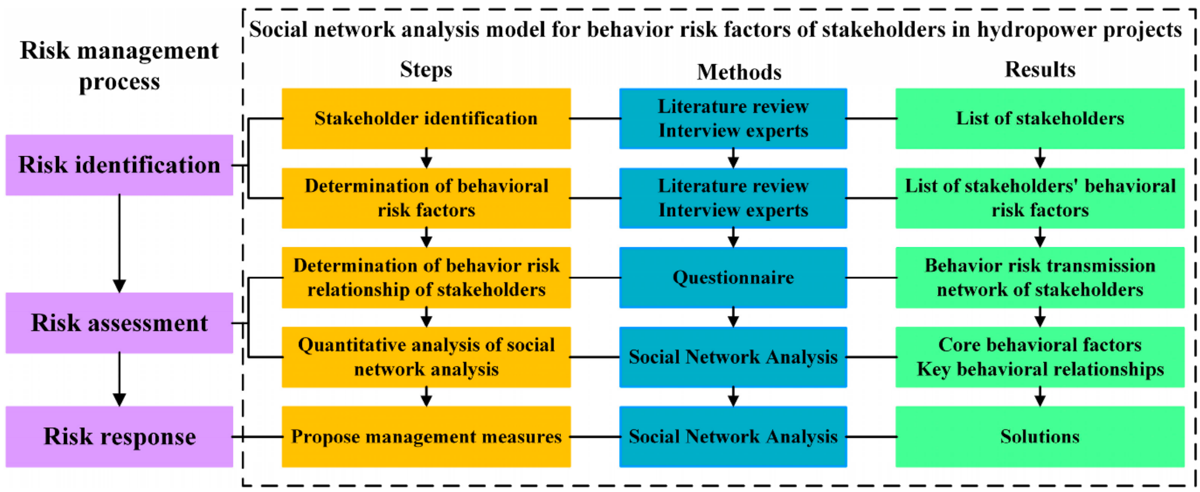

Figure 11. Framework for addressing risk, and stakeholder engagement in hydropower projects (An et al. 2022). The risk framework will be developed further and applied to fisheries mitigation in the LMB as part of FIS/2023/133.

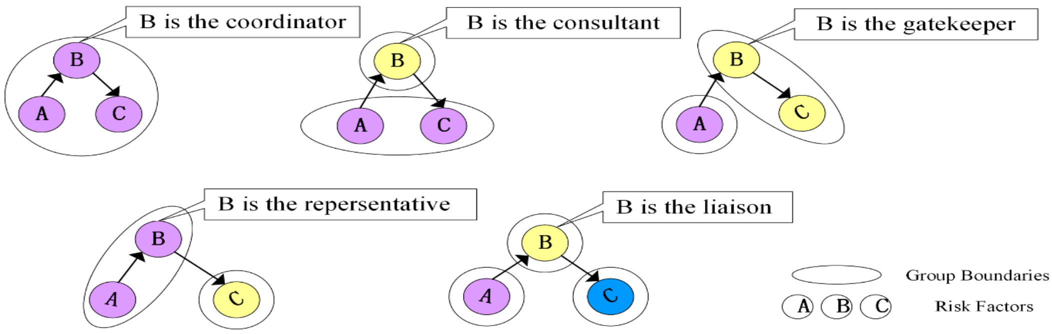

Figure 12. Role of different 'influencers' in mitigating risks associated with hydropower projects and their theoretical sphere of influence.

Commencing with the MRC, dam owner(s) and Lao government, we will hold key informant interviews to unpack the social networks associated with the decision-making process for each hydropower project including stakeholder identification, classification, influence, and overall ability to facilitate solutions. This will require a triangulated 'snowballing' strategy to understand the network of 'actors' and 'stakeholders' at various project stages. All data will be disaggregated by gender and social status to better-understand biases in the power dynamics of influential partnerships and allow GEDSI-based analyses. The general idea is to test cause-effect relationships related to decision making at key stages of the design and construct process.

The general approach will require:

1. Ranking; to demonstrate the importance and performance of relationships among stakeholders
2. Path analysis; to validate the relationships and cooperation among stakeholders at various stages
3. Social network analysis (SNA); to determine the simultaneous influence of key stakeholders in a multiple stakeholder environment.

As each construction project is essentially a combination of social interaction and collaboration, SNA is being increasingly applied into the stakeholder research in construction management discipline, where resources flow among network members through inter-organizational linking which is constrained by the network structure. Essentially, this will enable us to determine who is making key decisions, when, and why – as these will be the key stakeholders that the outcomes of EoPO1 and EoPO2 need to be communicated to. The learnings from the research into fish ecology/passage (EoPO 1) and socio-economic dimensions (EoPO 2) will inform the strategies to support stakeholder engagement and attain project outcomes and impacts across spatial and temporal scales, and stakeholder groups. A context-specific and tailored knowledge management system (that can be applied across countries and contexts) will then be developed to ensure continued policy uptake and adoption of project outcomes following project completion. Such analysis has never been completed before in the Mekong and may explain why the current approach to hydropower development is somewhat isolated, disparate and project specific.

EoPO 4: Capacity building (capacity building and knowledge brokering approach)

Rationale

Sustainable hydropower is quite a technical field. It is very difficult to explain concepts using theoretical means, and it is far more effective involving staff in on-ground research in a 'learning by doing' environment. Consequently, it is expected that the SNA will yield a list of key capacity requirements of stakeholders associated with hydropower projects. These key requirements will underpin targeted capacity building activities implemented through a capacity building through research (CBTR) approach. We need to ensure that the technical data (EoPO 1 and EoPO 2) is transferred to the most appropriate and influential stakeholders (EoPO 3) through targeted knowledge brokering and capacity building (EoPO 4).

Approach

We envisage this may comprise three levels of training:

1. **Formally recognised international courses.** In preparation for this project, Charles Sturt University has approved, for entry from second semester 2020, a Graduate Certificate in Fisheries Conservation. This has been developed as an in-kind contribution and will be specifically targeted as a training opportunity for international staff from developing countries. The course comprises two core subjects (BIO 403 – Fisheries Conservation and BIO 405 – Fish Movement and Management). Fish movement and management (BIO405) has been based on course material which was developed as part of FIS/2014/041 – Crawford Fund Masterclass in Fish Passage Engineering (Baumgartner et al. 2019). The course has been designed to comprise four subjects with intensive residential schools, meaning it can be taken 6 months full time (four subjects per semester), or 12 months part time (two subjects per semester). The curriculum for this course is flexible and bespoke. The content could be adjusted for a hydropower-focused cohort. We will enrol key staff, from each partner country, into this course to facilitate training and development over the course of the next four years. It will be impossible to export significant numbers of students for overseas training in Australia. So, this training will focus on university academics and mid-high-level officials based within fisheries and energy departments, with adequate English skills and Bachelor-level training. The focus will be on training graduates with potential to be future decision and policy makers.
2. **Targeted and specific short courses.** A key outcome from previous ACIAR investments (FIS/2014/041) was to develop a masterclass in 'Fish Passage Engineering'. The course is focused on in-country learning. It is targeted at in-country fisheries and engineering staff (at the federal, district and provincial level). It is taught by a series of international experts in fish passage and has a practical focus. Each student works in a team equally comprised of engineers and fish biologists and over the course of four days, they are required to develop a working concept for a fish pass at a real-world structure. They then develop a research and monitoring program to measure success. The course has been delivered in both Bangkok (to 60 high level professionals from all Mekong countries) and in Myanmar (to federal, district and provincial level staff). The outcomes of these courses have led to on-ground fish passage implementation in a range of Lower Mekong countries, including Myanmar, Lao PDR, Thailand and Cambodia. An outcome of the co-design workshop was to establish a 'Sustainable Hydropower' masterclass, which could focus on optimising fisheries solutions.

3. **National University of Laos Curriculum Improvement.** A key discussion point at the co-design workshop was that the existing course offerings at the National university of Laos (the major education institution in Lao PDR) does not have any subject offerings for hydropower nor sustainable hydropower. The Lao government officials suggested that this would be a useful focus of any extended project to ensure that future generations of managers and technical staff seeking an interest in the hydropower industry would be able to gain a grounding in based concepts relevant to sustainability in the industry.

Analysis

The research aspect of this component is important. There are existing frameworks in place to track career trajectories of Alumni following training activities. For (1) and (2) we will apply a system analogous to the Australia Award Alumni Tracer Facility. The Australia Award Tracer performs annual research which:

- conducts an Annual Survey, with online and telephone collection of the views and experiences of Alumni from a range of countries;
- identifies a series of case-studies, involving in-depth interviews with Alumni, employers and other stakeholders;
- collects and updates contact information for Alumni.

For the duration of our project, we will maintain contact with training Alumni and investigate benefits that have accrued. We will hold annual structured surveys which focus on understanding elements like (i) retention of technical information, (ii) technical involvement in development bank projects which have incorporated fish passage, (iii) development of new projects incorporating fish passage, and (iv) extension of training outcomes to other staff and a qualitative assessment of benefits. We will also poll graduates on the learning outcomes to ensure that the course remains fit-for-purpose and industry relevant. Key success (and failure) stories will be highlighted as case studies in our annual and final reporting processes.

2.3 Gender & Social Inclusion Strategy

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong Riverbank in Xayaburi and Luang Prabang provinces. Seven of these villages have required relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects, and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP must enhance the quality of life for the project-affected people (PAPs) and minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

The degree to which other power developers have developed such action plans is unknown but will presumably be uncovered during social network analyses.

Taking a twin-track approach to GEDSI

Development practice acknowledges that GEDSI strategies are more effective when they adopt a 'twin-track' approach (DFAT 2016). This means progressing opportunities for <u>mainstreaming</u> consideration of GEDSI across all components of a project, alongside <u>targeted</u> GEDSI activities that concentrate resources and seek new knowledge to address the underlying causes of exclusion or disparities. Targeted interventions typically generate analysis and evidence, and new partnerships and networks that can benefit the overall project. ACIAR and DFAT recommend a twin-track approach in their GEDSI policy guidance.

The proposed project will incorporate GEDSI considerations right from the outset of its co-design phase, and align with the ACIAR 'Gender Equity and Social Inclusion (GESI) Strategy and Action Plan 2022–2027'.

In particular, the proposed project team recognises that although women are highly active in fishing and marketing activities – engineering, and to a lesser extent fisheries management, are traditionally male-dominated fields (noting that this is a global trend and not just within SE Asia). Yet, women who often catch fish are the ones who prepare the fish for domestic consumption and to sell at the market. Training on safe fish handling for these objectives could enhance the nutritional quality and commercial price of the fish, while lowering the likelihood of food poisoning or unnecessary wastage.

The FIS/2023/133 team will enhance opportunities for women by:

- endeavouring to ensure equal participation of men/women in project meetings and discussions (including representative groups)
- engaging women-only training events for existing experts and students, which will be conceived in collaboration with line-agencies
- incorporating gender sensitive analysis and training into the project (especially SNA and village surveys) to ensure that the roles of both men and women are captured, and by allowing the space for both men and women to make appropriate, informed and targeted policies through gender appropriate activities
- seeking to increase the participation of women in strategic decision-making roles shaping governance and policy development.

These actions will be crucial to achieving sustainable project outcomes, and equitable, diverse and inclusive input from both women and men. It is pivotal that this knowledge is used to inform policies and strategies moving forward.

The project team has been actively working in Lao PDR for over fifteen years. Therefore, the gender inclusion strategy is largely derived from (a) our lived experience working and living in the region, (b) outcomes of structured interviews convened in association with existing projects, and (c) feedback on our proposal from reviewers. The team has also been investigating broader elements of inclusivity by including disability groups.

There are high incidences of unexploded ordnance injuries in the Lower Mekong Basin, and disability groups have been established to better-cater for the needs of impacted people. Our initial stakeholder mapping activities have identified a number of these groups that we will need to involve in the co-design process.

Nonetheless, a GEDSI advisor will be appointed, and the implementation team will consider these additional initiatives as part of project design to ensure GEDSI is integrated into all levels of activity implementation. As part of the FishTech (FIS/2018/153) initiative, under the advice of a gender advisor, the team has developed and endorsed principles to make explicit a range of GEDSI values and actions. We will apply a similar mechanism to the current project because the GEDSI considerations (of hydropower and irrigation development) are relatively similar in terms of their impacts on fisheries and fish-dependent livelihoods. During the co-design phase, a gender specialist will work with the team to adopt and adapt this approach for the context of this proposed project.

2.4 Capacity building strategy

The need for this project primarily arose because Lower Mekong partners were seeking advice and skills from international professionals with demonstrated expertise in fish passage and in fisheries monitoring using novel techniques (FIS/2017/017). Project EoPO 4 was specifically designed to enhance capacity in key hydropower development stakeholders so that they can make more informed decisions around hydropower planning and implementation.

Other partners and agencies in the region have recognised the value of the information generated from FIS/2017/017 and the demand for knowledge has grown. Despite the need, there are no systemic ‘sustainable hydropower’ capacity building programs being implemented. This project aims to create a platform for such a strategically orientated program of skill development across influencing actors.

The project team will initially conduct Menti surveys to assess the nature of the skills and/or capacity problem and the institutional environment in which the project will operate.

- The team will also assess the 'critical mass' in terms of training needs and key skill requirements to achieve institutional capacity, by employing systematic approaches like institutional motivation-ability (MOTA) analysis.
- These findings will be used to co-design capacity-building programs with the project partners.
- The co-design approach will be critical to assist with cultivating project partners' ownership of, and commitment to, the capacity building agenda.
- Upon running these capacity building programs, the team will conduct further Menti surveys to review the appropriateness of the skills and/or capacity building approaches, and make changes where necessary.

The project team's capacity building approach will be tailored to strategically enhance capacity in four key stakeholders:

Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are employed to implement research and monitoring on site. FIS/2017/017 partnered with this team and built their capacity for fish collecting, tagging, tagged fish monitoring and data analysis of fish passage. This team will broaden its responsibility for generating scientific data to inform dam operations at the new dam site at Luang Prabang.

The project will build the technical capacity of the XPCL (and research personnel in the Laos government) through peer-to-peer learning with the Australian research team, and via a range of appropriate skills development approaches, such as on-site training, online training videos (as developed during COVID-19), and workshops.

Educational institutions

A recurring discussion with universities in partner countries is their limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach, resulting in poor learning outcomes for graduates. This issue has largely arisen because academics (lecturers) have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. In response to this capacity gap, we will focus on educating these lecturers and researchers by delivering a master program through CSU (as done in FIS/2017/017 for fish pass design courses targeted at engineers in government and in donor agencies). We anticipate that, over the longer-term, some will potentially take up an international PhD (via CSU scholarships or the Australia Award platform).

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop CSU's newly developed Master's program on fish pass design. Our project team members will then help build capacity (1) through support in designing curriculums in the tertiary sector; (2) by holding targeted faculty masterclasses in Lao PDR and implementing research projects focusing on sustainable hydropower; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host Masters' students as part of the on-site project team. These local students, and their embeddedness within our project team, will be an important capacity-building strategy.

Government departments

A flow-on effect from poor educational institution capacity is that graduates entering the public sector have a poor capacity to effectively engage with fish passage issues in their professional life as public servants. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, there is little historical institutional capacity and no mentoring opportunities for graduates. This results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the contemporary approaches and learnings on fish passage in a hands-on way. Staff will be trained on-site at dam locations both in Lao PDR and Australia. The second approach will be targeted and opportunistic, by focusing on the most promising graduates within Lao PDR educational settings and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

Other developers

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity of, many developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this proactively by building on our trusted relationship with the Ministry of Energy and Mines, whilst engaging with key developers in the region as required. The MEM and hydropower developers both play key roles in influencing the decision making for dam designs. We have a highly effective masterclass approach to training such stakeholders. This has led to direct outcomes for fish passage design in their institutions when they return and apply their learnings to the dam construction projects under consideration.

2.5 Knowledge exchange strategy

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team, which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and developers
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool, which could be applied across the Lower Mekong Basin
- Capacity building of developers into sustainable hydropower practices
- Training of Lao and Thai scientists and managers.

The project outputs will include:

- Publications in high-ranking journals; the team anticipates ;
  (a) Modelling numbers of refresh fish for PIT tagging required in long-term fish migration monitoring programs

(b) Behaviour of Mekong River fish when approaching a hydropower plant (swimming depts, movement types, etc).
c) The effectiveness of downstream fish migration facilities at a large dam in a tropical river
(d) Improved turbine design criteria for Mekong fish species and fish friendly turbines in the LMB
(e) Social network analysis of hydropower stakeholders in the Lower Mekong Basin
(f) Socio-economic factors associated with dam construction in the Lower Mekong Basin

- A project final report
- Abstracts published in conference proceedings
- A series of online instructional videos
- Submitted manuscripts based on the findings
- Minutes and action plans formulated by the project advisory reference group
- Final report to ACIAR.

Intellectual property and other regulatory compliance

The key stakeholders and end-users of the knowledge generated through this project will consist of the XPCL, educational institutions (e.g. NUOL and CSU), government departments and other hydropower dam developers.

XPCL, educational institutions and government departments will be engaged during the project inception stage, while the project is being co-designed.

Other developers will be engaged later during the project at targeted knowledge exchange events.

Table 4. Success indicators linked to the long-term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Develop guidelines for acoustic or radio tracking at LMB HPP Revised criteria for fish friendly turbine pressure changes based on Mekong species tolerances Methodology for assessing downstream migration by fish at a large tropical river dam	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	Criteria accepted by MRC and used by other HPD (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Sensor fish trials Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified in upstream and downstream directions Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

2.6 Research activities, approaches, and outputs

EoPO 1

No.	Activity		Output(s)	Milestone date of output(s)
1.1	Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions		Data and knowledge to inform fish-friendly hydropower development	2024 - 2027
	Approach	Fish pass monitoring at Xayaburi Dam in upstream and downstream directions Acoustic fish tracking above and below Xayaburi Dam Monitoring fish that pass through turbines, the spillway, the downstream fish pass channel or the navigation lock at Xayaburi Dam Modelling limits of tolerance of Mekong fish species to changes in pressure, blade strike and fluid shear stress hydropower plants		
	Risks/Assumptions	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
1.2	Collect data/evidence on fisheries mitigation measures from existing sies (KG1)		Manuscripts on (1) Mekong fish species behaviour at HPP, (2) PIT tag refresh rates required for Mekong species to maintaining statistically robust tagged populations (3) limits of tolerance in Mekong fish species to pressure changes and shear stress (4) Improved criteria for fish friendly turbines and spillways at LMB HPP (5) Attractiveness (% of migrating fish that find) of the upstream fish ladder and downstream fish pass at a large tropical HPP.	2024-2027
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		

EoPO 2

No.	Activity		Output(s)	Milestone date of output(s)
2.1	Research to understand socio-economic impacts of dam & fish pass operations at Xayaburi & LP		Data and knowledge to inform socio-economically responsible hydropower development	2024-2028
	Approach	Social surveys and interactions with local communities		
	Risks/Assumptions	Access to local villagers is possible Developers agree to surveys taking place Human ethics committee permission is obtained Laos government approves, and facilitates, access to villagers		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
2.2.1	Research activities generate data/evidence on the community impacts of hydropower developments (KG2)		Manuscripts on community impacts of hydropower developments	2024-2028
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		
2.2.2	Data is disaggregated & analysed via a GEDSI twin-track approach (KG2)		Manuscripts on GEDSI implications of hydropower developments	2024-2029
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		

EoPO 3

No.	Activity		Output(s)	Milestone date of output(s)
3.1	GEDSI disaggregated data on stakeholder influence for each hydropower project, & to track power & influence		Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	2025-2029
	Approach	Stakeholder mapping and key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers		
	Risks/Assumptions	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared		
	Application of outputs	Identify key stakeholders for effective information dissemination Share insights with stakeholders to influence hydropower development agenda		
3.2	Influential stakeholders become engaged in contributing to formal & informal frameworks that embed best practice fish passage in hydropower developments (KG3)		Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	2025-2029
	Approach	Stakeholder mapping and key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers		
	Risks/Assumptions	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared		
	Application of outputs	Forge collaborative partnerships with stakeholders, shaping development strategies in line with governmental and regional priorities Developers are connected with researchers		

EoPO 4

No.	Activity		Output(s)	Milestone date of output(s)
4.1.1	Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of project outcomes beyond the life of the project		Knowledge management system	2025-2029
	Approach	Develop a knowledge management system for stakeholders identified in 3.1.		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange		
4.1.2	Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Deliver capacity building activities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		
4.2.1	Design & deliver fit for purpose training to build technical expertise on how to achieve fish friendly hydropower development based on value-for-money & socially inclusive impact (KG4)		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Targeted knowledge brokering activities and learning opportunities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		

	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		
4.2.2	Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG4)		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2027-2029
	Approach	Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		

Cross-cutting activities

No.	Activity		Output(s)	Milestone date of output(s)
5.1	Approvals to commence		Exa MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement
	Approach	Obtain approvals to commence from relevant stakeholders		
	Risks/Assumptions	Salaries and travel secured for Australian partners		
	Application of outputs	Establish the project team		
5.2	Continue PIT tagging more fish in the wild		Increased numbers of PIT tagged fish in the Mekong	Ongoing

	Approach	Continue PIT tagging more fish in the wild using the e-fishing boat		
	Risks/Assumptions	E-fishing boat is operating without issue		
	Application of outputs	Build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements models).		
5.3	Update and exchange knowledge with other groups		Sharing of key learnings Minutes from meetings	Opportunistically
	Approach	Liaise with MRC and other interested groups where work overlaps		
	Risks/Assumptions	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
5.4	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2025
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.5	Hold annual team meeting		Annual team meeting minutes	April 2025
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.6	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2025
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		

	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.7	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2026
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.8	Hold annual team meeting		Annual team meeting minutes	April 2026
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.9	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2026
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.10	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2027
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.11	Hold annual team meeting		Annual team meeting minutes	April 2027

	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.12	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2027
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.13	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2028
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.14	Hold annual team meeting		Annual team meeting minutes	April 2028
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.15	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2028
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		

	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.16	Final reporting		Final project report to ACIAR and DFAT	June 2029
	Approach	Final project report delivered in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Overview of final project results/outcomes and final report is accepted		
5.17	Hold project final review meeting		Meeting minutes	June 2029
	Approach	Key team members and project stakeholders meet to review final project outcomes and report		
	Risks/Assumptions	Key members can attend, and all milestones are completed		
	Application of outputs	Confirm that project has been satisfactorily completed and recommended changes made to final report		
5.18	Final manuscripts		Published papers	June 2029
	Approach	Complete and submit final manuscripts to target journals		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination of key findings to the scientific community		

3. Project management

3.1 Project performance and monitoring plan

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes foundational and intermediate activities, which take the activities and break them down into manageable sub-activities. Each activites has been included includes into the logframe (Figure 8) with defined impact pathways.

Medium-term cycles

The yearly reports and a forum will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place, which will include a facilitated lessons learned workshop, and a written final report.

Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large-scale impacts will accrue with time and may extend beyond the project funding envelope.

3.2 Management aspects

Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Under the contract terms of the first phase of research (FIS/2017/017), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated that the panel meet on an annual basis, at the dam site. The Project Reference Panel has advisory status and consists of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited, Ministry of Energy and Mining, plus representation of Lao nationals (Figure 2).

They conduct their business in confidence, which will be defined by a term of reference established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly funded data must be openly available according to ACIAR's contractual requirements, and that that some IP will be required to remain commercial-in-confidence.

Mid- and final-project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR 'mid-project review' (after 24 months) and 'end-of-project review' processes.

Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Lao PDR dating back over ten years). The team will communicate regularly:

- Through face-to-face meetings, on ground and in country visits and networking
- Using Internal information-sharing and communication strategies
- Through bi-annual face-to-face planning workshops
- By developing workplans for achieving each of the four EoPO's
- Holding regular work in progress meetings leveraging a full range of technology
- By documenting and distributing meeting minutes and action items
- Through routine monitoring and status reporting of deliverables
- Through the development of instructional videos and manuals as reference items.

Project coordination mechanisms and responsibilities

Project coordination will be undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Gulbali Institute, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations. Finally, each agency will have a nominated 'leader' who will coordinate activities and partnerships with the agency. Dr Oudom Phonekhampheng will represent the National University of Lao PDR, and Bounsong Vongvichthit will represent Living Aquatic Resources Research Centre. These officers will take on local leadership roles (including managing resourcing and project management) to ensure the project team can effectively operate within local frameworks.

3.2 Avoiding harm

The project will seek to extrapolate and adopt the principles and guidelines of International Organisation for Standardization (ISO) 31000:2018 Risk Management. Detailed risk mapping will be undertaken at the inception meeting. The main aspects of the project will be identified and related to:

- Risk mapping based on previous projects and outcomes in Lao PDR (since institutional frameworks and expectations are well-known to the project team from prior projects)
- A risk management strategy, with defined risks, treatments and mitigation measures, for each key project milestone/activity

- A routine audit of and assurance on activities, which will form a key part of project measurement and evaluation by ensuring that anticipated activities are tracking as expected
- Regular communication and sound project management.

Animal research undertaken in Lao PDR is governed by the provisions of Animal Care and Ethics under Australian Law.

Therefore, the project team will apply for, and maintain, appropriate Animal Care Authorities for the duration of the project to cover all planned animal research.

Any fish research will also be in accordance with the requirements of relevant legislation (i.e. the Environment Protection and Biodiversity Conservation Act 1999, The Australian Code for the Responsible Conduct of Research (2018), and The Australian Code for The Care and Use of Animals for Scientific Purposes 8th edition (2013)).

Likewise, all human research will be conducted in accordance with The National Statement on Ethical Conduct in Human Research (2007)—Updated 2018.

3.3 Data management plan

Research Data Management (RDM) is a recommendation of the Australian Code for Responsible Conduct of Research. To ensure Charles Sturt University researchers follow good RDM practice, Charles Sturt has established an RDM policy. This policy requires all active research projects (whether funded externally or not) to have a RDM Plan which follows a standard template, and that all researchers generating research data must perform compulsory training. The RDM Plan will be provided to ACIAR upon completion.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support. The data sharing and publication arrangements therefore need to be carefully considered, discussed, and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

In terms of ACIAR good management principles:

Findable: CSU will have cloud-based systems established for most data management. Social science data will be managed, and coded, within NVivo. Both PIT tag, and acoustic tag, data will be stored in the Cloud-based database *FishNet,* which is backed up, reliable and robust.

Accessible: Access to NVivo and FishNet is managed at a user-level. Users can be added and deleted by KarlTek Pty Ltd. We suggest that the project advisory reference group be appointed as the team that manages access.

Interoperable: The cloud-based databases can be accessed via and operating system platform from any location globally provided there is an internet connection.

Re-Usable: The databases have a set of pre-defined '*Queries'* which allow 'clickable' reports to be generated by the user at any time. The reports update whenever new data is added to the database making the data re-usable indefinitely.

3.4 Intellectual property and other regulatory compliance

CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties.

An intellectual property register will be established at the beginning of the project in accordance with ACIAR's requirements. The register will encompass foreground, background and third-party intellectual property, and will include details on proprietary materials, techniques; and other contracts, licenses or legal arrangements.

In addition, the Mid-Term Review will include a review of the use of Background IP in the project to date and any Project IP that is in development and likely to lead to IP that is protectable. The Mid-Term Review team will be tasked with recommending to ACIAR whether additional actions, beyond that defined in the Standard Conditions, are required to clearly define ownership and/or public access to Project IP, that has been funded by Australian taxpayers.

4. Resourcing

4.1 Project team and partnerships

Name	Gender	Organisation	Discipline	[redacted]
Prof. Lee Baumgartner	M	CSU	Professor in hydropower/ fisheries/ river management	[redacted]
Dr Wayne Robinson	M	CSU	Biometrician and hydropower/ fisheries/ river management	[redacted]
Dr Nathan Ning	M	CSU	Aquatic ecology and hydropower/ fisheries/ river management	[redacted]
Mr Tisi Tukuniu	M	CSU	Project co-ordination and management	[redacted]
Social scientist	F	TBD		[redacted]
Knowledge broker	M or F	TBD		[redacted]
Miss Mia Urbano	F	Alinea International	GEDSI-appropriate participatory research	[redacted]
Mr Karl Pomorin	M	KarlTek Pty Ltd	PIT tag system installation and management	[redacted]

FOI Act s. 47f

				[redacted]
Mr Garry Thorncraft	M	National University of Laos	Hydropower/ fisheries/ river management and fish passage expert	[redacted]
Dr Oudom Phonekhampheng	M	National University of Laos	Fisheries/ river management	[redacted]
Dr Bounsong Vongvichthit	M	Living Aquatic Resources Research Centre	Fisheries/ river management	[redacted]
Mrs Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Fisheries/ river management and social dimensions	[redacted]

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				[redacted]
Mr Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental engineering and hydropower	
Dr Michael Raeder	M	Xayaburi Power Company	Engineering and hydropower development	
Lamphone Dimmanivong	M	Ministry of Energy and Mines	Department of Planning Division	

The hydropower development space is a politically challenging environment. It takes time (years) to establish relationships, trust, and demonstrate an ability to deliver on research outcomes. The FIS/2017/017 project developed trust and a highly productive working relationship among partners. The project team currently includes a private-public partnership team that now has an established track record and positive reputation in the region.

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies involved have the scientific and financial capabilities to successfully complete an international collaboration. Specifically:

Charles Sturt University: Has a long history with ACIAR and in working in the SE Asian region and will lead the project. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. CSU has extensive experience with PIT system data analysis and installations. We also have extensive experience with social research. There are no other universities in Australia with such extensive experience and networks for fishway design and monitoring.

Xayaburi Power Company: Owns and operates the hydropower projects (Xayaburi and Luang Prabang, the latter of which is currently under construction). They will own the facilities for the next 30 years under a concession agreement. Their fish monitoring researchers will partner with the CSU team to conduct on-site project activities.

KarlTek Pty Ltd: Is a Melbourne-based, 100% Australian owned and operated company that provides PIT tag-based solutions to a wide range of wildlife monitoring applications. Set up the PIT database for Xayaburi and will continue to manage this PIT database and advise on any new PIT installation works at the new dam site. Has >20 years of experience in PIT installation projects and successfully completed the installation and database management work for the preceding Xayaburi projects.

National University of Laos (NUoL) and Living Aquatic Resources Research Centre (LARReC – a centre within the Ministry of Forestry and Agriculture): Will both assist with in-country project co-ordination, field work and project delivery.

NUoL: Is the primary university in Lao PDR. Has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum.

LARReC: Is the leading institute in aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Ministry of Energy and Mines (MEM): Currently the only agency with an outward facing discussion with all proponents of mainstem hydropower dams. Their role is to review and approve dam projects.

New team members: We will be seeking new skills in the team; policy decision making research and analysis; knowledge brokering expertise, community engagement and GEDSI-appropriate participatory research and capacity building activities.

4.2 Collaboration

The team will collaborate with additional entities who are involved in achieving optimal fish passage outcomes at LMB mainstem hydropower developments. This will require us to work more closely with the Lao Minister of Energy and Mines (than in the past). It will also require us to work in collaboration with individual companies involved in dam funding and development. Both these actors are engaged in dam design decision making for planned hydropower projects.

The team will need to engage the Mekong River Commission more strategically, so their hydropower guidelines and recommendations are updated to include new knowledge generated through this project.

Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

A panel was developed for the previous project (FIS/2017/017) to oversee and guide the project team. This governance structure proved to work very well, so the same structure will be applied to this proposed project for continuity of knowledge and learnings. We will continue to support the existing panel, which has representative stakeholders from all cash/in-kind investors including Charles Sturt University, DFAT, ACIAR, XPCL plus representation of Lao nationals and independent experts. The panel members each have >10 years' experience each in their respective fields. They will conduct their business in confidence and review their current terms of reference at the project initiation phase.

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	
John Dore	M	Department of Foreign Affairs and Trade	Water Specialist	Reference panel member	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	
TBD	TBD	ACIAR	Fisheries RPM	Reference panel member	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required. Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

4.4 Budget Required

[redacted]	TOTAL
	[redacted]
	$5,700,000

* This figure includes ACIAR's 10% Management Fee (red figures). ; ACIAR is providing $733k for bridging 2017/017 to new project start date.

Draft full budget required, including partner payments, to be administered by the commissioned organisation to deliver the work as scoped:

[redacted]	TOTAL
	[redacted]
	$5,700,000

Budget assumes a start date of July 2024. In-kind contributions from CSU, partner agencies and XPCL will be significant but will be determined during Phase 1 preparation.

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4.3 Budget justification

Charles Sturt University

Salaries: [redacted]. A key learning from the co-design workshop was that many of the project staff have been active now for almost 20 years. There is a need for succession planning. We therefore seek to recruit a junior social scientist (ideally specialising in Social Network Analysis) to work exclusively on EoPO 2 and 3. Also seeking to recruit a knowledge broker (ideally specialising in hydropower matters to extend knowledge from EoPO1 and EoPO2 to key stakeholders). It is essential that these staff can spend significant amounts of time, in-country, to connect with stakeholders. Finally, seeking support to cover the costs of the advisory reference panel, especially externally funded experts. This will ensure we have a robust and well-resourced project team with capacity to meet the needs of ACIAR/DFAT and the stakeholders we are trying to reach.

Research operating: Research consumables (each year across the four EoPO's); plus office consumables to assist with project running. Seeking support to develop/publish reports, briefs, posters, infographics and other dissemination materials (especially bilingual outputs). Including an allocation for developing educational materials needed for EoPO4 when short-courses and masterclasses are developers for stakeholders).

Travel: Allocated to cover advisory reference panel expenses (annual meetings in the region); with a specific allocation for a mid-term review; fieldwork at Xayaburi/Luang Prabang each year with additional support for social surveys and social network analyses. Allocated a specific amount to cover participation in final project review.

Capital: Seeking computers for project staff along with field tablets to record social survey information, an iPhone for remote fieldwork and printer to support the project team.

Infrastructure: CSU has a compulsory infrastructure levy of 25% but will discount to 13% as per ACIAR guidelines.

National University of Laos

Salaries: [redacted] This is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together and is also connected to MRC, government and developers.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs of the NUOL team. Boat hire and equipment use for remote fieldwork. There is a need for hatchery consumables for fish husbandry and long-term field trials. Have also included support for masterclasses and education materials as NUOL are the main in-country partner for education outcomes and will co-design and implement on ground knowledge brokering and capacity building.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1 and EoPO 2. Provision made for mid-term review and final project review.

Capital: Included moderate provision for ICT equipment (Year 1).

Infrastructure: National University of Laos sets the infrastructure recovery at 10%.

Living Aquatic Resources Research Centre

Salaries: Mr Douangkham Singhanouvong [redacted] an emeritus researcher but is a critical liaison point for the Lao government. He will continue his key role, on a part-time basis in his retirement. [redacted] As with NUOL, this is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs. LARReC will be organise the mid-term and end of project review and so provision has been made for these important workshops. Hatchery consumables are included to support fish husbandry and other field expenses.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1 and EoPO 2. Provision made for mid-term review and final project review.

Capital: LARReC purchased a vehicle to cover the ACIAR-suite of work in 2006. It has not been replaced since. The vehicle has been depreciated beyond its effective life and is overdue for replacement. Seeking an allocation. Also included moderate provision for ICT equipment (Year 1).

Infrastructure: LARReC sets the infrastructure recovery at 10% (which is mandated by its head institution, NAFRI).

Ministry of Energy and Mines

Salaries: [redacted]

Research operating: Included a consumables provision to cover expenses whilst assisting with fieldwork.

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: Provision for a laptop from project staff.

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Infrastructure: MEM sets the infrastructure recovery at 10%.

Xayaburi Power Company Limited

Salaries: Xayaburi Power Company Limited will provide four staff members, based on site, who will collaborate with the team and contribute to fieldwork. [redacted]

Research operating: Access to a boat, operating of the fish research facility, maintenance and expansion of the PIT system, including procurement of an acoustic system, will be covered as a cash contribution.

Travel: Any travel-related costs for XPCL staff will be borne by the company. Staff visiting XPCL-controlled sites will be provided with accommodation by XPCL.

Capital: XPCL will purchase any significant equipment and plant needed for the project.

Infrastructure: N/A. XPCL will not be receiving any funds.

4.4 Additional resourcing requirements

The FIS/2017/017 project was based on the premise that the Charles Sturt University team would source their salary and travel, and developers would cover all required equipment. This agreement will extend into the new project and so significant in-kind is provided from hydropower developers. CSU will also make contributions to Masters' courses, student stipends and masterclasses as needed throughout the project.

FIS successfully facilitated, through Clear Horizons Consulting, a co-design process for project logic and a theory of change framework that culminated in a Monitoring-Evaluation-Learning plan for the FishTech project. The project team would see great benefit in extending this approach to the project development phase of FIS/2023/133 should this proposal be accepted.

DFAT and ACIAR also implemented a MSA between the Australian and Lao governments, which acted as a template for the project team to operate in a complex political environment. This included the establishment of a project reference panel to oversee and guide the project. Renegotiating this MSA, and maintaining support for the project reference panel, will be critical.

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Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to
[redacted]

Administrative details

[redacted]

Plant or animal germplasm exchange

[redacted]

If 'yes' to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

[redacted]

Proprietary materials, techniques and information

[redacted]

'Data' means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical expertise and information reduced to material form by that Party. If 'yes' to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If 'yes' to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

Project, background and third-party Intellectual Property

This includes but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Project IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Project IP (IP that is expected to be developed during the project)

The following material is to be developed as part of the Project:

[redacted]

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If 'yes', for each applicable country provide brief details.

[redacted]

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Appendix B: Project variations

Variations to the project after commissioning should be documented in this section

Variation 1.

Variation Date	Purpose	
Example date	Brief explanation of purpose for variation	
Changes (omissions, substitutions, inclusions)	i.	Page 8, line 16-18. - **Omitted line**: '…*example*…' - **Substituted line**: '…example…'
	ii.	Page 9, line 12. - **Included line**: '...example...'
	iii.	
	iv.	
	v.	
	vi.	
	vii.	
	viii.	
	ix.	

Australian Government

Australian Centre for International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/017 v1
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organization, collaborating institution(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavors to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Project Variation

[redacted]

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Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/017
Project title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Proposal stage	Full Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/09/2019
Proposed finish date	[redacted]

Key contacts

Activity leader: Commissioned agent

Title and name	Dr Lee Baumgartner
Position	Associate Research Professor (Fisheries and River Management)
Organisation	Charles Sturt University
Phone	[redacted]
Fax	N/A
Email	[redacted]
Postal address	[redacted]
Street address (if different to postal)	[redacted]

Administrative contact: Commissioned agent

Title and name	Dr Jason White
Position	Director – Research Office
Organisation	Charles Sturt University
Phone	[redacted]
Fax	N/A
Email	[redacted]
Postal address	[redacted]

Collaborating scientist: Australian collaborating organisation

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Title and name	Karl Pomorin
Position	Managing Director
Organisation	KarlTek Pty Ltd
Phone	[redacted]
Fax	N/A
Email	[redacted]
Postal address	
Street address	[redacted]

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Collaborating scientist: partner country collaborating organisation

Title and name	Mr Douangkham Singhanouvong
Position	Deputy Director
Organisation	Living Aquatic Resources Research Center (Lao PDR)
Phone	[redacted]
Email	[redacted]
Postal address	[redacted]
Street address	[redacted]

Collaborating scientist: partner country collaborating organisation

Title and name	Dr Oudom Phonekhampheng
Position	Vice President,
Organisation	National University of Laos
Phone	[redacted]
Email	[redacted]
Postal address	[redacted]
Street address	[redacted]

Collaborating scientist: partner country collaborating organisation

Title and name	Dr Michael Raeder
Position	Owners Representative
Organisation	Xayaburi Power Company Limited
Phone	[redacted]
Email	[redacted]
Street address (Lao PDR)	[redacted]
Other address (Thailand)	[redacted]

Collaborating partner: DFAT, Australian High Commission, Lao PDR

Title and name	~~Mr Dominique Vigie~~ Rhonda Mann
Position	Manager – Greater Mekong Water Resources Program
Organisation	Department of Foreign Affairs and Trade
Phone	[redacted]
Email	[redacted]
Street address (Lao PDR)	[redacted]
Other address (Postal)	[redacted]

Contents

1 Project Summary

1.1 Background and Justification

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupts access to vital spawning, nursery and feeding habitat. The LMB fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, will be operational in 2019. Xayaburi Dam blocks the entire width of the river, presenting an impassable barrier to all fish species. Significant investment (US$300M) to provide for fish passage was incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world. Nevertheless, the facilities need to be rigorously assessed to determine if they meet the design specifications.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. The dam design includes a series of 70 different moveable gates which can be configured to alter fish pass flow in order to improve passage rates for specific species and/or specific seasonal flows. The project team will be able to, within the funding envelope on offer, adaptively alter the configuration of the fishway and determine if different settings alter passage rates for particular fish species and their life stages, and for different seasonal flow rates. This will provide XPCL with operational recommendations to optimise the performance of their facilities overall. This represents a substantial challenge and the question of whether the fish passage facilities will be effective in allowing a large proportion of fish numbers and species to pass is a question that the developer, Government of Lao PDR and scientists are all keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential to be developed in regions where poor people are dependent on natural resources. The Xayaburi facilities provide an opportunity to design and commence experiments to test the efficiency of the fish passage design, and to apply/adapt learnings to other sites.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods that will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and *in situ*. These trials will be used to install a functional tag detection system which will be used. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust approaches to calculating fish pass efficiency. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Assess upstream fish passage within the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the 30-year concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). The overall project budget, excluding the SRA commitment, is split between three cash contributors [redacted] XPCL are providing an estimated $560,617, as significant additional in-kind support over the three year time frame.

FOI Act s. 47

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defendable, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used to improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its support or publication of results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to other sites, for example, both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities and monitoring programs. The research methods developed here may lead to a new set of standards that can be applied at other sites.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams) (Commission 2010). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB (Hortle 2007, Baumgartner et al. 2016). Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein (ICEM 2010). Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction (Amornsakchai et al. 2000). The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade (Commission 2010), there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong’s productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB (Orr et al. 2012). All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing a productive river fishery. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 95% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. This work was done by a US company and did not involve Australian expertise. XPCL has invested US$300 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America (Williams 2008), but where investment only targets salmon species. XPCL invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site. The purpose was to exchange information especially in relation to possible future

research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.2 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households (Hortle 2007). Most rural Asian citizens are actively involved in inland capture fisheries and river, and fishery health is crucial to securing food and income for local communities (Dugan et al. 2006, Millar et al. 2018). The Xayaburi Dam was expected to have a potential impact on upstream food resources; which is why a fish pass is being constructed. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It will also address an important planning need across the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development (Dugan et al. 2006). Irrigation development has negatively impacted inland fisheries (Dudgeon 2000). This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating positive outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing (Siason et al. 2010). Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has brought together an international team of private, developmental and governmental sectors to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to develop methods which will be available to quantify fisheries migration studies into the future.

2.3 Relationship to other ACIAR investments and other donor and partner-country activities

2.3.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (Australian Government AusAID 2012). By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies if the fish pass is effective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising female professionals to use the newly established research infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining robust fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome 'Agriculture, Fisheries and Water'. Hydropower development is one of the most significant water management issues in the LMB; and Xayaburi Dam, being the first site, is of particular significance and international interest. This project has been initially established as a four-year initiative with cash funding provided by [redacted] Additional in-kind was provided (in terms of FOI Act s. 47 salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due in December 2019. To maintain continuity for project staff, the large follow-on project must commence in August 2019.

2.3.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in researching the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies on all aspects of fish passage (upstream and downstream). XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.4 Research questions

2.4.1 Xayaburi fishpass overview

Specific design parameters were incorporated into the dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Fig. 1). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a ‘gallery’ toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) ‘choose’ to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

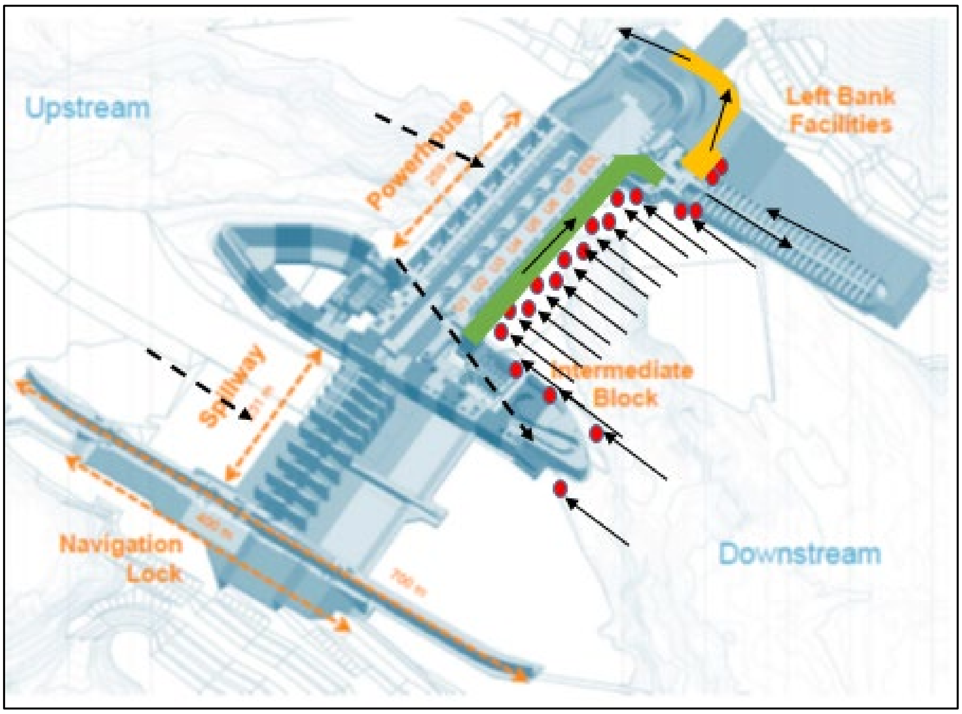


Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

2.4.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

2.4.3 Request from XPCL: Final selection of Research Questions

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, is beyond the scope of the available budget so the ACIAR/DFAT team is only focusing on methods to assess upstream fish passage at this stage. Consequently, the research questions posed are:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

2.4.4 Previous work on fish species selection for passage

There have been a number of fish studies done in the region of the dam as part of the environmental approval process, as well as earlier studies – in both the published and grey literature. These have generated a list of 308 potential adult species in the region, many of which are migratory.

Part of the GoL conditions of approval was that XPCL are required to provide for migratory fish to pass through the dam. To ensure the fish passage design catered to the slowest swimming species, FishTek, a British consulting company, performed a series of fish passage trials to identify the swimming abilities of key species. The swimming abilities of the slowest species formed the basis for the final design decisions for the fishway engineering. The GoL and XPCL agreed on a list of 26 potential migratory adult species (Table 2) that were the most important to monitor for effective passage. Their criteria for importance were based on a combination of food security and conservation significance.

XPCL contracted fishermen surveys to identify important species to the local fishers and communities (Team consulting, 2014). Using this study and others done in the region, we have highlighted in Table 2 (in bold) those species considered important for food security for local communities.

Thus, fish species selection in the project will be based on:

i) Those species that have been listed as important to pass through the fish passage by the GoL/XPCL, which includes species important to food security for local communities and conservation significance, and

ii) Those species that can be successfully tagged, released and monitored.

2.5 Gender focus

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong River bank in Xayaburi and Luang Prabang provinces, with seven of these requiring relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP has to enhance the quality of life for the project affected people (PAPs) and to minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Our research team is playing a very small, but important, role within XPCL's community consultation process. Our team will participate within the XPCL monitoring framework. In particular, we will engage with the XPCL consultation framework through our Lao government partners to ensure our decisions about fish species selection in relation to food security are endorsed by locals; including men and women. We also plan to include a Lao national on a project reference panel, so will report to them on our level of engagement with communities and inclusion of gender perspectives on key decisions, particularly regarding species selection.

Consideration of gender within the research team

Our research team consists of XPCL staff, Laos government (LARReC) and university staff (NUOL) and the Australian team. The XPCL monitoring team was selected by the company and staff were allocated to our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately, this has provided a gender structure among the project team which is predominantly male.

Outside the nominated project team in-country, the Australian team strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female Australian honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, but that the team is more balanced.

3 Research strategy and partnerships

3.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass, upstream, large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems.

The logical sequence for the proposed research is to:

1. Perform laboratory and *in situ* trials of three techniques (PIT detection antennas, electrofishing boat and a long-term tagging study) to optimise tag and recapture methods
2. Implement these methods at the dam site

3. Perform real-time monitoring of upstream fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual upstream fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, to report on the daily operation of the fish pass
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. Most of the current knowledge pertaining to the effectiveness of fishway designs has been for temperate species, and/or has come from laboratory-based trials (Mallen-Cooper 1992), whereas very little knowledge has been obtained via *in situ* field-based evaluations (Baumgartner et al. 2012). Indeed, only two *in situ* fishway evaluations have been published thus far in the LMB (Baumgartner et al. 2012, Baumgartner et al. 2018). At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defendable; and
c) When combined, provide an overall picture of upstream fish pass effectiveness.

4.1 Project aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities to move fish upstream.

The project team has been asked to provide advice on optimizing fish passage performance, not to set targets for triggering changes in operational procedures. We will select a subset of the 70 moveable gates within the fish passage design as reference points for fish pass performance. Each of these reference points will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. The results for various species, life stages and times of the year will be used to establish maximum achievable passage rates for each target species. These rates will be used to advise when and what operational changes should be made to the fishway to optimise the fishway's effectiveness for the target species, life stages and/or times of year.

The specific objectives are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

We note that passing fish downstream, including eggs and larvae, is also a significant challenge at the site. However, at this stage the team has only been asked to focus on upstream moving fish through the fish pass facilities. Downstream movement studies are equally important but, at this stage, are beyond the scope of the available budget and

request from XPCL. The team are very experienced with downstream movement work and can consider additions at a later stage if requested and appropriately resourced.

4.2 Research activities, methods and outputs

4.2.1 Monitoring upstream fish movement at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods (Williams 2008). Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters) (Williams 2008). In terms of fish monitoring research, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation, thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field

6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system), but have low overall ongoing running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely (Castro-Santos et al. 1996). At other dam sites world-wide, PIT data is being used to advise daily operations in relation to upstream migration rates. For instance, Bonneville Dam on the Columbia River (USA) has an elaborate set of fish passes and PIT systems (Williams 2008). The PIT systems report daily fish movement rates, both upstream and downstream, to a cloud-based database. Scientists monitor, in real time, passage rates and species arrivals. The PIT systems also report entrance efficiency and percentage passage rates based on pre-calculated algorithms. When different species arrive, or passage rates change, the flow rates through the dam gates or fishway channel are changed to maximise efficiency. These are ways in which PIT data can be used to provide real-time feedback between fish movement efficiency and dam operations.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

<u>Integrity:</u> This is the critical component of any system. A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

<u>Veracity:</u> It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system, a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events.

<u>Reliability:</u> This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency.

In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance (Castro-Santos et al. 1996). They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Selection of fish tracking technologies relevant to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL need to demonstrate through their research and monitoring program that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific upstream fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate fish are moving upstream.

PIT tags were determined to be a suitable technology upon which to base initial trials for upstream migration studies. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully (Castro-Santos et al. 1996, Baumgartner et al. 2010), (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in*

and *ex-situ*. Based on successes at other dam sites internationally (Castro-Santos et al. 1996, Baumgartner et al. 2010), PIT tagging has been identified as the most suitable technique. If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase (18 months): There is the actual testing (offsite) and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation.

(2) Operational Implementation (18 months): Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise the Xayaburi fishway's adjustable settings and integrate fish movement requirements into dam operation management.

4.2.6 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a "high dam" fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA) (Williams 2008). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System (PTAGIS) framework. PTAGIS is a large, spatially integrated upstream fish migration monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is 'pinged' within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement (Downing et al. 2001, Williams 2008).

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass (Barrett and Mallen-Cooper 2006). Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative

benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales) (Barrett and Mallen-Cooper 2006). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to that based on PTAGIS (See https://www.ptagis.org/). With two such systems operating successfully in cascade rivers internationally, and with a cascade proposed for the LMB, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

4.2.7 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a ‘loop’ that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency (K. Pomorin pers. comm.). PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway ‘slots’ to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions. The team have identified research questions that could be answered using a PIT system installed into the slots (of various widths) located along the length of the fish passage (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each is necessary.

Stage 2: Obtain detailed engineering drawings. The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped to identify optimal design configurations.

Stage 3: **Construct prototype antennas and set up ‘in the dry’.** KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions; Figure 2). The antennas, as indicated in the options diagrams over page, will be constructed. The efficiency tests will be performed scientifically. Antennas will be tested for a range of width’s and length’s and two tag sizes will be assessed (23 mm tag and 12mm tag). The 12 mm tag is preferable as it is much smaller and produces a lower “tag burden” on fish. However, it has a smaller read-range

than the 23mm tag. Determining if 12 mm tags will perform efficiently with large antennas is essential. The approach will be to construct and establish each antenna, take five tag readings (each of a 12 mm and 23 mm tag) and record the read distances (in cm). These readings will be plotted to provide an efficiency map for each antenna morphology. This approach is considered world-standard for antenna efficiency tests.

Figure 2. Slots where antennas are proposed to be installed and possible configurations.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the *ex situ* test in stage four in terms of percent number of tagged fish detected (See Table 3 for list of fish passage criteria to be assessed), we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these *in situ* tests will then advise the locations where fixed antennas should be located.

Additionally, and based on *ex situ* testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway. Here we will initially focus on the entrance and exit locations of the fishway. A 'bank' of antennas will be fitted to the entrance slots; a second 'bank' will be fitted to the exit slots.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

4.2.8 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable

because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others) (Thorstad et al. 2013). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

Research activities

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 300 migratory species at the Xayaburi site and at least 26 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Two previous fish studies have been conducted at the site. The first, by “Team Consulting”, and the second by “FishTek”. These studies firstly, quantified the species present on site and, secondly, determined the swimming ability of these species to inform fishway design. These data, along with information from the community consultations as to which species are important food sources, was used to generate a shortlist of potential priority species for fish passage. (Table 2). The fish pass infrastructure was designed specifically to accommodate these species. What is unknown is whether these species are optimal candidates for PIT tagging. It is proposed, to test the efficacy of PIT tagging for each species under laboratory conditions.

Stage 2: Construct a fish hatchery facility to house the wild caught fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction is due for completion in June 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial ACIAR-funded work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish (Grieve et al. 2018a). So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days (Grieve et al. 2018a). However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the batch of tagged fish to inform on fishway operation.

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

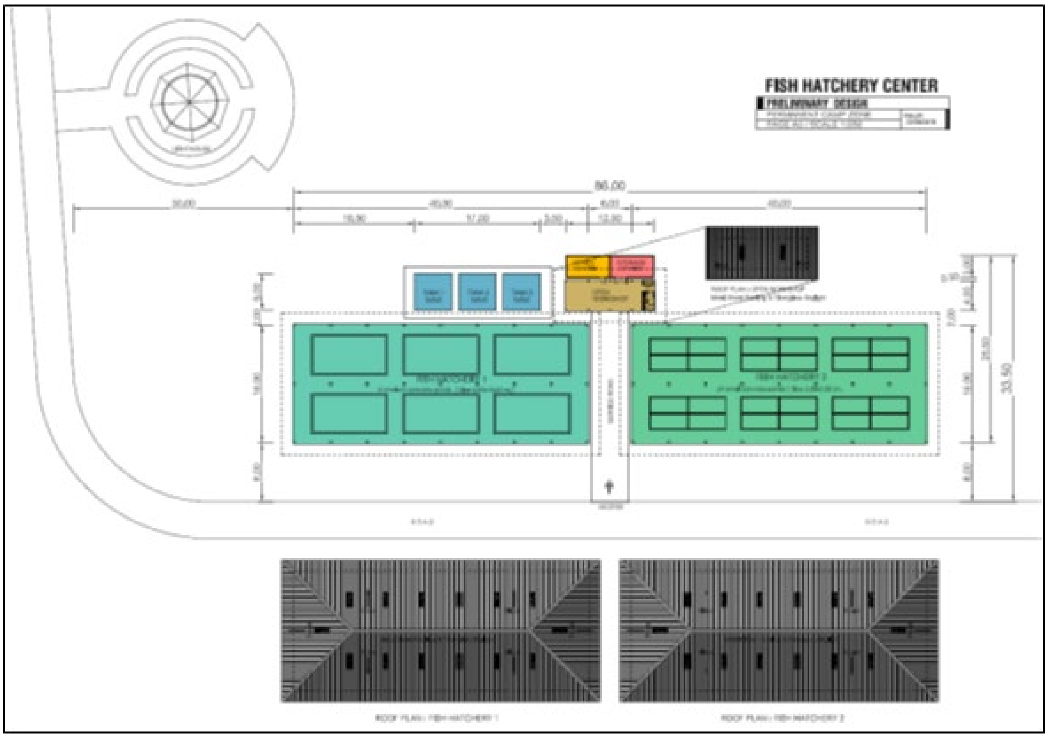
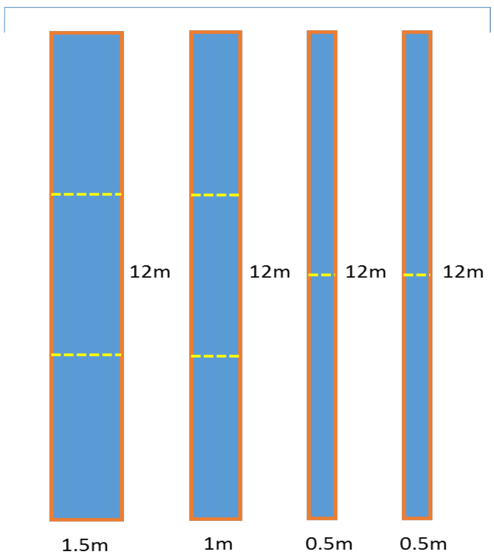


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	Diagram
Maximum predicted number of antennas for each width of fish slot in the fish passage: three antennas for the wider slots (1.5 and 1m), and two for the two narrower slots (0.5 m). antenna fitted into the 12m high fish slots. Number of slots to be fitted = 8.	

4.2.9 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. However, gill netting is a harsh technique that can cause stress and, in extreme cases, impact survival. Tagging a fish that has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish (Sigourney et al. 2005). It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL has provided all funds to purchase the vessel and will allocate contractors to fit out the vessel. This was on the basis that CSU can guide operation and train Lao government, University and XPCL staff in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish (Bohlin et al. 1989). It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival (Burkhardt and Gutreuter 1995). It is widely used in Australia, and Charles Sturt University will run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river; therefore, combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. There are two commonly applied approaches to electrofishing; the "grunt method" and the "power transfer" method.

For the "grunt" method, the boat is started and the voltage settings gradually raised until the generator is significantly working to input electricity into the water. It is the most commonly applied approach in Australia.

For the "power transfer method", the electrofisher settings are optimised to the water conductivity. "Power transfer theory" predicts that electrofishing will be optimised when the conductivity of the fish matches that of the water. As such, voltage and amperage settings can be optimised depending on the water conductivity in order to match, as closely as possible, the target species.

For this research component, we will compare the "grunt" and "power transfer" fishing methods. We will need to firstly determine the "conductivity" of the target species. This is achieved by using a multimeter to measure the conductivity of target fish. Then we will

manipulate the voltage settings of the electrofishing unit (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong. For each electrofishing "shot" all species will be collected, measured and weighed. Statistical analyses will be performed to determine if any differences exist between the two methods.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into the Mekong River Commission Design Guidelines for Mainstem Dams.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

Table 2. List of migratory adult species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Green indicates the upstream migration season and yellow the downstream migration season. Imp column indicates the primary importance of the species whether for food, conservation or income.

Species	Imp	Local name	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Cyclocheilichthys enoplos	F	Pa Joke												
Cyclocheilichthys repasson	F	Pa Joke-sai												
Henicorhynchus lobatus	F	Pa Sroi												
Labeo chrysophekadion	F, I	Pa Pia												
Hemibagrus nemurus	F, C, I	Pa Kod												
Mekongina erythospila	F	Pa Sa-ee												
Sikukia gudgeri	F	Pa Mang												
Chitala sp.	F, I	Pa Tong												
Pangasius macronema	F, C, I	Pa Yorn												
Hemisilurus mekongensis	F, C, I	Pa Dangdaeng												
Phalacronotus apogon	F, I	Pa Sa-ngua												
Bagarius suchus	F, I	Pa Khae												
Paralaubuca typus	F	Pa Teab												
Tenulosa thibaudeaui	F	Pa Mak-pang												
Pangasianodon hypophthalmus	F, C, I	Pa Sway												
Cyprinus carpio carpio	F, I	Pa Nai												
Yasuhikotia modesta	C	Pa Kiaw-Gai												
Macrochirichthys macrochirus	F	Pa Fak-pa												
Pristolepis fasciata	F, C	Pa Chang-yeab												
Pangasius bocourti	F, C, I	Pa Phor												
Pangasius conchophilus	F, C, I	Pa Mong												
Pangasius larnaudii	F, C, I	Pa Thay-po												
Phalacronnotus bleekeri	F, C, I	Pa Sa-ngua												
Wallago attu	F, C, I	Pa Kaow												
Hemibagrus filamentus	F, C, I	Pa Kod-rueng												
Pangasianodon gigas	C	Pa Buek												

4.2.10 Research component 4: Measuring upstream fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study the project team were to use PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations which are all being applied to the work at Xayaburi. So the team are starting from a strong knowledge and experience base.

For application at Xayaburi there is a defined chronological sequence that needs to be completed in order to arrive at this research component. For example, the antennas must be installed, then it will be possible to use the PIT system to determine the overall efficiency of the fish pass. The tag validation trials must have been completed, and we must be able to collect sufficient sample sizes of fish. Some of this is seasonal and some will vary annually. So the proposed species list will need to be revised on an opportunistic basis.

Once all stages are completed, and if the PIT tag system reveals that the fish pass is demonstrated to be sub-optimal (for one or more species), then the dam constructors have incorporated a series of 70 different moveable gates which can be configured to alter fish pass flow in order to determine if improved passage has been achieved. So the project team will be able to adaptively alter the configuration of the fishway and determine if different settings alter passage rates.

It is important to emphasise here that optimal passage rates are difficult to set at this fish pass facility. Our approach will be to record the current rates, seek to understand where design points could be improved and manipulate the adjustable gates to optimise passage rates. So our aim is to achieve a change in percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation (using methods developed in research component 2). Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will shed tags, there will be a need to re-tag fish in every year to maintain a sufficient sized pool of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating at maximum efficiency.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	~~Conclude~~ Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	Covid has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos Assumes that remote training will be effective To minimise risk, training will continue under the instruction of Dr Wayne Robinson (whilst he is based in Laos)	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on Covid-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during Covid travel restrictions	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.7	Project steering committee meeting (May need to be delayed depending on Covid-19)	Hold team meeting on site	Nov 2020 Or pushed into early 2021 if travel restrictions continue	All milestones are met	Project progress is on track

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	~~Aug 2022~~ Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are four main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission and community beneficiaries.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway for upstream migrants.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.

The Mekong River Commission (MRC) is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “Mainstem Dam Hydropower Guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a “Joint Environmental Monitoring Initiative” (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. There is some overlap between the JEM initiative and the proposed research plan. Where overlap exists, then is an opportunity to ensure that so that results can inform the environmental monitoring requirements and standards for future dams. We will also be the first to have trialled many of these technologies on the Mekong. So there is significant interest from the JEM team, where there is obvious mutual interests, to integrate their training of local staff with the technologies being implemented on site. Of prime importance is that the process of fish selection for testing considers the food security needs of impacted communities. The interests of community beneficiaries will be considered by inclusion of a civil society representative on the Advisory Panel.

Project extension and communication

Project extension and communication will be promoted to the extent agreed by project partners, and by the terms negotiated through the reference panel. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam

and it is important research results are presented in a defendable manner. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect these items and is unwilling for the technical details of its product to enter the public domain during the research phase. XPCL also have commercial-in-confidence considerations. With these issues in mind, the project team has entered into a confidentiality arrangement where no public project messaging will be made without the approval of all parties. Thus, extension and outreach will need to be carefully managed throughout project implementation.

4.4.2 Capacity building

Partner countries
Fish passage technology and implementation, as pertaining to hydropower dams, will provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL has a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from our research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Covid has created significant disruptions to international travel. The disruption has restricted access to the Xayaburi site and created additional administrative requirements to obtain permission to gain access. A reduced ability to visit site will place an increasing reliance on remote learning. The team as had discussions with Darren Grigg, a videographer from Grigg media, to develop a series of instructional videos. These will be developed and passed onto Lao-based staff as reference items. These will be important over the short (during Covid restrictions) and long term (if new staff enter the project team).

Australian team
Australian researchers will benefit from involvement in the project. The tropical rivers of South East Asia offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes than they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with future hydropower development activities.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, there is potential to link with the Mekong River Commission's JEM initiative and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Action Plans', which take the activities and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These annual plans are devised before each New Year, and assessed at the end. These Action Plans then inform Progress Reports.

Medium-term cycles

The yearly reports and a forum, will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year, and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program

- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai (XPCL employed) scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) Factors influencing PIT antenna efficiency at high dam fishways
  (b) Tag retention and mortality in key Lower Mekong Basin species
  (c) Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers
  (d) Optimising electrofishing for deployment in the Lower Mekong Basin
- A project final report
- Abstracts published in conference proceedings

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.6 Intellectual property and other regulatory compliance

See Section 7. Appendix A.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site, and the overall fish pass performance has implications at a site, national and international level. Site based impacts relate to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and the development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam’s day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we plan to influence the design and construction of other dams into the future (Figure 5).

Importantly, our team focusing on upstream migration only will limit the extend of applicability to other dams. It is important to note that, if the majority of fish are migrating upstream to recolonize habitat, or to spawn, it follows that these fish may need to move downstream at a later date to complete important life history stages. Focusing on upstream migration, at least initially, effectively mitigates a series of risks because our team is only focusing on one aspect initially. Thus, the political pressure to provide answers to <u>all</u> migration questions is significantly reduced by this focused scope.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The “gold standard” Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs.

Long term (strategic):

1) PIT tagging incorporated into the Mekong River Commission Design Guidelines for Mainstem Dams
2) PIT tag systems installed at other mainstem dam sites
3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key South East Asian economies on a common issue.

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across South East Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

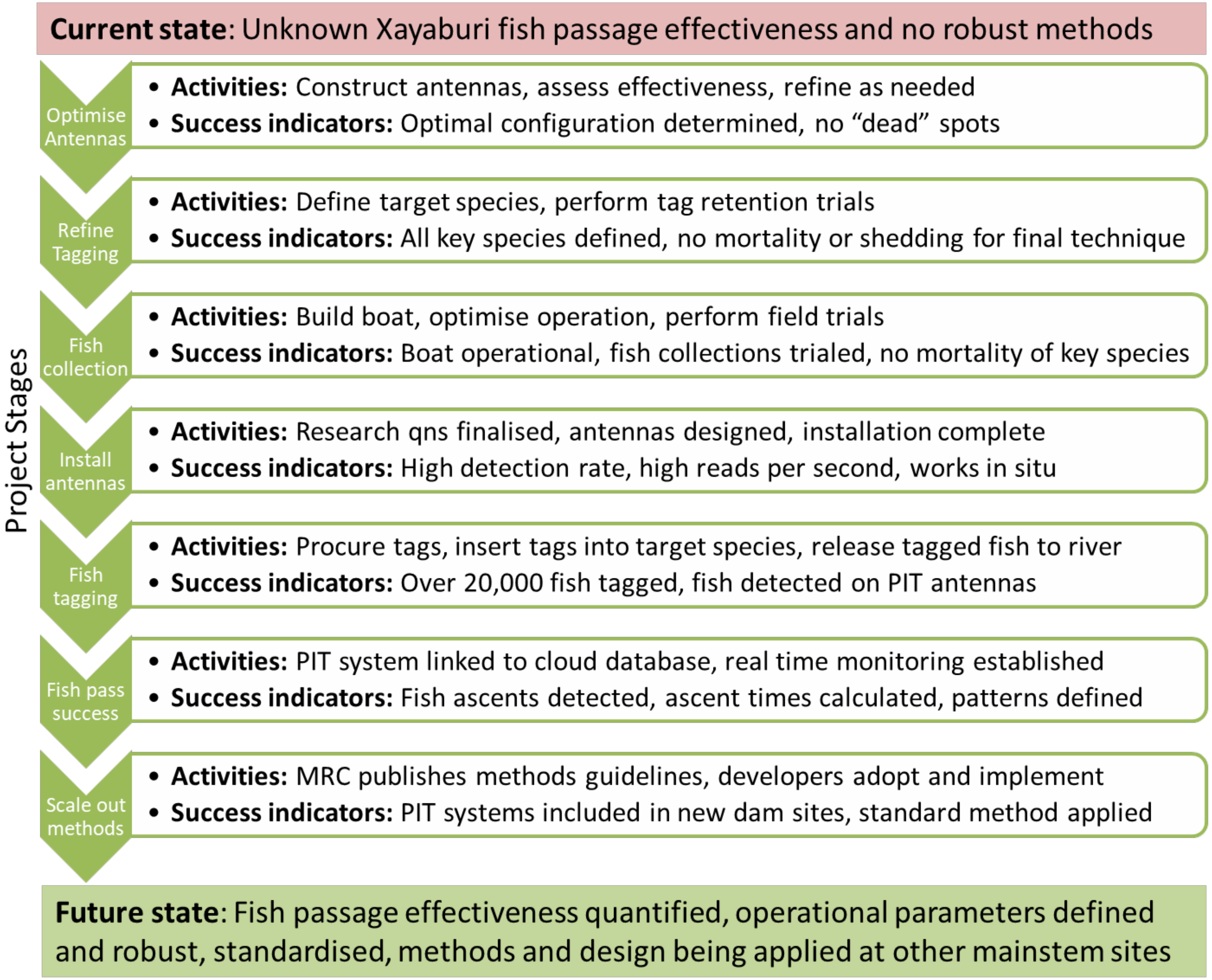


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the LMB and globally. It is important to note that the methods being developed will be applied in the LMB for the first time. Further, the implementation is occurring at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground, but we recognise that there are many assumptions and challenges that may lead to compromised data and outputs. To mitigate this risk, we have consulted with a biostatistician experienced in the Australian hydroelectric research field to advise on how to ensure statistically robust methods in the event of each possible failure point.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring upstream movement using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility for their research and monitoring program, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. <u>PIT tagging</u>: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. <u>Electrofishing:</u> A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating masters students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have conditional approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is imported from outside over the short term and built through a steady stream of learned graduates over the longer term.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hands-on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.4 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by participating in MRC dam guidance discussions and development where appropriate. An important platform for these discussions will be through the reference panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4 Community impacts

The science justifying fish passage implementation is sound (Williams 2008, Baumgartner et al. 2016). Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems. The research impact of this project is within the footprint of the Xayaburi Dam

site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner that can influence these outcomes, particularly through the Advisory Panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards (Commission 2010). The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction cost is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $300M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year (Nam et al. 2015). Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to meet the performance specifications set by the GoL, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region, while recognising the immense technical challenges we face in realising these results.

5.4.2 Social impacts

It is expected that effective fishway construction on mainstem dams will ultimately maintain fisheries productivity, although many technical and operational challenges must be overcome before this is verified through the project. The local benefits to communities from this research are maintained food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls in decision-making (Siason et al. 2010, Baumgartner et al. 2016)

Local communities will directly benefit through unchanged access to fish for food and income if the Xayaburi facilities are demonstrated to work. Nonetheless, if the Xayaburi facilities are demonstrated to not work effectively, this research will be critical to informing XPCL's business decisions about which aspects of the fish pass to target for maximising improvements to triple bottom line outcomes.

Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed and operated, any fish that move upstream through the dam will become accessible to the upstream villages, thus creating an equitable access to the resource. However, there are likely to be considerable negative social impacts as there are numerous unknowns about the design and function of the fish passage infrastructure. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative social impact, considering the reliance of the capture fishery of the LMB for food security and income (Nam et al. 2015). Apart from those adverse effects due to dam construction and forced relocation, is the likely overall reduction, to some extent, in fish passage compared to pre-dam conditions, leading to a reduced abundance and range of fish species accessible to fishers. The project is likely to indirectly improve social benefits by minimising this negative impact - through advice to XPCL on operational management to optimizing fish passage at the Xayaburi Dam, and more broadly to the GoL on standardised tools and protocols for fish tagging and monitoring, and improvements in fish passage design for future hydropower development.

Therefore, demonstrating fish passage functionality through robust research is very important for XPCL to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The Xayaburi fish pass facilities were constructed to ensure fish are able to pass the dam. The overall aim is to demonstrate, through sound operation and integration into dam operations, fish pass effectiveness. The overall aim is to ensure fish communities upstream of the dam do not decline. The flow on effects to livelihoods and nutrition are being measured through the XPCL community program.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the region can be measured by the ability to influence Mekong River Commission mainstem dam guidelines, ensuring new dams include functional fish passes, as well as adopt standard monitoring methods.

6 Project management

6.1 Management aspects

6.1.1 Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be

responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work. A recommendation from these consultations was to establish a Project Reference Panel consisting of the major stakeholders that would be regularly briefed and consulted regarding project progress and outcomes.

Under the contract terms of the first phase of research (the SRA), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated the panel meet on an annual basis, at the dam site.

The Project Reference Panel will have advisory status, and consist of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited plus representation of Lao nationals (Figure 2).

They will conduct their business in confidence which will be defined by a terms of reference will be established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly-funded data must be openly available according to ACIAR’s contractual requirements, and also that that some IP will be required to remain commercial-in-confidence.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. We need to respect that our research team are invited ‘guests’ on the project site. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support.

The data sharing and publication arrangements therefore need to be carefully considered and discussed and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

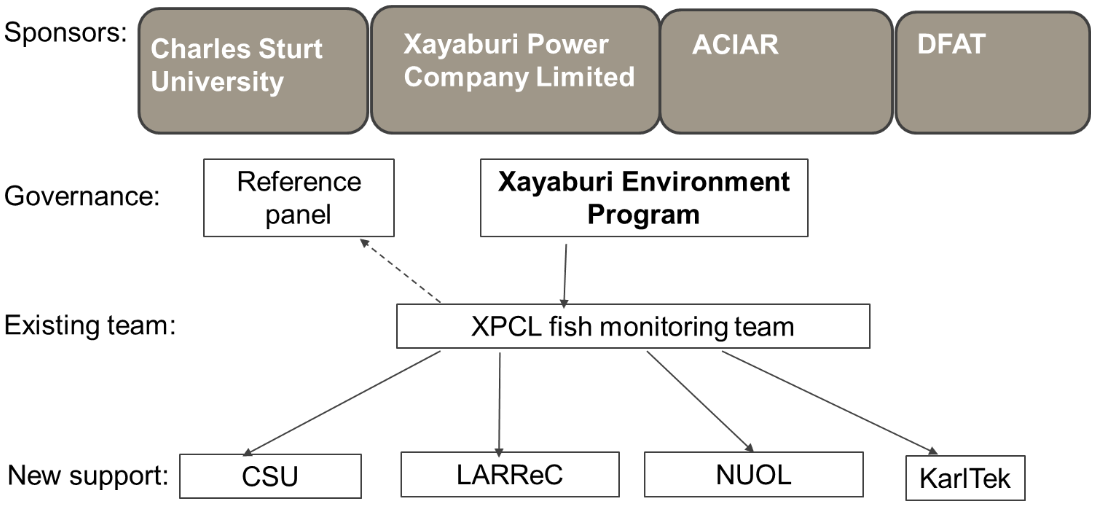


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will integrate within existing governance arrangements.

6.1.2 Mid and final project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR "mid-project review" (after 18 months) and "end of project review" processes.

6.1.4 Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables
- Development of instructional videos and manuals as reference items

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role on-ground in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Douangkham Singhanouvong (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Coordinator and Government rep	
Douangkham Singhanouvong	M	Living Aquatic Resources Research Centre	Deputy Director	Coordinator and Government rep	
Thonglom Phommavong	M	National University of Laos	Research Associate	Collaborating scientists	
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	
Phousone Vorsane	M	National University of Laos	Research Associate	Field technical support	
Saleumphone Chantavong	M	Living Aquatic Resources Research Centre	Research Associate	Field technical support	
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	
Michael Raeder	M	Xayaburi Power	Owner Representative	Owner representative	
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Collaborating Scientist~~	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	
John Dore	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	
Casual Staff	TBA	Charles Sturt University	TBA	Assistance with fieldwork or other project requirements	

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Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Wayne Robinson	M	Charles Sturt University	Research Fellow	Field and biometric support	
Lauren Withers	F	Australian Volunteers	Volunteer	Project support	
Garry Thorncraft	M	National University of Laos	Research Associate	Collaborating Scientist	
Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental Monitoring	Project support	
Jarrod McPherson	M	Charles Sturt University	Research assistant	Field support and coordination	
Nathan Ning	M	Charles Sturt University	Scientist	Manuscript preparation and writing	
Chris Barlow	M	IP Matters	Director	High level support and writing	
Darren Grigg	M	Grigg Media	Videographer	To produce a series of instructional videos on PIT tagging and fish husbandry	

6.3 Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
~~Jürgen Geist~~	~~M~~	~~Technical University of Munich~~	~~Chair of Aquatic Systems and Director of FITHydro initiative~~	~~Reference panel member~~	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	

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Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member	
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Reference panel member~~	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required. FOI Act s. 47

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

6.4 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	[redacted]
Jarrod McPherson Charles Sturt University	[redacted]
Thanasak Poomchaivej Xayaburi Power Company	[redacted]
Dr Michael Raeder Xayaburi Power Company Limited	[redacted]
Garry Thorncraft National University of Laos	[redacted]

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Name	[redacted]
Dr Oudom Phonekhampheng National University of Laos	
Douangkham Sinhanouvong Living Aquatic Resources Research Centre	
Karl Pomorin KarlTek Pty Ltd	
Dr Nathan Ning Charles Sturt University	
Dr Chris Barlow Fish Matters IP	
Lauren Withers (and others) Australian Volunteer	

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Name	[redacted]
Phousone Vorsane (NUOL) and Saleumphone Chantavong (LARReC)	
Thonglom Phommavong (NUOL) Khampheng Homsombath (LARReC)	
Wayne Robinson (CSU)	
Darren Grigg (Grigg Media)	

6.5 Summary details of proposed reference panel participants

Name	[redacted]
Jody Swirepik (chair) Australian Government	
Dr Elizabeth Pope Snowy Hydro	

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Name	[redacted]
~~Prof Jürgen Geist~~ ~~Technical University of Munich~~	
Dr Daniel Deng PNNL	
Dr Michael Raeder XPCL	
Lao citizen representative TBA	
Dr Ann Fleming ACIAR	
Dominique Vigie DFAT	

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6.6 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including

Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR. CSU has extensive experience with PIT system data analysis and installations throughout Australia and has extensively collaborated with researchers and the Australian government on the installation of fish monitoring systems since 2001. There are no other universities in Australia with such extensive experience and networks for fishway monitoring.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (HDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

7 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

7.1 Administrative details

Project ID	FIS/2017/017
Project title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Assessment provider	Lee Baumgartner
If not Australian project leader, provide title	
Date of assessment	~~15th May 2019~~ 17th June 2020

7.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

Does the project involve:	Yes	No
provision of germplasm by Australia to a partner country?		X
provision of germplasm from a partner country to Australia?		X
provision of germplasm from or to an IARC or another organisation and a project participant?		X
use of germplasm from a third party		X
material subject to plant breeders/variety rights in Australia or another country?		X

If "yes" to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	Details of plant or animal germplasm exchange

Proprietary materials, techniques and information

[redacted]

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"Data" means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

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[redacted]

Other agreements

[redacted]

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

7.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

[redacted]

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Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

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Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

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Other contracts, licences or legal arrangements

[redacted]

If "yes", for each applicable country provide brief details.

[redacted]

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Australian Government
Australian Centre for International Agricultural Research

Annual report

project	
project number	FIS-2017-017 Variation 3
period of report	Jan 2022 – April 2023
date due	30 April 2023
date submitted	6th May 2023
prepared by	Nathan Ning and Lee Baumgartner
co-authors/ contributors/ collaborators	Khampheng Homsombath, Douangkham Singhanouvong, LARReC Thanasak Poomchaivej, Michael Raeder, Xayaburi Power Company Limited Oudom Phonekhampheng, Garry Thorncraft, National University of Laos Karl Pomorin, KarlTek Pty Ltd
approved by	Ann Fleming

Contents

1 Progress summary

The Lower Mekong Basin (LMB) is home to the world's most productive inland fishery, but its tributaries are currently being developed for hydropower generation. Indeed, 11 hydropower projects are scheduled for construction on the mainstem of the Mekong River, and many more on its tributaries. Without suitable fish passage consideration, these fish will be hindered from accessing vital feeding, spawning and nursery habitat, and their populations will be greatly reduced or even potentially become locally extinct. The first of these 11 dams at Xayaburi, in Lao PDR, was commissioned in October 2019. Substantial investment was allocated towards restoring fish passage, with the purpose of setting the best-practice standard for future mainstem hydropower developments. So optimising the Xayaburi fish pass facilities is the focus of a significant public-private research program between Australia, Thailand and Lao PDR. The primary objectives of this project are to: (1) develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB; (2) optimise the Xayaburi fish pass facilities; and (3) provide a standard for monitoring and constructing other fish passes in the LMB.

1.1 Research activities

1.1.1 Objective 1: To develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB

<u>PIT antenna design</u>

- The PIT antenna (microchip) system has continued to function well since being established in November 2019.
- A third antenna system (comprised of 7 antennas) was installed and activated upstream of the fish lock on 25 September 2022, to assess passage through the lock as well as the fishway entrance and exit. It was tested upon commissioning and was found to successfully support maximum read distances of more than 40 cm for both 12 mm and 23 mm PIT tags.
- Face-to-face filed trips were resumed in 2022 once Lao PDR's borders re-opened, but the CSU team has continued to also host monthly online meetings with the in-country project members (XPCL, NUOL) to advance project tasks and resolve any issues.

<u>PIT tag retention trials</u>

- Dr Wayne Robinson has continued to coordinate the project from within country, with support from XPCL, NUOL and LARReC.
- Fourteen PIT tag retention/mortality trials have been completed thus far on nine different species/size class combinations.

<u>Electrofishing boat</u>

- The electrofishing boat was operable again for the reporting period and was used to continue the PIT tagging program.

<u>Sensor fish trials and training</u>

- Sensor fish training and study (WR and GT), with visit from an expert turbine engineer from Andritz (Dr Pedro)

1.1.2 Objective 2: To scientifically optimise the Xayaburi fish pass facilities

- The monitoring and evaluation program for the Xayaburi fish pass facilities was initiated in early 2020. More than 3500 microchipped fish (3,651 individual fish, from 37 species as of 22-2-23) have now been released into the Mekong River. Of the tagged and released fish, over 1200 have been detected within the fish pass (see 3.5 for more details), and 1123 (87.1%) of these fish ultimately ascended the fish pass successfully.
- We are continuing to collect data on fish migration and fish pass optimisation.
- We are starting to assess the impact outcomes, using a range of 'success measures', including the number of fish tagged annually, percentage of tagged fish detected, and percentage of fish successfully ascending.
- The data so far suggests that most species are easily ascending the fish pass.

1.1.3 Objective 3: To provide a standard for monitoring and constructing other mainstem fish passes in the Mekong catchment

- There are at least two other mainstem dams, Pak Beng and Pak Lai, which have been scoped and have entered the prior notification/prior consultation period. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.
- Also, the MRC is re-drafting the "Mainstem Dam Hydropower Guidance" document. This is a resource tool that sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a "Joint Environmental Monitoring Initiative" (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway.

1.2 Overall progress

- FIS-2017-017 remains on track to address its end-of-project-outcomes (EOPOs) of (1) developing a robust, and scientifically-defendable, research program, which will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB; (2) ensuring that fish passage is fully integrated into Xayaburi's day-to-day dam operations; and (3) scaling out the learnings from Xayaburi Dam to improve the design of other fish passes at future mainstem dams.
- This is evidenced by (a) the team successfully PIT tagging > 3,500 fish in the river at Xayaburi so far, with a significant detection percentage and many contributing to fish passage information (see the results section of this report); (b) the research protocols developed for PIT detection systems and PIT tagging now being sought after by the MRC (e.g. team members were invited to present at the MRC International conference in April 2023 – see the project publications list); (c) the team being invited by ACIAR and DFAT to submit a proposal for a new 5-year project that would see the learnings from Xayaburi scaled out to the next mainstem damsite at Luang Prabang and other dams.
- In addition, an extension was just granted to the project team to delay the end of the project from 31 December 2022 to 30 June 2024. This variation (Variation 3) will allow the team to both build upon the research done so far (by undertaking new research activities), co-design a critical second stage, and to complete activities that were delayed by disruptions associated with COVID-19. The new research activities will involve co-designing the new 5-year stage of the Xayaburi project; refining and publishing the PIT tagging requirements model; continuing the PIT tagging program to

build up the wild PIT-tagged populations of key species; continuing to engage KarlTek Pty. Ltd. to manage the PIT tag database (FishNet); and participating in the Mekong River Commission international conference in April 2023 (which was just addressed). The COVID-delayed activity will involve publishing the initial key findings from the first stage of the project.


Figure 1: The team assisting with PIT tagging (left) and sensor fish (right) trials at the project site during 2022 (source: Garry Thorncraft).

2 Achievements against project activities and outputs/milestones

2.1 Achievements to date

The project activities of FIS-2017-017 have had to be strictly completed in chronological order, as they have been imposed by sequential timeframes and dependencies on one another. This order has involved initially constructing and optimising the PIT detection system; then undertaking PIT tag retention trials to validate the effectiveness of PIT tagging local species; then developing a safe method for gathering fish from the Mekong River; then PIT tagging the fish and releasing them back into the river; and then monitoring and appraising the PIT tagged fish negotiating the fish pass to optimise the operation of the fish pass. Given the sequential timeframes and interdependencies of the project activities, they and the milestones are presented here in a chronological order (i.e. by year, rather than by objective). The strategic connections to project objectives are still contained in the table to meet project development requirements.

The team has also extended engagement with the Lao government and XPCL through its new project at Luang Prabang. The methodological approaches, many of which attempted in the Mekong for the first time, have generated much interest among government agencies, developers and, more broadly, the MRC (through the Joint Environmental Monitoring program) and scientists. In fact, there has been a significant increase in requests to access the data and for the data to be presented at various regional forums. The team recognise these demands and are now working to publish the data in reputable international journals ahead of planned meetings. This is to ensure the data is defensible and has passed peer review.

Table 1. Progress on project activities.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Completed.

No.	Activity	Outputs/ milestones	Completion date	Comments
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	Completed. Antenna specifications from SRA have been successfully applied to the Xayaburi site. Functional and effective system has been installed. Linked to cloud-based database to maximise user efficiency.
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Completed. Antennas have been operating effectively and efficiently since being commissioned.
1.4	Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	Completed. Fourteen PIT tag retention trials have been undertaken so far.
1.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunistically	In progress. CSU has nearly completed its involvement in the JEM project. This project has been testing the effectiveness and efficiency of acoustic tagging and PIT tagging around the Don Sahong hydropower dam near Khone Falls.
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	DEVIATION FROM PLANNED ACTIVITY: Cancelled due to site closure associated with a regal visit by the Thai Princess. Meeting deferred to 2021. Not COVID-related.
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Completed. XPCL/Lao staff have been successfully trained in electrofishing and can operate the boat independently now.

No.	Activity	Outputs/ milestones	Completion date	Comments
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	Ongoing. Variation funding by ACIAR provided an opportunity to develop a series of instructional videos with an expert videographer. The variation funding also permitted Dr Wayne Robinson, to work on the project. He visited the site four times during the COVID lockdown, and enabled this work to progress efficiently.

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Annual reporting	Annual reporting to DFAT	March 2021	Completed. Annual report was shifted to December 2020 to enable reporting on any COVID-delays. Successfully accepted as per ACIAR contracting conditions.
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on COVID-restrictions)	Meeting on site	Nov 2020	DEVIATION FROM PLANNED ACTIVITY: Was shifted into a virtual mode and deferred to early 2021 during the Pandemic, and used to progress a Pandemic plan. The meeting was effective in gaining strong participation and engagement (as evidenced by the meeting participant list and minutes).
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	Completed successfully; but also being refined as the project advances. Not impacted by COVID.

No.	Activity	Outputs/ milestones	Completion date	Comments
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during COVID travel restrictions	Dr Wayne Robinson, along with NUOL and LARReC staff, visited the site every 1-2 months during the period of COVID-related border closures to maintain continuity of field activities. The rest of the team has resumed face-to-face visits now that the borders have re-opened.
2.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunistically	The team has successfully run demonstrations of PIT and acoustic tag use at Don Sahong. The team also participated in a virtual meeting with ministry of energy and mines and DFAT. The meeting was effective in gaining strong participation and engagement (as evidenced by the meeting participant list and minutes).
2.7	Project steering committee meeting (May need to be delayed depending on COVID-19)	Hold team meeting on site	Pushed into early 2021	DEVIATION FROM PLANNED ACTIVITY: Switched to virtual mode whilst travel restrictions were in place. First meeting held and written up. Commitment to discuss disseminating key messages in 2022 and beyond. The meeting was effective in gaining strong participation and engagement (as evidenced by the meeting participant list and minutes).

Year 3 (Sep 2021 – Dec 2022)

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Monitoring and evaluation continues	Regularly reporting project outcomes	Jul–Dec 2021	The electrofishing vessel is now operational again. We were aiming to tag several thousand fish per year and release into the river. So far we have tagged around 3600 fish from 37 species. These fish have been effectively providing robust data on species movement patterns at the damsite.
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	DEVIATION FROM PLANNED ACTIVITY: COVID ended up delaying these papers, so a project extension has been granted until June 2024 to complete them.
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	The annual report was completed on time and accepted. Also, a face-to-face meeting was held with the reference panel in Oct 2022. The meeting was effective in gaining strong engagement (as evidenced by the meeting participant list and minutes).
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	DEVIATION FROM PLANNED ACTIVITY: Travel restrictions were lifted in 2022 and travel has resumed. The final workshop and project review have been delayed because a project extension has granted now until Jun 2024 (see 1.2 for an explanation).

No.	Activity	Outputs/ milestones	Completion date	Comments
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Reporting requirements have continued to be successfully met as per the contracting requirements. An additional annual report was provided in Apr 2023 (this report) in accordance with the project being granted an extension until Jun 2024. The report was structured and formatted to effectively address both ACIAR and DFAT's reporting requirements. This will be the approach for all future reports, as it avoids duplication and is more efficient for the project reporting.
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	Dec 2022	DEVIATION FROM PLANNED ACTIVITY: The final reporting and project review have been delayed because a project extension has granted now until Jun 2024 (see 1.2 for an explanation).

Final 18 months (Jan 2023 – Jun 2024) (Variation 3)

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Plan the next 5-year stage of the Xayaburi project	Face-to-face workshop at XPCL headquarters in Bangkok to co-design the next stage of the Xayaburi project, with XPCL, ACIAR and DFAT. Follow-up online workshops to continue co-designing the project extension.	Feb 2023 Mar 2024	Co-design workshop was successfully run in Bangkok, with strong participation and engagement (as evidenced by the meeting participant lists and minutes). It will set the framework for the project's activities over the next five years.

No.	Activity	Outputs/ milestones	Completion date	Comments
4.2	Publications on key results from first stage of project	Publish the initial key findings from the first stage of the project (there will be at least four papers – (1) antenna design trials, (2) assessing PIT tag retention in Mekong species, (3) modelling the PIT tagging requirements, and 4) assessing the fishway's effectiveness).	Mar 2024	The first publication (on PIT tag trials) is currently being drafted. Key results and messages from Xayaburi will be disseminated to the international scientific community. Learnings can be applied to enhance the ecological sustainability of future Mekong (and beyond) hydropower projects.
4.3	Refine the PIT tagging requirements models	Refine the PIT tagging requirements models, and in particular — the ages of the PIT tagged fish, by undertaking an otolith (fish earbone) aging study.	Mar 2024	TBC. Models will be available for efficiently determining the numbers of key species needing to be PIT tagged to maintain tagged populations in the wild.
4.4	Continue PIT tagging more fish in the wild	Build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements models).	Mar 2024	TBC. Maintenance of high numbers of key species with PIT tags in the wild — allowing for continued statistically robust assessments of fishway effectiveness and efficiency. The team are also building a mathematical model to guide XPCL in terms of how many fish need to be tagged each year to offset natural, fishing and tag shedding losses.

No.	Activity	Outputs/ milestones	Completion date	Comments
4.5	Continue engaging KarlTek Pty. Ltd. to manage the PIT tag database (FishNet)	FishNet maintained so that the fishway's effectiveness can be assessed using the recently installed upstream PIT antenna system (i.e. third antenna system that was installed upstream of the lock in September 2022).	Mar 2024	Allows for continued statistically robust assessments of fishway effectiveness and efficiency.
4.6.	Support ongoing activities of project advisory reference group	Meetings to discuss and agree upon long term direction of project	Mar 2024	Agreement of the reference group on the way forward.
4.7	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	Dec 2022	TBC. Conclusion of project requirements, dissemination of outputs.

2.2 DFAT reporting requirements

1. Establish a Reference Panel

The project reference panel has continued to meet annually, with the following representatives.

Name	Gender	Agency	Position at agency	Project Responsibilities
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member
Daniel Deng	M	Pacific Northwest National Laboratory		Reference panel member
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member
John Dore	M	Australian government (DFAT)	Lead Water Specialist	Reference panel member
Lao citizen representative	F	Lao government or local community	Local	Reference panel member
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member

2. Annual Meeting of Reference Panel

The project reference panel held their first meeting online in early 2021. Minutes were prepared and a subsequent meeting, with a smaller subset of members, was held with the Ministry of Energy and Mines in November 2021.

A face-to-face reference panel meeting was held at the Xayaburi Dam site in October 2022 after the COVID travel restrictions were eased. The main purpose of this meeting was to update the panel with the project's key findings and to gauge the interest of the key stakeholders in supporting an extension and/or additional phase for the Xayaburi research project. All stakeholders confirmed their interest in pursuing an additional phase of up to 5 years.

Another face-to-face meeting was held in February 2023 at XPCL's headquarters in Bangkok. The main purpose of this meeting was to update the key stakeholders on project progress and to co-design, identify remaining knowledge gaps, and to scope another 5-year phase of research. The meeting resulted in a prioritised list of potential knowledge gaps and associated research questions. The team has since used these knowledge gaps and research questions to develop a research concept note for a new 5-year research phase, and submitted it to ACIAR and DFAT for appraisal in March 2023. If the concept note is successful, the team will be invited to submit a full proposal for the new 5-year phase, later this year.

3. Prepare an Annual Report

DFAT requires an Annual Report in March each year. CSU and ACIAR have agreed to prepare these in April each year so that they can be reviewed and submitted in line with the DFAT reporting cycle (which has a due date of April 30). We have also worked with the consultancy, Clear Horizons, to make sure that the ACIAR template additionally addresses DFAT's reporting requirements by including extra reporting sub-sections where required.

2.3 Summary of achievements to date (for ACIAR website)

Project Stories

The Lower Mekong Basin (LMB) is currently being increasingly developed for hydropower generation. There are plans to build eleven hydropower facilities on the mainstem of the Mekong River, and many more on its tributaries. The first mainstem Mekong hydropower facility — at Xayaburi in Lao PDR — has already been built and began operating in October 2019. Significant investment for fish passage was incorporated into the final design of the Xayaburi Dam to minimize its potential impacts on the Mekong fishery. Our project is assessing the effectiveness of the Xayaburi fish pass on the Xayaburi Hydropower Project in Lao PDR and using the learnings to optimise fish pass mitigation measures at subsequent hydropower developments. We have designed and installed a microchip detection system for migrating fish, built and tested the performance of an electrofishing boat to safely collect fish, and commenced a microchipping study to monitor and optimise fish migrations through the fish pass. This is the first time such technology has been applied in the Mekong. The project has already boosted the technical and institutional capacity of in-country scientists, engineers, and managers, so that eventually they will be capable of autonomously monitoring fish movement at the site. A successful system has been installed and is actively scanning for fish. More than 3500 microchipped fish have been released into the Mekong River from 37 species so far. The data is generating significant interest from scientists, managers, developers and government agencies and hopes to influence sustainable outcomes at other projects into the future.

Figure 2: PIT tagging wild caught fish on the Mekong River near Vientiane to augment to the populations of tagged fish in the river (source: unknown). These fish were tagged near Vientiane while the upstream Xayaburi damsite was closed to outsiders during periods of high COVID-case numbers in Lao PDR.

3 Impacts

3.1 Scientific impacts

Scientific advances

The FIS-2017-017 project has continued to enhance our understanding of fish ecology and rehabilitation techniques for restoring fish passage at hydropower projects throughout the LMB. Specifically, it has:

- Developed empirically-tested research techniques and technology for appraising the effectiveness of mainstem hydropower fishways in the LMB (e.g. the PIT antenna design experiments have resulted in an empirically-validated approach for setting up PIT antenna systems on other hydropower projects in the LMB).
- Augmented our knowledge of the migrations of key migratory species in the LMB, through the M&E program.
- Informed the development of a best-practice standard for monitoring and constructing other mainstem fishways in the LMB.
- Generated new knowledge on PIT tag retention and mortality within key Mekong species (see 3.5 for details on the species that have been assessed so far).

Scientific outputs

- A total of nine reports have been produced since FIS-2017-016 started in 2019 (Appendix I). One of these reports was produced in 2022–23.
- Five papers are being prepared for publication in international journals (with a sixth as a possibility) to scientifically validate the new techniques and technology being developed (Appendix II). Three of these are being led by Thanasak Poomchaivej (the Fisheries Team leader at XPCL), as part of his PhD and in partnership with the CSU team as his PhD supervisors.

3.2 Capacity impacts

The team's other ACIAR projects (FIS-2006-183, FIS-2009-041, FIS-2014-041, FIS-2018-153) have been successful in already improving capacity in Lao government officials and fishery managers, research staff, villagers, and Australian volunteers. Capacity has been improved by engaging each of these stakeholders in various project activities such as fishway construction and operation, fish sampling, and household fishing surveys. Consequently, Lao villagers now understand project benefits at the Pak Peung fishway site, and have adequate knowledge of the experimental methods and fishway hydraulics to operate the fishway independently.

The Xayaburi project aims to continue developing capacity within the team itself; in addition to in other research staff, XPCL staff, fishers, village nibans, students, and fisheries officials in Lao PDR. The project capacity building strategy entails enhancing capacity within:

XPCL

The project team has been primarily working with XPCL to build capacity in two key areas:

1. PIT tagging: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality.

2. Electrofishing: A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia.
3.

Educational institutions

There is currently limited technical capacity to deliver tertiary courses In Lao PDR. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This was discussed at length at the project co-design meeting with the suggestion that sustainable hydropower modules be prepared for National University of Lao courses. This would enable future employees in the hydropower industry, and government line agencies, to better-understand how to gain sustainable outcomes for power generation and healthy rivers.

Government departments

[redacted] FOI Act s. 47

[redacted]Consequently, all learning occurs in an employment context. A self-defeating cycle can result if there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates. This was raised by the Ministry of Energy and Mines at the recent co-design meeting. They would like their employees to have the opportunity to learn about sustainable hydropower. The option to develop a "sustainable hydropower" masterclass or formal undergraduate units was discussed.

Developers and the MRC

Hydropower developers are financing and constructing a suite of new dam projects as part of infrastructure development plans in the Mekong River Basin. Therefore, it will be essential to engage with, and enhance the capacity, of these hydropower developers to ensure that fish passage technologies are widely adopted as part of regional hydropower programs.

Progress for 2022–23:

- CSU staff have continued to mentor XPCL staff in setting up aquaria, general fish husbandry, and conducting PIT tag retention trials. This was done face-to-face in 2020 prior to the COVID-19 pandemic; via online meetings while the international borders were closed during the COVID-19 pandemic; and has returned to face-to-face since the borders re-opened in 2022. More than 3500 fish have been tagged and released so far (see 1.1).
- The in-country staff (XPCL and NUoL) staff were given applied training in PIT antenna design and construction while they assisted with installation of the third antenna system upstream of the lock, in September 2022 (see 1.1).
- The in-country staff were also trained in the use of Sensor Fish (robotic data logging fish that can assess the hydraulic conditions fish may potentially be exposed to while passing through hydropower turbines) during a field trip in October 2022. The training was provided Dr Daniel Deng (a Pacific Northwest National Laboratory (PNNL) engineer who developed the Sensor Fish) and the CSU team. The in-country staff then assisted in undertaking actual trials to apply their learnings.
- Thanasak Poomchaivej (XPCL), has continued to progress his PhD. He met with his supervisory team (Lee Baumgartner, Wayne Robinson, Nathan Ning and Xiaodi Huang) about starting his data analyses, at CSU in January 2023.

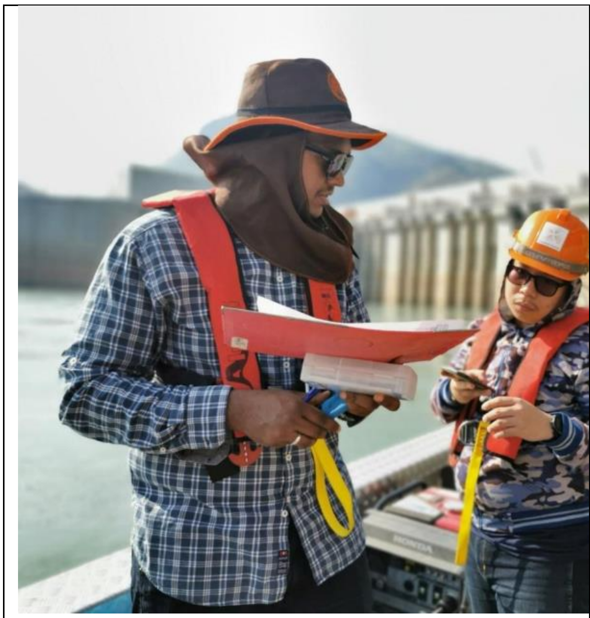


Figure 3: XPCL staff using their electrofishing boat at the Xayaburi damsite (source: unknown).

3.3 Community impacts

3.3.1 Economic impacts

The LMB fishery is estimated to have an annual first-sale value of approximately US$17 billion, and this value is even greater when other related economic benefits are added. Therefore the fishery is vital to supplementing the livelihoods of many southeast Asians, especially those in rural areas. If the fish passage remediation measures at Xayaburi are found to work successfully, they will thwart fishery declines and related negative impacts on the livelihoods of many rural residents in the LMB. Alternatively, if the Xayaburi rehabilitation measures provide sub-optimal fish passage, then the project team will re-focus its research towards improving fish passage by (1) concentrating on adjusting the fish pass's design features, and (2) refining and improving its operational procedures. Those improvements should then be encompassed in engineering designs at subsequent mainstem hydropower projects to optimise outcomes for the fishery.

Progress for 2022–23:

The 1100+ fish recorded ascending the Xayaburi fish pass (see 1.1.2 and 3.5) thus far, will economically benefit upstream fishers, both directly themselves, and by seeding reproduction and therefore additional productivity upstream. Indeed, at least one tagged migratory fish was captured by a fisher 80 km upstream from the study site. XPCL continue to engage with local communities and integrate them into the tagging program. Locals are now looking for tagged fish and receive a cash reward if they provide data.

3.3.2 Social impacts

Fish and other aquatic animals from the LMB fishery are responsible for making up around 50% of the animal protein intake of Lao PDR residents. If the Xayaburi fish pass is proven to work effectively, it will conserve fisheries production, and thereby maintain food security and incomes for fishing families.

Additional likely benefits will include:

Community cohesion:

The construction of a privately-managed asset can incentivise local cohesion. Locals become unified in their objective to see the project succeed, and express their enthusiasm to work on the project. We will emulate the successes of one of the team's preceding ACIAR projects (the Lao PDR fishway project (FIS/2014/041 (Variation 3)) by employing local staff to co-ordinate community co-management meetings and communicate information about the project throughout the community; join workshops; and help with fieldwork. Active participation will be sought from women in addition to men, and considered on a case by case basis by XPCL.

Improved community co-management frameworks:

Floodplain capture fisheries are considered by villagers to be shared resources. Many villages are located within the Xayaburi region, at varying proximities away from the fish pass site. Yet, the community generally considers that all of the villages should benefit equally from the fish pass if it functions as planned. Consequently, once the Xayaburi fish pass is operating, fish should move upstream and become more accessible to the other villages; improving equitability in access to the fishery resource.

Progress for 2022–23:

To date, community engagement with the project has occurred through:

(1) Community members (PAFO office) being involved in training exercises (in February 2020). Local provincial and district fisheries office representatives partook in training activities and learned about the project and its objectives.

(2) XPCL undertaking an ongoing education program with local villages to alert them that some fish may possess microchips and how to manage such situations. These consultations slowed during the COVID-19 pandemic, but have been welcomed by locals.

3.3.3 Environmental impacts

If the fish pass functions as planned, the most likely environmental outcome will be to safeguard the fishery at the Xayaburi site from diminishing, and there will be no adverse environmental impacts on the LMB fishery. The project team will seek to empirically confirm that, through suitable operation and incorporation into hydropower plant operations, the project will not lead to negative environmental outcomes.

Fish passes can yield quantifiable recovery outcomes within 12 months of construction. Quantifiable benefits for short-lived species are expected within 12 months (Category 1), whereas such benefits are expected within 5 years (Category 2) for longer-lived species. The ensuing benefits to livelihoods and nutrition will be quantifiable, and our learnings from the ACIAR Lao PDR fishway project (FIS/2014/041 (Variation 3)) suggest that these timeframes are credible.

Progress for 2022–23:

- The assemblage of released fish found to be ascending the Xayaburi fish pass so far has consisted of nineteen species, demonstrating that a diverse range of Mekong fish have already been able to navigate the fish pass to reach upstream habitats.
- We have been continuing to work with the XPCL team to ensure fish pass operations are optimized by incorporating fish pass data into fish lock operations.
- The recent addition of the third PIT antenna system upstream of the lock will now provide the capacity to determine what percentage of fish are able to ascend the fishway and then get through the lock system.

3.3.4 GEDSI outcomes

The current Xayaburi project has been advancing opportunities for women, by attempting to ensure equal participation of men/women in project meetings and dialogues (including representative groups). It will seek to further augment opportunities for women, as well as for disabled and socially disadvantaged members, by developing and implementing a tailored GEDSI Strategy for the new 5-year project (should it be successful in receiving funding). The GEDSI Strategy will be developed by engaging Alinea International, to enhance project understanding and responsiveness to GEDSI considerations throughout the Xayaburi implementation and research cycle. The GEDSI Strategy will include: GEDSI objectives; context analysis for GEDSI in the Xayaburi project; domains for understanding and monitoring women's empowerment, disability inclusion and ethno-linguistic inclusion; and an action plan prescribing mainstreaming and standalone activities, and associated team member responsibilities. Alinea is already assisting the FishTech team in ensuring that these GEDSI considerations are incorporated into all aspects of the FishTech program logic, and has just drafted a GEDSI plan for that project.

3.4 Communication and dissemination activities

Meetings:

- A face-to-face Reference Panel meeting held at the dam site on 17/10/22, and a co-design meeting was held at XPCL headquarters in Bangkok in February 2023.
- We have also continued holding regular online meetings (approximately every 4–6 weeks) among project team members progress tasks and resolve issues.

Communication and extension activities targeted towards end users:

- CK Power released an online video outlining how the Xayaburi hydropower plant, and the fish pass, operates: https://youtu.be/IslaT7L15x0
- The PIT tagging training videos were translated into three languages (Lao, Vietnamese and Bahasa) and uploaded onto the Crawford Fund You Tube site: https://www.youtube.com/watch?v=adz7tNNoTd8&list=PLvLMhkEc96QGDV0wKNV7hu632x2ZRu5ok
- The Sensor Fish instructional movies have also been shared with the in-country project members (see 1.1).

Hands-on training of fisheries scientists, managers and students in Asia and Australia:

- The hands-on training provided by CSU staff to XPCL and NUOL staff in constructing and operating PIT antenna systems during the September 2022 field trip for installing the third antenna system
- Also, the hands-on training provided by CSU and PNNL staff to XPCL and NUOL staff on using Sensor Fish in October 2022

Publications of scientific reports and manuscripts in high-impact international journals:

- The nine reports produced from the Xayaburi project thus far (Appendix I).

Conference presentations:

- The 5 conference presentations produced so far (Appendix I).

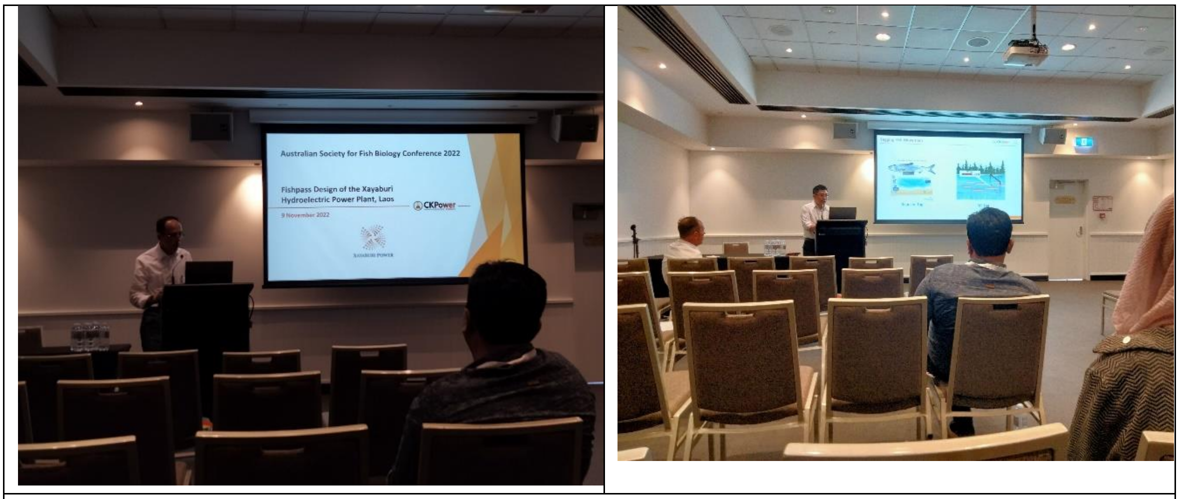


Figure 4: Dr Michael Raedar (left) and Thanasak Poomchaivej (right) presenting results from the Xayaburi project at the ASFB conference on the Gold Coast in November 2022 (source: Nathan Ning).

3.5 Key results so far

3.5.1 PIT tag retention trials

Fourteen PIT tag retention/mortality trials have been completed thus far on nine different species. These trials are focusing on key species to determine whether the tagging process needs to be refined. Ensuring that the tagging does not contribute to mortality, and that the fish do not shed tags, is essential to ensure the veracity of the data collected within the fish pass. Sound experimental design has allowed isolation of cause and effect for the results in every trial. We have thus identified and improved any issues with fish husbandry; as well as any differences in fish health, fish mortality and tag rejection rates associated with the tag insertion techniques, operators, and/or water quality in the experimental tanks.

Table 2. List of species/size combinations used in PIT retention trials to date. Pending = to be completed. ** = one of the five high priority target species for investigation in this project (FishTek performed swimming speed trials on these 'target' species and used the data to help initially design the Xayaburi fish pass).

Species	Key findings
Pa saee (*Mekongina erythrospila*)	Susceptible to increased mortality after tagging
Pa mang (*Sikukia gudgeri*)	Very low mortality rate suitable for tag and release in the field
Pa pak >210 mm (*Hypsibarbus lagleri*)**	Very low mortality rate suitable for tag and release in the field
Pa pak 150 to 210 mm (*Hypsibarbus lagleri*)**	Very low mortality rate suitable for tag and release in the field
Pa pak all sizes (*Hypsibarbus lagleri*)**	Very low mortality rate suitable for tag and release in the field
Pa sway (*Pangasianodon hypophthalmus*)	Difficult to maintain in captivity. Requires better understanding of diet/habits

Species	**Key findings**
Pa kot reung (*Hemibagrus filamentus*)	Low mortality rate suitable for tag and release in the field
Pa sakang (*Puntioplites falcifer*)**	Low mortality rate suitable for tag and release in the field
Pa vien fai (*Barbonymus schwanenfeldii*)	Very low mortality rate suitable for tag and release in the field
Pa pakpian (*Scaphognathops bandanensis*)	Low mortality rate suitable for tag and release in the field
Pa kott (*Hemibagrus nemurus*)**	Pending
Pa ort (*Pangassius elongates*)**	Pending
Pa sroi (*Henicorhynchus lobatus*, *H. siamensis*)**	Pending

There have been notable improvements in the tagging techniques of the local operators as they have become more experienced. For instance, trial's 3, 4 and 5 compared two tagging techniques — scalpel-assisted insertion and syringe-assisted insertion. Both techniques returned similar tag retention and mortality results. Syringe-assisted insertion has been used in all other trials before and since. But we found that some of the operators preferred syringe insertion methods, whilst others preferred scalpels. Several species have proven to be very well suited to PIT tagging (e.g. Pa pak, Pa sakang, Pa viengfai) and are now deemed suitable for large-scale tag and release upon collection in the field.

Some species are either sensitive to tagging or have been difficult to care for in the fish research centre. For instance, one of the migratory species commonly captured at the site, Pa saee (*Mekongina erythrospila*), experiences high mortality from handling and significantly reduced growth rates after tags are inserted. Several trials are trying to resolve these matters, but it could simply be that this species in not suitable for longer term migration trials. It is important to note that this highlights the value of tag retention trials prior to large-scale tagging in the field. Ideally, once fish are tagged and released into the Mekong, they should have a high probability of retaining the tag and surviving. This is the best mechanism to gain high quality data from the PIT system.

Other species have not performed well during the trials. Declines in the health of both control (untagged) and tagged fish suggest that health issues are unrelated to tagging; rather, they are a consequence of the transition from the 'wild' to 'captivity'. Some fish have failed to eat whilst being held in concrete tanks, whilst others have been injuring themselves because a rectangle-shaped tank does not suit their biology. This is new information on these species and will be transferrable to other captive-holding applications beyond this project. For the species which are most affected, the team now have management plans in place, including not being held in captivity or undergoing a feeding trial experiment to ensure good health before being used in future tagging trials.

LARReC staff are also producing natural fish food and transporting it to Xayaburi for the team to trial.

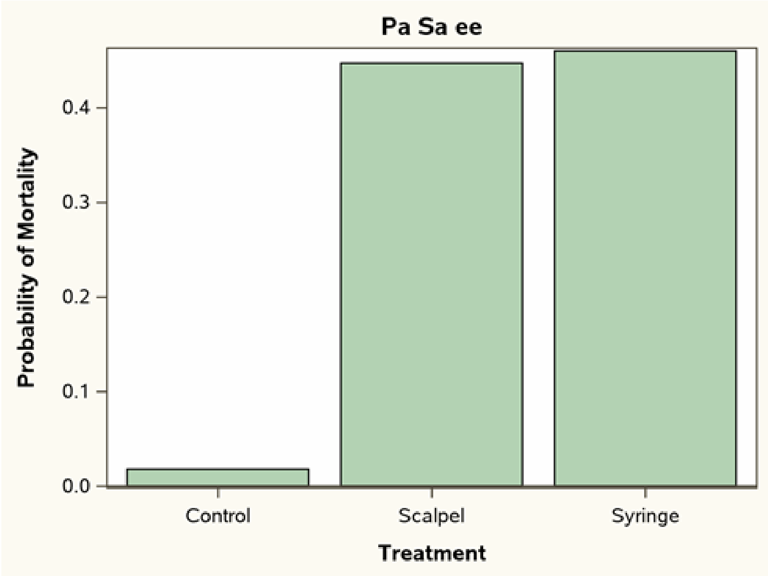


Figure 5. The probability of mortality of Pa saee (*Mekongina erythrospila*) for the three treatments tested in the PIT tag retention trial: scalpel-assisted PIT tag insertion, syringe-assisted PIT tag insertion and control (i.e. no tag). The figure demonstrates that tag insertion by either method resulted in about 40% of fish mortality.

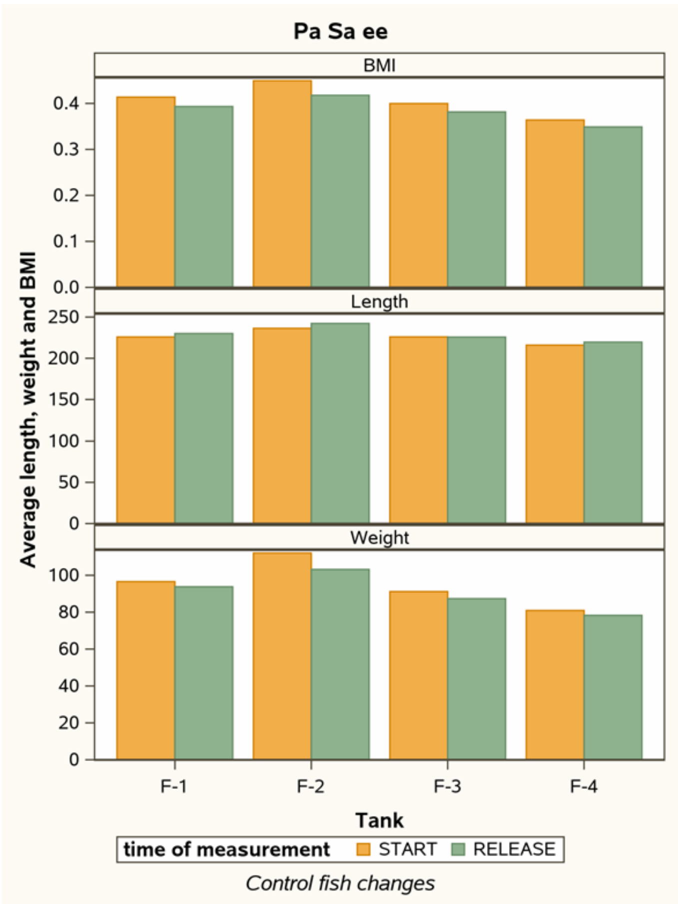


Figure 6. Changes in the length (mm), weight (g) and condition (as assessed by body mass index — BMI) of untagged (i.e. control) Pa saee in each tank (F1–F4), between the start and end (release point) of PIT tag retention trial 3. The declines in weight and body mass index during the trial indicate that even non-tagged fish of this species were not easy to husband in 2020.

3.5.2 Modelling the PIT tagging requirements to maintain the tagged populations

Models were developed to determine how many fish should be PIT tagged each year to maintain a population of fish needed for long term studies. Sufficient populations of PIT-tagged fish should be maintained in the Mekong to generate usable tag data. To calculate the number of fish that need to be tagged each year to maintain the tagged fish populations, three main sources of tag loss need to be considered:

1. Shedding of tags and mortality for the tagging process
    a. Addressed by undertaking PIT tag trials
2. Harvest by anglers
    a. Addressed using the literature/empirical data
3. Natural mortality (age-related)
    a. Addressed using age/length relationship data (literature/empirical) along with the Von Bertalanffy growth function.

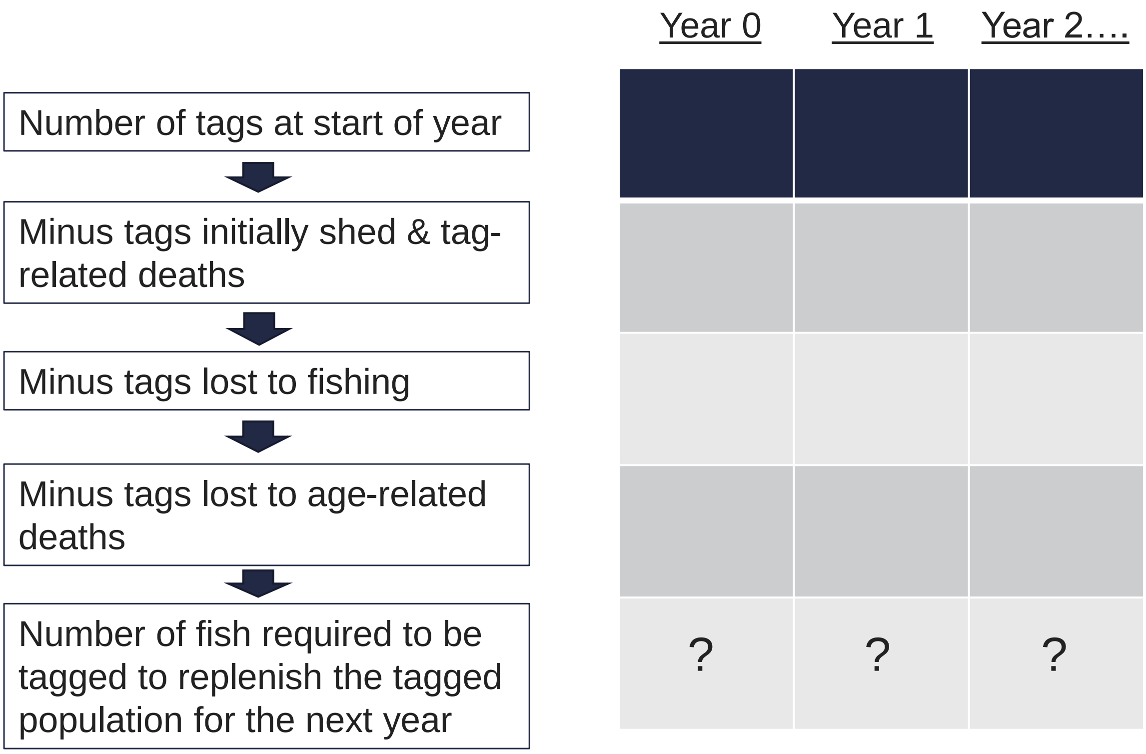


Figure 7. Factors leading to the depletion of PIT tagged fish from a PIT-tagged population in the wild.

For example, if we started with 137 tagged Pa vien fai (*Barbonymus schwanenfeldii*) at the end of 2023 (Year 0) and did not tag any new fish, the tagged population would rapidly be depleted. The table below shows the nature of this population decline.

Table 3. The modelled annual depletion in the number of Pa vien fai (*Barbonymus schwanenfeldii*) PIT tagged individuals if we started with 137 at the end of 2023 (Year 0) and did not tag any new fish.

	2023	2024	2025	2026	2027	2028	2029	2030
Remaining AFTER initial shedding/mortality	132	61	28	13	6	3	1	1
Remaining AFTER angler harvest	66	30	14	7	3	1	1	0
Remaining AFTER natural mortality	61	28	13	6	3	1	1	0
Remaining AFTER fishway migration	??	??	??	??	??	??	??	??

Table 4 models the numbers of Pa vien fai that would have to PIT tagged annually to maintain targets of 137 (Case 1), 500 (Case 2) and 1000 (Case 3) individuals.

Table 4. The numbers of Pa vien fai that would have to PIT tagged each year to maintain targets of 137 (Case 1), 500 (Case 2) and 1000 (Case 3) individuals.

Targets	2022	2023	2024	2025	2026	2027	2028	2029
Pa vien fai (*Barbonymus schwanenfeldii*)								
Case 1: 137	76	75	75	75	75	75	75	75
Case 2: 500	439	277	274	274	274	274	274	274
Case 3: 1000	939	554	547	547	547	547	547	547

3.5.3 Tag release data

To date, 3,651 individual fish, from 37 species, have been tagged and released into the Mekong. Large-scale tagging has commenced, but many tag/releases have still been via the release of surviving fish at the completion of each tag retention trials, and/or by actively tagging and releasing fish into the Mekong on an opportunistic basis. The most released fish have been *Puntioplites falcifer* (Pa sakang) and *Hypsibarbus* spp. (Pa pak). The team have attempted to tag a wide range of fish sizes. The biggest fish so far *Hemibagrus wyckioides* (Pa kheung) was 1150 mm. There has been limited harvest of these larger fish so far. But the team are on standby to tag significantly sized fish (over 1 m), given their overall social and economic value in the Mekong; and that these were a key species size upon which the fish pass was designed.

Table 5. Total number of fish tagged and released into the Mekong since training commenced in February 2020. Maximum and minimum length (mm) of each fish is also given to provide an indication of the size range released so far (* = total as of 22 February 2023).

Common name	Species	Min length (mm)	Max length (mm)	Number
Hypsibarbus	*Hypsibarbus* sp.	145	450	2
Laotian shad	Laotian shad	182	217	2
Pa Bok	*Henicorhynchus siamensis*	120	211	6
Pa Chaun	*Channa striata*	366	366	1
Pa Ern	*Probarbus jullieni*	750	750	2
Pa Joke-gheaw	*Cosmochilus harmandi*	141	523	33
Pa Kae	Pa Kae	140	605	213
Pa Kaeng	*Cirrhinus molitorella*	217	446	32
Pa Kaeng-kong	*Cirrhinus mrigala*	502	637	2
Pa Ka-ho India	Pa Ka-ho India	501	501	1
Pa Ka-Soob	*Hampala macrolepidota*	210	374	4
Pa Khae	Pa Khae	430	600	5
Pa Khae-kwai	Pa Khae-kwai	324	740	12
Pa Kheung	*Hemibagrus wyckioides*	300	1150	13
Pa Ki-lam	*Labiobarbus leptocheilus*	159	235	40
Pa Ki-leung	*Mystacoleucus obtusirostris*	115	163	77
Pa Kob	Pa Kob	595	595	1
Pa Kod-Reung	*Hemibagrus filamentus*	101	484	78
Pa Koh	*Gyrinocheilus pennocki*	156	191	3
Pa Kot Mohr	Pa Kot Mohr	325	325	2
Pa Mang	*Sikukia gudgeri*	14	225	533

Common name	Species	Min length (mm)	Max length (mm)	Number
Pa Naeng Daeng	*Hemisilurus mekongensis*	285	285	1
Pa Nang-daeng	*Hemisilurus mekongensis*	333	351	2
Pa Nuo	Pa Nuo	225	382	11
Pa Pak	*Hypsibarbus* spp.	93	590	972
Pa Pak-Pian	*Scaphognathops bandanensis*	122	345	202
Pa Phia	*Labeo chrysophekadion*	177	650	56
Pa Pung	Pa Pung	285	678	33
Pa Sa-Ee	*Mekongina erythrospila*	18	393	68
Pa Sakang	*Puntioplites falcifer*	103	406	1047
Pa Sanak	*Raiamas guttatus*	200	365	3
Pa Sood-Jam	*Hampala dispar*	210	315	4
Pa Sway	*Pangasianodon hypophthalmus*	285	350	12
Pa Tong	*Chitala ornata*	406	406	1
Pa Vien Fai	*Barbonymus schwanenfeldii*	150	310	145
Pa Vien Fai (Altus)	*Barbonymus altus*	126	242	31
Pa Wa	Pa Wa	465	465	1
		14	**1150**	**3651**

3.5.4 Fish detection data

A PIT detection system has been installed to monitor both the entrance and exit fish-pass baffles. It has been fully active since November 2019. The third antenna system was then installed and activated upstream of the fish lock on 25 September 2022, to assess passage through the lock. Twenty species have been detected by the fish pass PIT system so far (with many of these involving the same fish being detected on multiple occasions). In total, across all 20 species detected, there have been more than 146,715 detections within the fish pass. The detection data is providing an excellent source of continual seasonal movement data. The preliminary data collected so far is showing that some species have defined migration seasons. This will provide significant opportunities for fish pass optimisation into the future because entrance and flow settings could be 'manipulated', in various seasons, to maximise fish passage during peak periods.

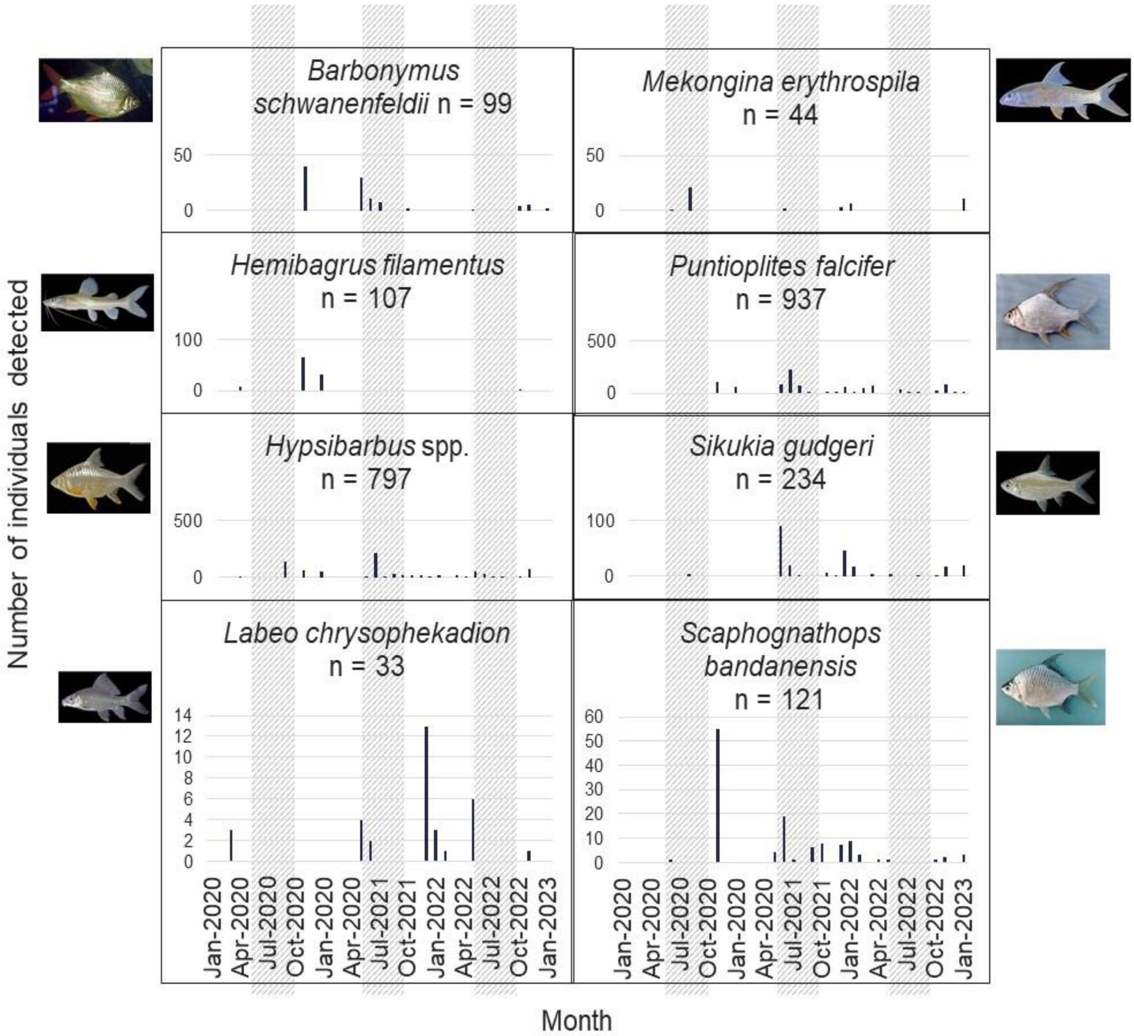


Figure 8. Migratory seasonality of key species that occurred in all three years, based on PIT detection data (unique tags per month) within the fish pass. Shaded periods = wet seasons.

3.5.5 Fish pass movement examples

A total of 1290 unique (i.e. individual) fish have been detected in the fishway so far. When compared with the 3651 tagged fish which have been released in the Mekong (at Xayaburi, Vientiane and Don Sahong), this equates to an overall "recapture" rate of 35.3% (most studies worldwide report values <15%). One-thousand-one-hundred-and-twenty-three 1123 (87.1%) of these unique fish that were detected ultimately ascended the fishway successfully. Some species are more successful at ascending the fish pass than others. For *Henicorhynchus siamensis* (Pa bok), Pa Ka-soob, Pa Khae-kwai, *Labiobarbus leptocheilus* (Pa Ki Lam), *Mystacoleucus obtusirostris* (Pa Ki leung), *Gyrinocheilus pennocki* (Pa koh) and Pa Sood-jam – there was 100% passage success. Other species, such as *Labeo chrysophekadion* (Pa phia) (79%), *Scaphognathops bandanensis* (Pa Pak-Pian) (78%) and *Cosmochilus harmandi* (Pa Joke-gheaw) (78%) were not quite as successful at ascending the fishway. Two fish species, *Probarbus jullieni* (Pa Ern) and Pa Wa, had a zero-passage success rate.

Of the 1290 unique fish that have ascended so far, 576 were ‘simple’ ascents where they were detected at the entrance, then the exit, then not again. Five-hundred-and-forty-six were ‘complex’ ascents, which were detected at multiple antennas over extended periods of time, before they ultimately ascended.

- *Barbonymus altus* (Pa vien fai (altus)) individuals provided examples of a simple ascent behaviour.
- *Hemibagrus filamentus* (Pa kod-reung) is an exemplar species with a complex ascent behaviour. These fish regularly move up and down within the fish pass over multiple-days and months.

Table 6. All fish that have successfully ascended the Xayaburi fish pass so far. These are fish that have been detected at both antennas and then not again for a significant period.

Species	Common name	Total detected (unique individual fish)	Ascended	Did not ascend	% passing
Henicorhynchus siamensis	Pa Bok	1	1	0	100
Hampala macrolepidota	Pa Ka-Soob	1	1	0	100
Pa Khae-kwai	Pa Khae-kwai	1	1	0	100
Labiobarbus leptocheilus	Pa Ki-lam	19	19	0	100
Mystacoleucus obtusirostris	Pa Ki-leung	5	5	0	100
Gyrinocheilus pennocki	Pa Koh	2	2	0	100
Hampala dispar	Pa Sood-Jam	2	2	0	100
Mekongina erythrospila	Pa Sa-Ee	25	24	1	96
Hemibagrus filamentus	Pa Kod-Reung	32	30	2	94
Barbonymus schwanenfeldii	Pa Vien Fai	59	55	4	93
Puntioplites falcifer	Pa Sakang	472	426	46	90
Cirrhinus molitorella	Pa Kaeng	18	16	2	89
Sikukia gudgeri	Pa Mang	173	149	24	86

Species	Common name	Total detected (unique individual fish)	Ascended	Did not ascend	% passing
Barbonymus altus	Pa Vien Fai (Altus)	13	11	2	85
Hypsibarbus spp.	Pa Pak	382	316	66	83
Labeo chrysophekadion	Pa Phia	19	15	4	79
Scaphognathops bandanensis	Pa Pak-Pian	55	43	12	78
Cosmochilus harmandi	Pa Joke-gheaw	9	7	2	78
Probarbus jullieni	Pa Ern	1	0	1	0
Pa Wa	Pa Wa	1	0	1	0
Total		**1290**	**1123**	**167**	

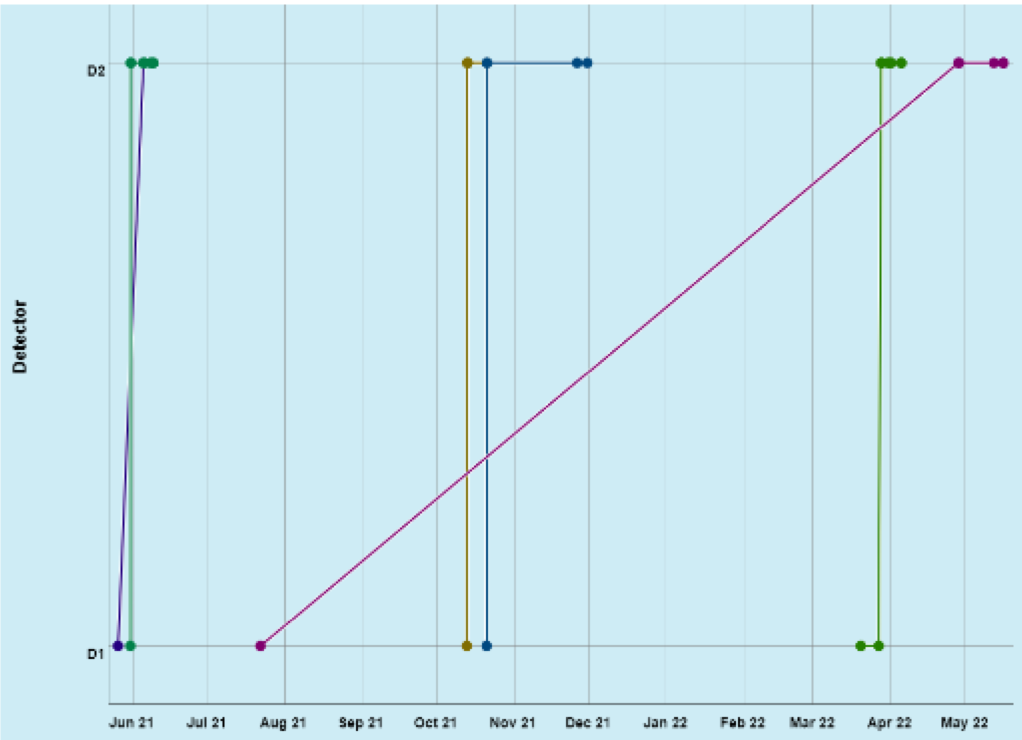


Figure 9. Example of 'simple' ascents for six *Barbonymus altus* (Pa vien fai (altus)) individuals. The different colours represent each individual. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

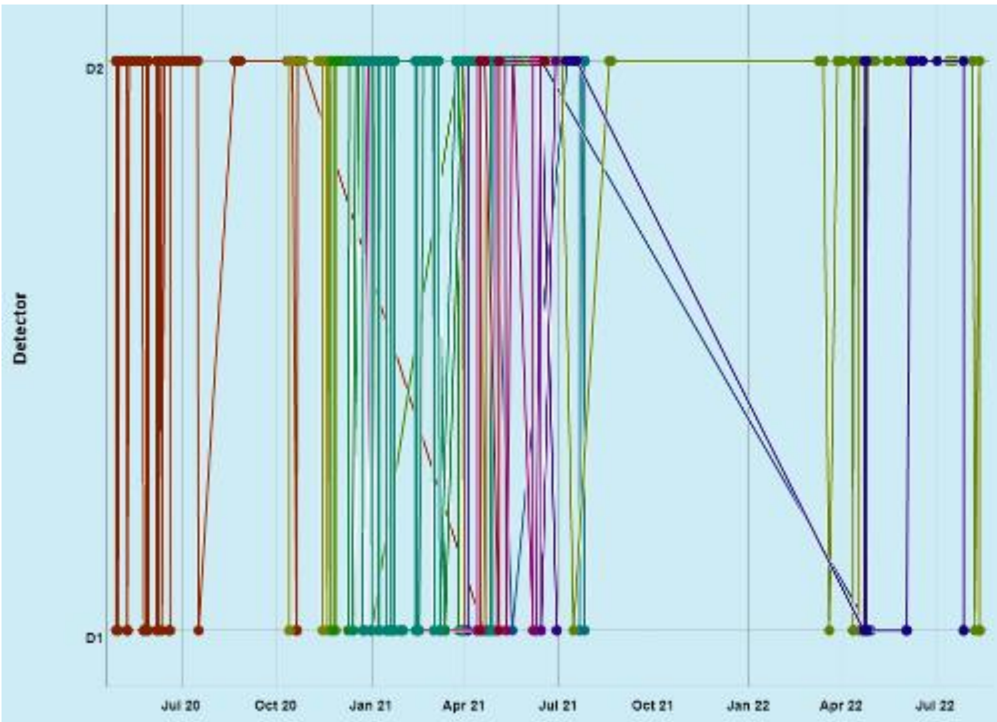


Figure 10. Example of 'complex' ascents for 22 *Hemibagrus filamentus* (Pa kod-reung) individuals. The different colours represent each individual. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

The data suggests that most species are easily ascending the fish pass. Many are detected at the entrance and then again at the exit shortly after. They appear to be able to navigate the internal flows and slots easily and many are ascending in a few hours. But the fish making complex ascents are more difficult to understand. They are either using the fish pass channel as a place of residency, possibly with the repeat up and down movements indicative of feeding on other fish in the channel. Alternatively, they may be having some difficulty ascending through the fish lock.

Evidence of complex ascent behaviour from many species. Fish are frequently observed ascending the fish pass between the entrance and exit before descending again. Some fish then, presumably, leave the fish pass before returning after a period and attempting again. These ascents are successful for the fish ladder, but may not indicate a successful ascent through the fish lock. It is difficult to determine the reasoning for this behaviour and warrants further investigation.

One line of investigation would be to correlate the periods of fish ascent with fish lock operation. If the fish ascend through the fish pass but reach the fish lock when it is not in attraction phase, then successful passage would not be possible or the fish could be delayed. Some species are known to quickly descend fish passes if there is no obvious passage and will attempt to try again via another route. But the only way fish lock synchronicity can be determined is by comparing lock operation records to fish ascent data.

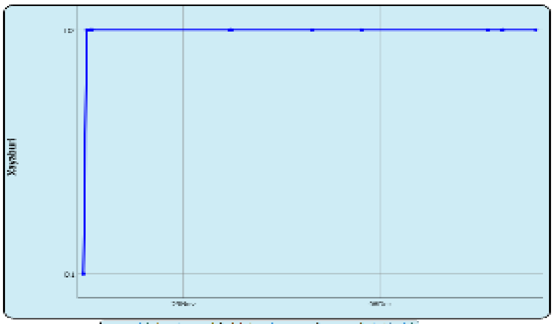
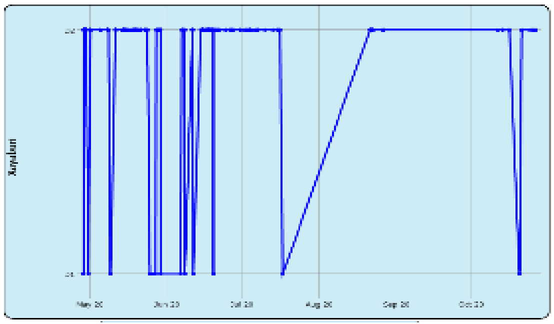
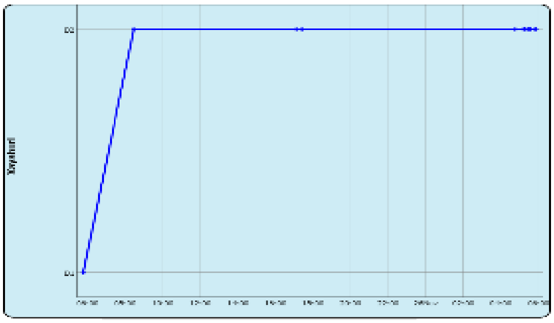
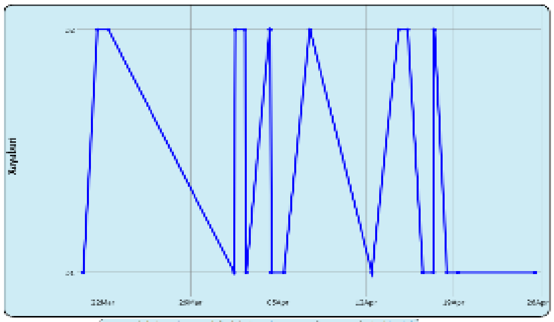
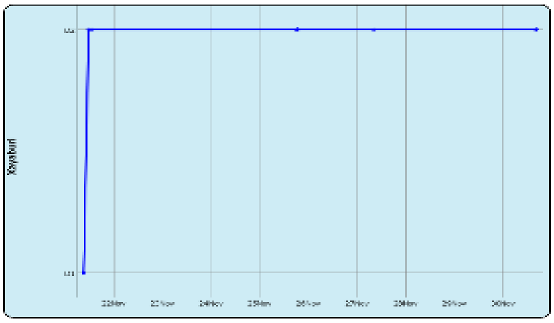
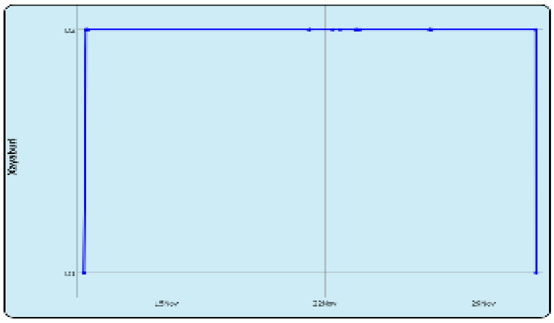
Successful ascent examples	Unsuccessful ascent / resident examples
***Hemibagrus filamentus* (Pa kod-reung), tagged 24th November 2020** 	***Hemibagrus filamentus* (Pa kod-reung), tagged 1st March 2020** 
***Mekongina erythrospila* (Pa saee), tagged 6th August 2020** 	**Pa keng; tagged 1st March 2020** 
***Gyrinocheilus pennocki* (Pa koh), tagged 10th June 2020** 	***Hypsibarbus* spp. (Pa pak), tagged 5th August 2020** 

Figure 11. Examples of fish ascent data through the fish pass. Y-axis depicts the antenna (D1 – entrance; D2 – exit). X-axis depicts time since tagging. These fish were selected as examples of fish displaying complex behaviour within the fish pass. Far more detailed analysis is planned for the final report, across all fish detected to identify any trends and patterns.

4 Training activities

The following training activities were undertaken during 2022–23:

PIT system design

- The further training provided to NUOL, LARReC and XPCL staff on PIT tagging systems during the 2022 field trip for installing the third antenna system.
- Ongoing online tutorials for database mining and fish data interpretation. These have been taking place as part of regular monthly meetings.

Sensor Fish

- The hands-on training provided by CSU and PNNL staff to XPCL and NUOL staff on using Sensor Fish in Oct 2022 (see 1.1).

5 Intellectual property

Intellectual property matters remain unchanged from the project proposal. CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties.

There are some critical key learnings which can now be considered for dissemination as the team enters the data analysis and final write-up stages of the project.

6 Variations to future activities

The PIT tag trials have still been progressing, but there was an initial nine-month delay in being able to commence the project due to the difficulties of working at a remote site, undertaking many tasks for the first time, and dealing with unexpected lengthy bureaucratic processes.

There were also further delays associated with COVID-19, mainly due to travel restrictions and/or site access, preventing both Australia-based and in-country staff from travelling to the study site to provide face-to face guidance and mentoring. Indeed, the Xayaburi Hydropower site is considered critical infrastructure. Any COVID-related outbreak on site could have significant implications for power generation. Hence, there are strict travel restrictions and quarantine procedures in place. The project team was unable to gain permission to access site during the peak of the COVID outbreak in Lao PDR.

As a result, progress towards the completion milestones has been slightly delayed, but a project variation (Variation 3) has recently been granted to extend the project from 31 May 2023 to 30 June 2024, and this will allow the project to still deliver upon its original milestones. The purpose of Variation 3 is to both build upon the research done so far (by undertaking new research activities), co-design a critical second stage and to complete activities that were delayed by disruptions associated with COVID-19 during the first stage of the project. Implicit in this is continuity of salary and operating support for research partners.

The new research activities will involve:

1. workshopping and co-designing the next 5-year stage of the Xayaburi project, with XPCL, ACIAR and DFAT (which was recently held in Bangkok)
2. refining our PIT tagging requirements model, and in particular — the ages of the PIT tagged fish, by undertaking an otolith (fish earbone) aging study
3. publishing a PIT tagging requirements model
4. continuing the PIT tagging program to build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements model)
5. continuing to engage KarlTek Pty. Ltd. to manage the PIT tag database (FishNet) so that we can assess the fishway's effectiveness using the recently installed upsteam PIT antenna system (i.e. third antenna system that was installed upstream of the lock in September 2022).
6. participating in the Mekong River Commission international conference in April 2023.

The COVID-delayed activity will involve publishing the initial key findings from the first stage of the project (there will be at least three papers – (1) antenna design trials, (2) assessing PIT tag retention in Mekong species, and (3) assessing the fishway's effectiveness).

7 Variations to personnel

Dr Wayne Robinson has returned from living in Lao PDR, but he is still travelling back regularly to provide in-country guidance now that international travel has recommenced. He has reduced his role to 0.6 FTE.

We intent to engage a project officer (Tisi Tukuniu) over the next 12 months to ensure the project team remain on target to meet various project goals.

8 Problems and opportunities

Problems

1. In addition to the initial nine-month delay experienced during the SRA project (see Section 6 for details), the COVID-19 travel restrictions and border closures prevented the CSU team from travelling to Lao PDR from 2020–2022. They even prevented our in-country team members from travelling to the Xayaburi site for most of 2021.
2. There was no ongoing practical training for boat electrofishing for the XPCL staff during the period of international and damsite border closures for 2021 and part of 2022. COVID-19 travel restrictions prevented experienced electrofishing boat operators from CSU and USA travelling to Xayaburi and providing ongoing practical training and guidance.
3. XPCL staff were unable to operate the electrofishing boat for most of the 2019–20 financial year. One of the outboard motors had experienced mechanical issues, and it was difficult for a qualified marine mechanic from Thailand to access the Xayaburi site due to the strict COVID-19 travel restrictions. This reduced the ability of the team to capture wild Mekong fish during 2021. It was intended that the electrofishing boat would be the main capture method of fish for the PIT tag retention trials, since boat electrofishing causes the least stress and injury to the fish. The boat was fixed in 2021 and is operational now.
4. The PIT monitoring system installed on the Xayaburi fish pass has experienced occasional communications loss. This communication loss has been caused by issues with the Lao mobile phone network and power outages at the site. The team continue to work to resolve these issues.

Opportunities

1. The installation of the third PIT antenna system upstream of the lock will now provide the capability to assess what proportion of fish are able to ascend the fishway and then get through the lock, so that any potential obstruction points at the fish pass entrance, exit and lock be individually identified (see 3.3.3).
2. The recently approved Variation 3 will allow the team to:
    a. enhance our PIT tagging requirements model — especially the ages of the PIT tagged fish, by conducting an otolith (fish earbone) aging study. We will also then be able to publish this model so that it becomes accepted by and disseminated throughout the broader scientific community.
    b. continue the PIT tagging program to build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements model) and to obtain a statistically valid (> 1 year) dataset with the third PIT antenna system in place.
    c. participate in the Mekong River Commission international conference in April 2023 to distribute the findings to relevant managers and other decision makers throughout the region (this one has just been addressed).
    d. finish publishing the initial key findings from the first stage of the project (there will be at least three papers – (1) antenna design trials, (2) assessing PIT tag retention in Mekong species, and (3) assessing the fishway's effectiveness) – given that these publications were delayed by COVID-19-related disruptions.

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10 Appendices

Appendix I: Publications record (see the separate Microsoft Excel document)

Appendix II: Papers proposed:

1. Factors influencing PIT antenna efficiency at high fish passes.
2. PIT tag retention and mortality in key Lower Mekong Basin species
3. Monitoring the effectiveness of fish migration in tropical rivers
4. Optimising electrofishing for deployment in the Lower Mekong Basin
5. Modelling the PIT tagging requirements for maintaining wild PIT tagged fish populations
6. Nutritional benefits from restoring fish passage

Appendix III: financial management system and other administrative arrangements supporting implementation

<u>Administrative inefficiencies in organising for the team's international partners to attend events</u>

There are a number of inefficiencies associated with the process of CSU distributing project funds to international project partners for them to travel to events, such as conferences and meetings.

Specifically:

1. because of administrative and financial management restrictions, the DSA's for some international partners currently must be paid from the personal funds of an in-country team member and then reimbursed to that in-country team member from the project budget.
2. CSU currently carries the financial risks associated with international project partners not attending pre-booked events, such as meetings and conferences.

Appendix V: Impact Log

Date	Description of change- what changed and for who?	What is this based on (observation, informal dialogue, feedback etc)	Contributing factors or link to your activities	Significance
14/02/2023	Invitation from Mekong Water Solutions to provide advice on a water security project in Cambodia	Invitation to provide expertise for a paid consultancy	Support for addressing the end-of-project-outcome (EOPO) of scaling out the learnings from Xayaburi Dam to improve the design of other fish passes at future mainstem dams	Evidence of growing demand for the team's expertise
7/03/2023	3 MRC documents (co-authored by FishTech team members) posted on MRC website: Guidelines to Prioritising Fish Passage Barriers in the Lower Mekong River Basin, Fishway Inspection Manual, Fishway Monitoring Manual	Email from MRC to LB	Support for addressing the EOPO of developing a robust, and scientifically-defendable, research program, which will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB	Evidence of significance of the team's expertise and work in the region
7/03/2023	MRCS has contracted with national consultants in each Member Country to implement in this year the Potential Barrier Identification & Remote Assessment in a selected catchment and fishway monitoring in a selected fishway with 2 national workshops	Email from MRC to LB	Support for addressing the EOPO of developing a robust, and scientifically-defendable, research program, which will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB	Evidence of significance of the team's expertise and work in the region
1/04/2023	Model fishway displayed at MRC conference	Emails from DFAT/ACIAR to LB	Support for addressing the EOPO of scaling out the learnings from Xayaburi Dam to improve the design of other fish passes at future mainstem dams	Evidence of significance of growing recognition of the role of fishways in the region

Australian Government

Australian Centre for International Agricultural Research

Annual report

project	**Assessing fisheries mitigation measures at Xayaburi Hydropower project in Lao PDR**
project number	FIS-2017-017
period of report	31st March 2020 – 1st December 2020
date due	31st December 2020
date submitted	31st December 2020
prepared by	Lee Baumgartner, Charles Sturt University
co-authors/ contributors/ collaborators	Chris Barlow, Fish Matters IP Khampheng Homsombath, LARReC Jarrod McPherson, Charles Sturt University Nathan Ning, Charles Sturt University Thanasak Poomchaivej, Xayaburi Power Company Limited Oudom Phonekhampheng, National University of Laos Karl Pomorin, KarlTek Pty Ltd Michael Raeder, Xayaburi Power Company Limited Wayne Robinson, Charles Sturt University Douangkham Singhanouvong, LARReC Garry Thorncraft, National University of Laos Kyle Weatherman, Charles Sturt University
approved by	Dr Ann Fleming

Contents

1 Progress summary

1.1 Background to the project

The site of the world's most productive inland fishery — the Lower Mekong Basin (LMB) — is currently experiencing development of rivers for hydropower generation. There are currently 11 hydropower projects scheduled for the main Mekong River channel, and many more on its tributaries. Without suitable fish passage consideration, these fish will be blocked from reaching crucial feeding, spawning and nursery habitat, and their populations will be greatly reduced or even potentially become locally extinct. The first hydropower project at Xayaburi, in Lao PDR, was commissioned in October 2019. A significant level of investment allocated to mitigating fish passage, with the purpose of setting the best-practice standard for future mainstem dam developments. So optimising the Xayaburi fish pass facilities is the focus of a significant public-private research program between Australia, Thailand and Lao PDR.

The main objectives of this project are to:

(1) develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB;

(2) optimise the Xayaburi fish pass facilities; and

(3) provide a standard for monitoring and constructing other fish passes in the LMB.

1.2 Research activities

1.2.1 Objective 1: To develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB

PIT antenna design

- The CSU team submitted a final Short Research Activity (SRA) report to ACIAR and DFAT on 31 March 2020 (representing year 1 of the four-year activity).
- The PIT antenna installed in the field has performed well since commissioning
- Since the COVID-19 travel restrictions were enforced, regular online meetings have been held between the CSU team and the in-country project members (XPCL, NUOL) to progress project tasks and resolve any issues.
- Cloud-based solutions have been established to exchange data/information between the CSU team and in-country project members.

PIT tag retention trials

- A PIT tag experimental protocols report was drafted and provided to in-country staff prior to a field trip being undertaken in February 2020 (the final trip prior to the COVID-19 travel restrictions were enforced).
- The February 2020 field trip with Dr Alan Temple (US Geological Services) resulted in the release of 14 tagged fish.
- Dr Wayne Robinson chose to remain in Lao PDR following the COVID-19 border closures and has consequently been able to continue undertaking regular field trips during this period ensuring the project remains on track, with support from XPCL, NUOL and LARReC.
- To date, eleven tagging trials on nine different species/size combinations have been performed, and exactly 646 tagged fish have been released into the Mekong River. This number includes fish from one non-trial tagging event.

- The CSU team developed a series of instructional PIT tagging movies to guide the in-country team members in the absence of being unable to be on-site with them (Figure 1, Figure 2).
- Through the Crawford fund, these videos were additionally translated into Lao, Vietnamese, and Bahasa Indonesian; and posted on the Crawford fund You Tube Channel.
- An updated animal ethics permit application for the project was approved by the CSU animal ethics committee early this year, extending the permit conditions until 2022. It endorses all work to be completed in accordance with Animal Care procedures.

Figure 1. The Murray cod for the PIT tagging movies being acclimated in the 1000 L tanks at the CSU Albury Aquatic Laboratory in August 2020. The films were produced by Grigg Media (source: Nathan Ning).

Figure 2. Professor Lee Baumgartner shooting one of the instructional PIT tagging films to guide the in-country team members (source: Nathan Ning).

<u>Electrofishing boat</u>

- The team drafted boat electrofishing training guidelines and accreditation protocols
- The team then implemented these guidelines and protocols to provide boat handling and safety training in February 2020.
- Theoretical and practical electrofishing training was delivered by Dr Alan Temple (Lead Fish and Wildlife Biologist from US Fish and Wildlife Service) with support from CSU staff. Twenty-one participants attended from four countries over four days during the February 2020 field trip
- Further boat handling and electrofishing training was given to in-country staff during a field trip in July 2020 by Garry Thorncraft.
- The electrofishing boat has not been operational since July 2020 as one of the outboard motors has experienced mechanical issues. It has proven difficult for a specialized marine mechanic from Thailand to access the Xayaburi site due to the strict COVID-19 travel restrictions.

1.2.2 Objective 2: To scientifically optimise the Xayaburi fish pass facilities

- All tasks are being advanced to facilitate the initiation of the monitoring and evaluation program for the Xayaburi fish pass facilities
- Several hundred tagged fish have been released into the Mekong River
- Preliminary data on fish migration ecology and fish pass optimization are being collected
- The translation of project activities to project outputs and eventually impact outcomes, will be assessed via a range of ‘success measures’, including number of fish tagged annually, percentage of tagged fish detected, and percentage of fish successfully ascending.

- An extra component, which involves using specially designed data loggers to assess the physical conditions (changes in pressure, shear stresses, current velocities) through the turbines, is being explored.
- The data loggers, known as Sensor Fish, will be used to assess the physical conditions that fish are exposed to when moving along various pathways past the Xayaburi structure.

1.2.3 Objective 3: To provide a standard for monitoring and constructing other mainstem fish passes in the Mekong catchment

- Team members have opportunistically provided some advice on the technical aspects of PIT tagging equipment to others interested in this technology
- A project governance panel meeting will be held online in January 2021 to introduce the project to the panel members and discuss its progress.

1.3 Overall progress

- The project has continued to meet its milestones on time despite the COVID-19 travel restrictions. This has been largely thanks to (1) still having some staff in-country (Dr Wayne Robinson and Garry Thorncraft); (2) successfully switching to regular online project meetings and using cloud-based systems to share data and information; and (3) developing instructional films for the in-country staff.
- An additional Sensor Fish data logging component has been added to the project, which will be funded by XPCL.
- The project has continued to receive attention from the government and media, in Australia and Lao PDR.
- Partnerships with external agencies have been strengthened by maintaining online communications.
- We have continued to share knowledge arising from the project with senior government officials and scientists at national and international conferences, strategic workshops and NGO meetings.

2 Achievements against project activities and outputs/milestones

2.1 Achievements to date

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fish pass can be optimised. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team	Completed

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the Xayaburi site Functional system installed Linked to cloud-based database	Completed
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas	Completed
1.4	Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised	Completed
1.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other hydropower projects Commence dialogue with other developers in terms of applying outputs to their site	In progress. CSU will be involved in the JEM project which will test acoustic tagging and PIT tagging at Khone Falls.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track	Cancelled due to site closure associated with a regal visit by the Thai Princess. Meeting deferred to 2021. Not COVID-related.
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing	Completed.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	COVID has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos Assumes that remote training will be effective To minimise risk, training will continue under the instruction of Dr Wayne Robinson (whilst he is based in Laos)	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides	Completed but also ongoing. Variation funding by ACIAR provided an opportunity to develop a series of instructional videos. These have been completed in collaboration with an expert Videographer. The variation funding also permitted Dr Wayne Robinson, who is currently based in Laos, to work on the project. He has visited the site twice, during the COVID lockdown, and has enabled this work to progress. No COVID impacts.

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track	Annual report has been shifted to December 2020 to enable reporting on any COVID-delays.
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on COVID-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists	Recent progress meeting with ACIAR suggested that we shift this into a virtual mode and use it to progress a Pandemic plan. Scheduled for early 2021.
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world	Completed; but also being refined as the project advances. Not impacted by COVID.
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during COVID travel restrictions	Weather permits commenceme nt All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to hydropower generation operations	Dr Wayne Robinson, along with NUOL and LARReC staff, have mapped a plan where the site can be visited every 40 days to maintain continuity of field activities.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
2.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunistically	Other groups are keen to engage	Include tagging in design of other hydropower projects Commence dialogue with other developers in terms of applying outputs to their site	The team will work to demonstrate if PIT tags and acoustic tags will work at Don Sahong. A COVID plan has been prepared to ensure no delays to this important work.

2.7	Project steering committee meeting (May need to be delayed depending on COVID-19)	Hold team meeting on site	Pushed into early 2021	All milestones are met	Project progress is on track	**COVID-19 Response** Will switch to virtual mode whilst travel restrictions are in place. The group will still play a vital role in reviewing progress and commenting on the annual report even if travel to site is not possible.

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
3.1	Monitoring and evaluation continues	Regularly reporting project outcomes	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible	The main issue here is that the electrofishing vessel requires servicing and there are difficulties with a service technician accessing the site. We were aiming to tag several thousand fish per year and release into the river. So far we are less than 700. Despite less than 700 fish being released so far; we have already generated over 25,000 data points.
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work	Based on current levels of progress; COVID will not impact the ability to publish work on this.
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted	By this stage we expect restrictions to have been lifted and travel to have resumed.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted	By this stage we expect restrictions to have been lifted and travel to have resumed.
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated	By this stage we expect restrictions to have been lifted and travel to have resumed.
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs	Despite the COVID difficulties; our existing mitigation strategies mean we will not need to alter this date.

2.2 DFAT reporting requirements

1. Establish a Reference Panel

As outlined in the full project proposal, a project reference panel was established containing the following representatives.

Name	Gender	Agency	Position at agency	Project Responsibilities
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member
Daniel Deng	M	Pacific Northwest National Laboratory		Reference panel member
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member
John Dore	M	Australian government representative (DFAT)	Lead Water Specialist	Reference panel member
Lao citizen representative	F	Lao government or local community	Local	Reference panel member
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member

2. Annual Meeting of Reference Panel

The project reference panel will convene their first meeting in early 2021. A series of meeting cancellations and COVID-restrictions have precluded a formal face-to-face meeting. However, progress has been such that an urgent meeting has not been warranted. To introduce members and to report on progress, a zoom meeting will be scheduled for early 2021.

3. Prepare an Annual Report

DFAT requires an Annual Report in March each year. CSU and ACIAR have agreed to prepare these in December each year so that they can be reviewed and submitted in line with the DFAT annual reporting cycle.

2.3 Summary of achievements to date (for ACIAR website)

There are presently nine large hydropower projects scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of hydropower construction for creating jobs, supplying, and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. Developers are investing in technology to help ameliorate fisheries declines. To optimise performance of these technologies, the project will (1) design and install a microchip detection system, (2) build and assess the performance of an electrofishing boat to safely collect fish, and (3) commence a microchipping study to monitor and optimise fish migrations. The current project has enhanced the technical and institutional capacity of in-country scientists, engineers, and managers, so that eventually they will be capable of autonomously monitoring fish movement at the site. A successful system has been installed and is actively scanning for fish. Several hundred microchipped fish have now been released into the Mekong River and over 25,000 data points have been generated so far. Scientists are planning to analyse this data, across multiple species, and use it to help improve fish pass operations.

3 Impacts

3.1 Scientific impacts

Scientific advances

The project has so far developed:

- Knowledge on the maximum dimensions of PIT tag antennas to detect fish within a large tropical fish pass (antennas of these dimensions have never-before been implemented
- Understanding of electrofishing settings required to effectively catch Mekong fish (this is the first time an electrofishing vessel has been used to collect fish from the Mekong)
- Understanding of fish husbandry techniques for captive-held Mekong fish (many species used in our trials have never been held in captivity before)
- New knowledge on tag retention and mortality of tags within key Mekong species (11 species detected so far)

Scientific outputs

- Three reports were produced from the SRA project (the final SRA report and two training manuals) (Appendix I).

3.2 Capacity impacts

<u>Capacity impacts on government officials, scientists, and power company practitioners</u>

A main outcome of the project is to enhance technical and institutional capacity within power company practitioners (Xayaburi Power Company Limited (XPCL), government officials and scientists from countries in the LMB to better-understand the technical challenges regarding fish studies associated with hydropower production and the basis for scientific approaches to develop and run fisheries monitoring and evaluation programs.

<u>Progress for 2020:</u>

- Thanasak Poomchaivej (XPCL), has enrolled in a PhD through CSU. Thanasak met his PhD supervisory team at CSU (Albury), to develop his project proposal and methods.
- CSU staff provided further mentoring to XPCL staff in setting up aquaria, general fish husbandry, and undertaking PIT tag retention trials. This was done face-to-face during field trips in February, June, August, and October and via online meetings. Several hundred fish have been tagged and released (Figure 3; Figure 4; Figure 5).
- The in-country staff were given boat handling and safety training during the February and June 2020 field trips
- The February 2020 field trip with Dr Alan Temple resulted in the release of 14 tagged fish (see 1.2). The overall objective is to train for XPCL operations staff who will be operating the hydropower plant and fish pass facilities for the next 30 years over the concession period.
- Project staff from LARReC, NUOL and XPCL received initial hands-on training interpreting PIT tag data, PIT database management by KarlTek during the February 2020 field trip. They will eventually be trained in more detailed data mining and analysis so that, over the long term, they are able to autonomously generate data summaries and reports. CSU staff will work closely with the in-country team members to ensure that all facets of data management and future use are understood and applied.

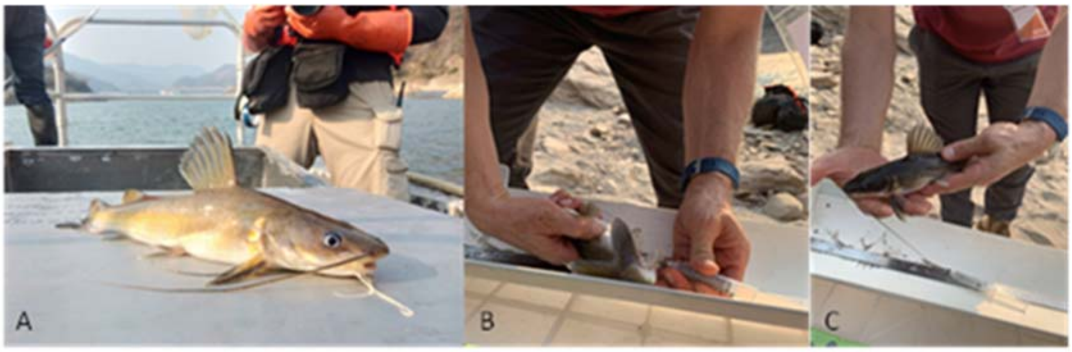


Figure 3. A catfish (Pa Kod; *Hemibagrus filamentus*) that was detected by the PIT system after the February 2020 trip. These three photos show the fish at the point of capture downstream of the Xayaburi Hydropower project (A) (source: Jarrod McPherson), the fish being PIT tagged (B) (source: Karl Pomorin), and the fish after being PIT tagged (C) (source: Karl Pomorin).

Figure 4. XPCL team members measuring a fish during the August 2020 field trip (source: Wayne Robinson).

Figure 5. Dr Wayne Robinson releasing a PIT-tagged fish at the Xayaburi site during the August 2020 field trip (source: Rohit Babloo).

3.3 Community impacts

3.3.1 Economic impacts

The LMB fishery has an estimated annual first-sale value of around US$17 billion, and this value is even greater when other related economic benefits are considered. Consequently, the health of the LMB fishery is vital to supporting the livelihoods of many southeast Asians, particularly those in rural areas. If the Xayaburi mitigation measures are found to work effectively, they will avert fishery declines and accompanying negative impacts on the livelihoods of many rural citizens in the LMB. Conversely, if the Xayaburi mitigation measures are found to provide sub-optimal fish passage, then research will need to (1) focus on design features that need adjustment, and (2) fine-tune and enhance operational processes; and engineering designs at future mainstem dams will need to integrate those aspects.

3.3.2 Social impacts

Fish and other aquatic animals comprise approximately 50% of the animal protein intake for people in Lao PDR, and nearly 80% of the animal protein intake for the people further downstream in Cambodia.

Progress for 2020:

Community engagement has occurred on two levels. Firstly, community members (PAFO office) were involved in the February training exercises. Representatives from the local provincial and district fisheries offices participated in training activities and learned about the project and its objectives. Secondly, there has been an ongoing education program with local villages to expect that some fish may contain a microchip and what to do if this occurs. These consultations have slowed due to COVID but have been appreciated by local people.

3.3.3 Environmental impacts

If the Xayaburi fish pass operates successfully, there will be no adverse environmental impacts. Rather, the fish pass will safeguard the fishery at the Xayaburi site from being diminished. The overall goal of the project will be to optimise fish pass operations so that any environmental impacts are minimised. Fish passes can generate detectable fish recovery benefits within 12 months of construction. Short-lived species will exhibit benefits within 12 months (Category 1), whereas longer-lived species are more likely to exhibit detectable benefits within 5 years (Category 2). The resultant benefits to nutrition and livelihoods will be quantifiable, and our findings from the ACIAR FIS/2014/041 (Variation 3) project indicate that these timeframes are realistic.

Progress for 2020:

- The community of released fish observed to be ascending the Xayaburi fish pass was made up of eleven species, providing evidence that a significant range of Mekong fish have already been able to navigate the fish pass and access upstream habitats for their life-cycle requirements.
- The team continue to work with the XPCL team to ensure fish pass operations are optimized through integrating fish pass data into fish lock operations

3.4 Communication and dissemination activities

Meetings:

- The meeting between XPCL's fisheries team leader, Thanasak Poomchaivej, and his PhD supervisory team at CSU (Albury), to progress his PhD.
- The regular online meetings among project team to deal with the COVID-19 travel restrictions.

Site visits from officials:

- The Australian ambassador visited Xayaburi on 5 October 2020. Presentations were given to him about the operations (by the XPCL site manager), the ACIAR Xayaburi fish passage project (by Dr Wayne Robinson from CSU), and PIT tagging trials (by one of the XPCL fish technicians).
- He was then taken on a tour of the facilities (including the fish research centre and fish monitoring station) (Figure 6) and participated in releasing some PIT-tagged fish (Figure 7).

Communication and extension activities targeted towards end users:

- Presentations of the 2018 fish passage conference have been loaded online by University of Massachusetts (https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=2287&context=fishpassage_conference).
- CK Power has released an online video outlining how the hydropower plant, and the fish pass, operates: https://youtu.be/IslaT7L15x0
- PIT tagging training videos have been translated into three languages (Lao, Vietnamese and Bahasa) and uploaded onto the Crawford Fund You Tube site: https://www.youtube.com/watch?v=adz7tNNoTd8&list=PLvLMhkEc96QGDV0wKNV7hu632x2ZRu5ok
- CSU, XPCL and the Australian embassy coordinated a series of twitter posts on the Australian ambassador visit
    - https://twitter.com/CSUMedia/status/1318703302092218370
    - https://www.facebook.com/1615859382008899/posts/2666592953602198/
    - https://fb.watch/2k1SV8CqdX/

Hands-on training of fisheries scientists, managers and students in Asia and Australia:

- The hands-on training provided by KarlTek to LARReC, NUOL and XPCL project staff in fish pass assessment, interpreting PIT tag data, PIT database management during the February 2020 field trip.
- The hands-on training provided by CSU/NUOL staff to XPCL staff in conducting PIT tag retention trials during field trips in February, June, August, October, and December 2020.
- The boat handling and electrofishing training provided to XPCL, LARReC and NUOL staff during the February and June 2020 field trips.

Publications of scientific reports and manuscripts in high-impact international journals:

- The three reports produced from the Xayaburi project thus far (Appendix I).

Figure 6. The Australian ambassador, Mr Jean-Bernard Carrasco (fourth from the left) being given a tour of the Xayaburi Fish Montioring Station during a visit to the site on 5 October 2020 (source: Thonglom Phommavong).

Figure 7. Ambassador H.E. Jean Bernard Carrasco (on the left) releasing a PIT-tagged fish with one of the XPCL staff into the Mekong River during his visit to the site on 5 October 2020 (source: Wayne Robinson).

3.5 Preliminary results

3.5.1 PIT tag retention trials

Eleven PIT tag retention/mortality trials have been completed thus far on nine different species/size class combinations (Table 1). These trials are focusing on key species to determine whether the tagging process needs to be refined. Ensuring that the tagging does not contribute to mortality, and that the fish do not shed tags, is essential to safeguard the veracity of data collected within the fish pass. Sound experimental design has allowed isolation of cause and effect for the results in every trial. We have thus identified and improved any issues with fish husbandry; as well as any differences in fish health, fish mortality and tag rejection rates associated with the tag insertion techniques, operators, and/or tank water quality.

Table 1. List of species/size combinations used in PIT retention trials to date. TBC = to be completed. ** = one of the five high priority target species for investigation in this project (FishTek performed swimming speed trials on these 'target' species and used the data to help initially design the Xayaburi fish pass).

Species	Trial	Key findings
Pa saee (*Cirrhinus molitorella)*	1, 3	Susceptible to increased mortality after tagging
Pa mang	2	Susceptible to increased mortality after tagging
Pa pak >210 mm (*Hypsibarbus* sp.)**	4	Very low mortality rate suitable for tag and release in the field
Pa pak 150 to 210 mm (*Hypsibarbus* sp.)**	5	Very low mortality rate suitable for tag and release in the field
Pa pak all sizes (*Hypsibarbus* sp.)**	6	Very low mortality rate suitable for tag and release in the field
Pa sway (*Pangassius concephalus*)	7	Difficult to maintain in captivity. Requires better understanding of diet and habits before next trial
Pa kot reung (*Hemibagrus* spp)	8	Low mortality rate suitable for tag and release in the field
Pa sakang (*Puntioplites falcifer*)**	9	Low mortality rate suitable for tag and release in the field
Pa vien fai *(Barbonymus schwanenfeldii)*	10	Very low mortality rate suitable for tag and release in the field
Pa pakpian *(Scaphognathops bandanensis)*	11	Low mortality rate suitable for tag and release in the field
Pa kott (*Hemibagrus nemurus)***	TBD	Pending
Pa ort (*Pangassius elongates)***	TBD	Pending
Pa sroi (*Henicorhynchus lobatus, H.siamensis*)**	TBD	Pending

There have been notable improvements in the tagging techniques of the local operators as they have become more experienced. For instance, trials 3, 4 and 5 compared two tagging techniques — scalpel-assisted insertion and syringe-assisted insertion. Both techniques returned similar tag retention and mortality results. Syringe-assisted insertion has been used in all other trials before and since. But we found that some of the operators preferred syringe insertion methods, whilst others preferred scalpels. Several species have proven to be very well suited to PIT tagging (e.g. Pa pak, Pa sakang, Pa viengfai (trial in progress)) and are now deemed suitable for large-scale tag and release upon collection in the field.

Some species are either sensitive to tagging or have been difficult to care for in the fish research centre. For instance, one of the migratory species commonly captured at the site, Pa saee (*Cirrhinus molitorella*), experiences high mortality from handling and significantly reduced growth rates after tags are inserted (Figure 8; Figure 9). Several trials are trying to resolve these matters but it could simply be that this species in not suitable for longer term migration trials. It is important to note that this highlights the value of tag retention trials prior to large-scale tagging in the field. Ideally, once fish are tagged and released into the Mekong, they should have a high probability of retaining the tag and surviving. This is the best mechanism to gain high quality data from the PIT system.

Other species have not performed well during the trials. But declines in the health of both control (untagged) and tagged fish suggest that health issues are unrelated to tagging but, more broadly, from the transition from the “wild” to “captivity”. Some fish have failed to eat whilst being held in concrete tanks, whilst others have been injuring themselves because a rectangle-shaped tank does not suit their biology. This is new information on these species and will be transferrable to other captive-holding applications beyond this project. For the species which are most affected, the team now have management plans in place, including not being held in captivity or undergoing a feeding trial experiment to ensure good health before being used in future tagging trials. LARReC will also start producing fish food and transporting to Xayaburi for the team to trial some natural feed.

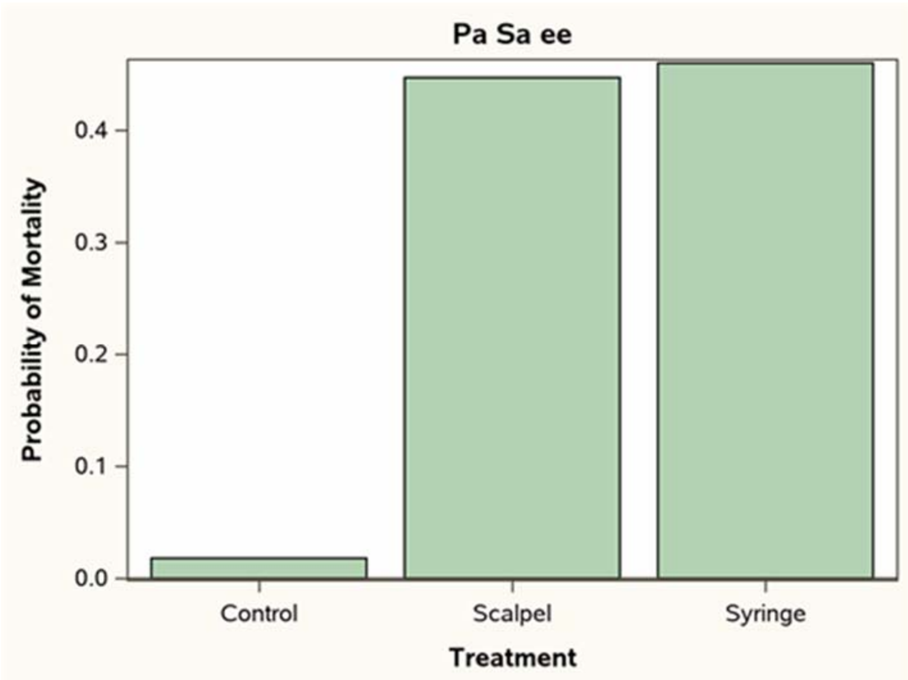


Figure 8. The probability of mortality of Pa saee (*Cirrhinus molitorella*) for the three treatments tested in the PIT tag retention trial: scalpel-assisted PIT tag insertion, syringe-assisted PIT tag insertion and control (i.e. no tag). The figure demonstrates that tag insertion by either method resulted in about 40% of fish mortality.

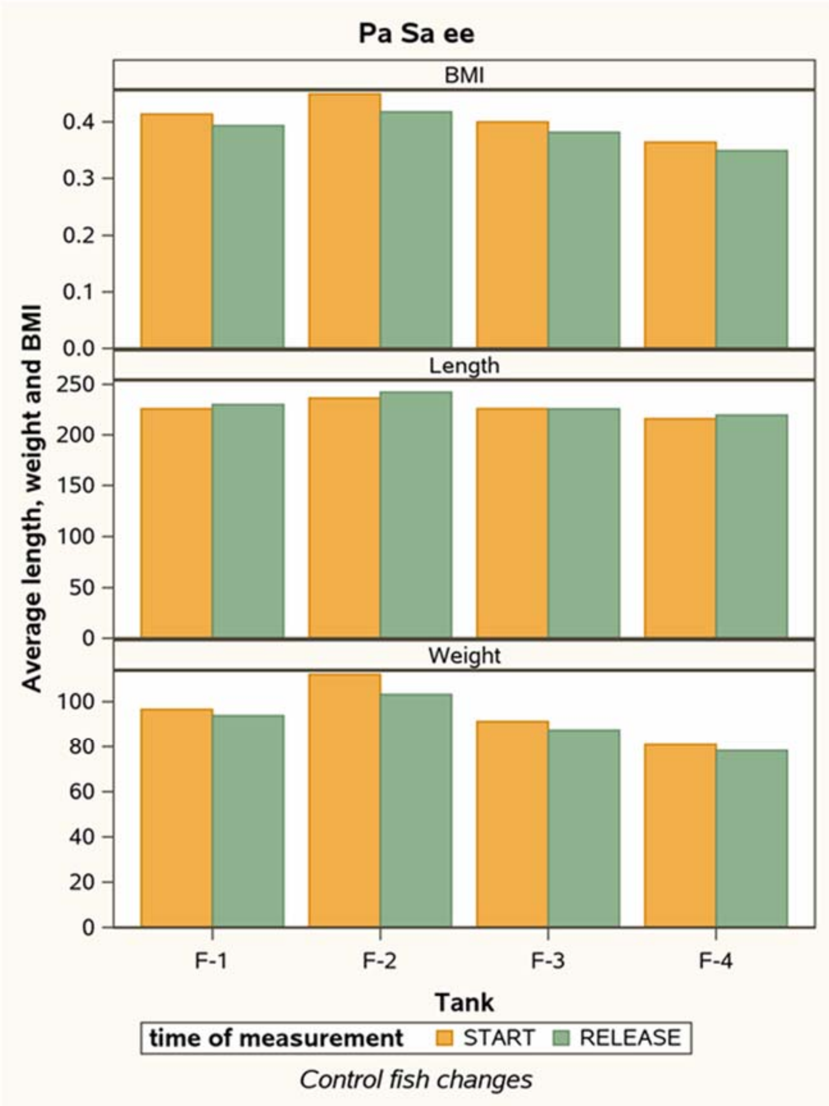


Figure 9. Changes in the condition (as assessed by body mass index — BMI), length (mm) and weight (g) of untagged (i.e. control) Pa saee in each tank (F1–F4), between the start and end (release point) of PIT tag retention trial 3. The declines in weight and body mass index during the trial indicate that even non-tagged fish of this species were not easy to husband in 2020.

3.5.2 Tag release data

To date, 646 individual fish, from 9 species, have been tagged and released into the Mekong. Large-scale tagging is yet to commence on a significant scale. Most tag/releases so far have been via the release of surviving fish at the completion of each tag retention trials. Major releases dates were in February (when the Australian team last visited), August (coinciding with a scheduled visit from CSU/NUOL/LARReC) and October (coinciding with a scheduled visit from CSU/NUOL/LARReC). But XPCL staff have been, where possible, actively tagging and releasing fish into the Mekong on an opportunistic basis. The most released fish have been Pak and Pa Sakang (Table 2).

The team have attempted to tag a wide range of fish sizes. The biggest fish so far (Pa Pak) was 469mm (weight = 1.6 kg). There was limited harvest of larger fish during the year. But the team are on standby to tag significantly sized fish (over 1m), given their overall social and economic value in the Mekong; and that these were a key species upon which the fish pass was designed.

Table 2. Total number of fish tagged and released into the Mekong since training commenced in February 2020. Maximum and minimum length (mm) of each fish is also given to provide an indication of the size range released so far.

Species	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Grand Total	Max length (mm)	Min length (mm)
Pa Pak	1			124		43		28	196	469	118
Pa Sakang	1	1				160		44	206	285	160
Pa Vien Fai	1						63		64	301	142
Pa Pak-Pian		3			1		54		58	245	140
Pa Kod-Reung	2					41		11	54	350	192
Pa Sa-Ee		1		28					29	393	179
Pa Mang			19						19	200	116
Pa Koh		3							3	191	156
Pa Ka-Soob	2								2	250	210
Pa Kaeng	2								2	230	217
Hypsibarbus	2								2	450	145
Pa Bok	2								2	175	120
Pa Nang-daeng					2				2	351	333
Pa Phia	2								2	460	177
Pa Sway					1			1	2	340	340
Pa Chaun		1							1	366	366
Pa Ki-lam		1							1	196	196
Pa Sanak		1							1	238	238
Grand Totals	**15**	**11**	**19**	**152**	**4**	**244**	**117**	**84**	**646**		

3.5.3 Fish detection data

A two-antenna detection system has been installed in the fish pass and has been fully active since November 2019 (See Appendix III for conceptual layout). One hundred and five (n=105) individual fish from 11 species, have been detected by the fish pass PIT system (overall detection rate of 16.2%). In total, across all species there have been more than 25,000 detections within the fish pass. There have been occasions when orphan tags have been detected by the system. Orphan tags are those that have been recorded on the PIT system but cannot be correlated to a tagging event. This occurs when tagging data has not been submitted for inclusion in the database prior to the fish being detected.

Interestingly, the detection data is providing an excellent source of continual seasonal movement data. The preliminary data collected so far is showing that some species have defined migration seasons (Figure 10Figure 16). This will provide significant opportunities for fish pass optimisation into the future because entrance and flow settings could be “manipulated”, in various seasons, to maximise fish passage during peak periods.

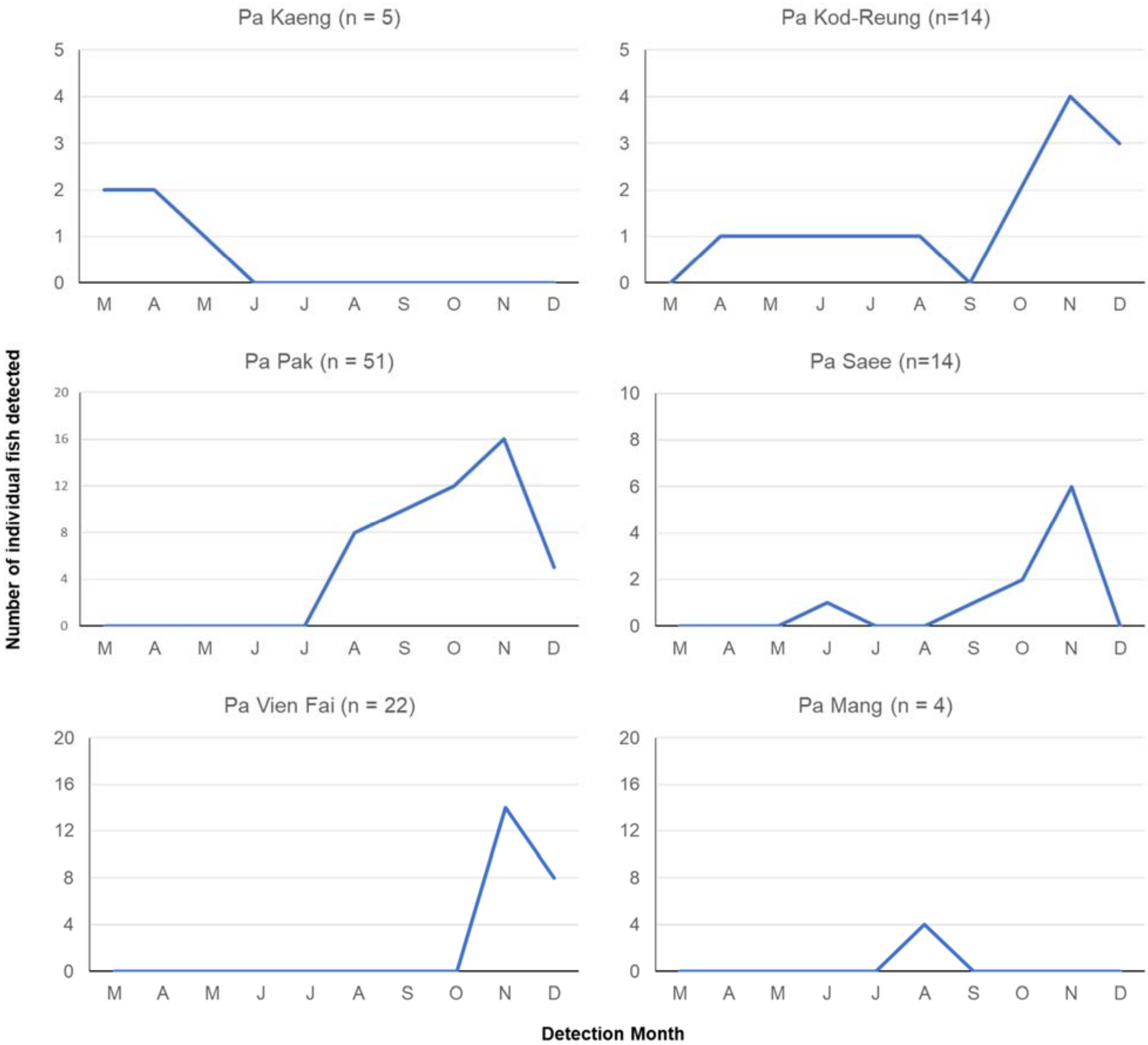


Figure 10. Examples of migratory seasonality based on PIT detection data within the fish pass. Y-axis depicts total number of individual fish detected. X-axis provides the months. The six species here are showing seasonal patterns which will provide a powerful dataset when a multi-year dataset is available.

3.5.4 Fish pass movement examples

Of the 105 fish detected in the fish pass, 84 ultimately ascended successfully for an entrance/exit efficiency of 80%. Of these, 64 were “simple” ascents where they were detected at the entrance, then the exit, then not again. 20 were “complex” ascents, which were detected at multiple antennas over extended periods of time, before they ultimately ascended (Table 3).

Pa Kod-Reung is an exemplar species with a complex ascent behaviour. These fish regularly move up and down within the fish pass over multiple-days and months. There are no “simple” ascents and their behaviour in the fish pass is consistent with residency for some individuals. The two fish that successfully ascended were active within the fish pass over several months (Figure 11).

A Pa Mang provided a good example of a “simple” ascent. Here a single fish was detected within the fish pass on 3rd August at 1400. It ascended the fish pass in two hours and was detected at the exit at 1600 and then not again (Figure 12).

A single species, Pa Koh, was recorded as “descending” the fish pass. But the “descent” was inconsistent with tagging data (the fish was released on the downstream side of the hydropower project in June). It is likely that this fish “ascended” the fish pass either (a) when there was a power outage and the PIT system was down or (b) when the top antennas were not activated because of water level changes (see Appendix IV for detailed explanation). There is a chance that the fish ascended the navigation lock and then descended the fish pass. However, this is less plausible given that there were known power outages and a period of elevated tailwater when the top “bank” of antennas was deactivated.

Table 3. All fish that have successfully ascended, and descended, the Xayaburi fish pass so far. These are fish that have been detected at both antennas and then not again for a significant period. The assumption is that these fish have moved upstream through the fishlock.

Species	Total detected	Simple ascent	Complex ascent	Descent
Pa pak	36	19	6	0
Pa Saee	9	9	0	0
Pa Vien fai	15	8	5	0
Pa Pak Pian	7	7	0	0
Pa Kod-Reung	5	2	3	0
Pa Koh	2	1	0	1
Pa Mang	4	1	0	0
Pa Sakang	1	1	0	0
Pa Kaeng	2	0	2	0
Pa Ki-Lam	1	0	1	0
Pa Phia	1	0	0	0

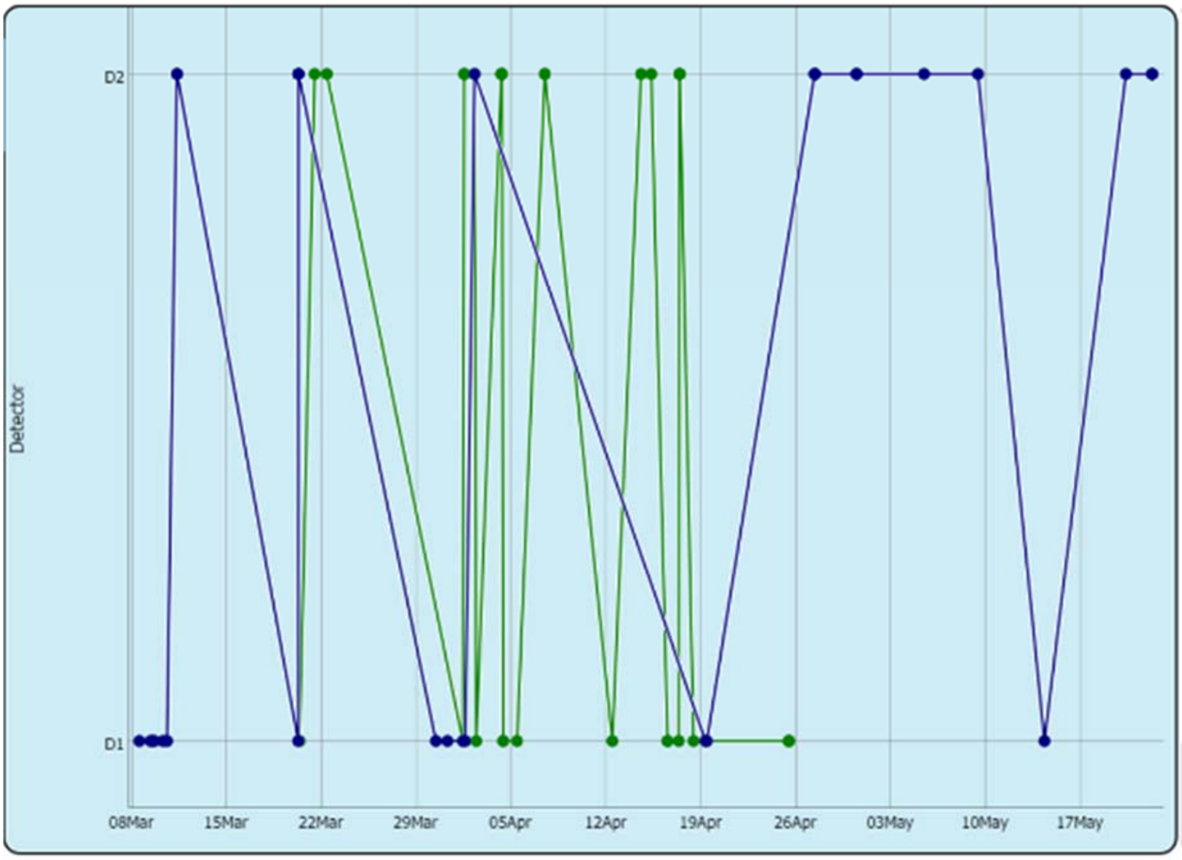


Figure 11. Example of "complex" ascents for two Pa Kod-Reung. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

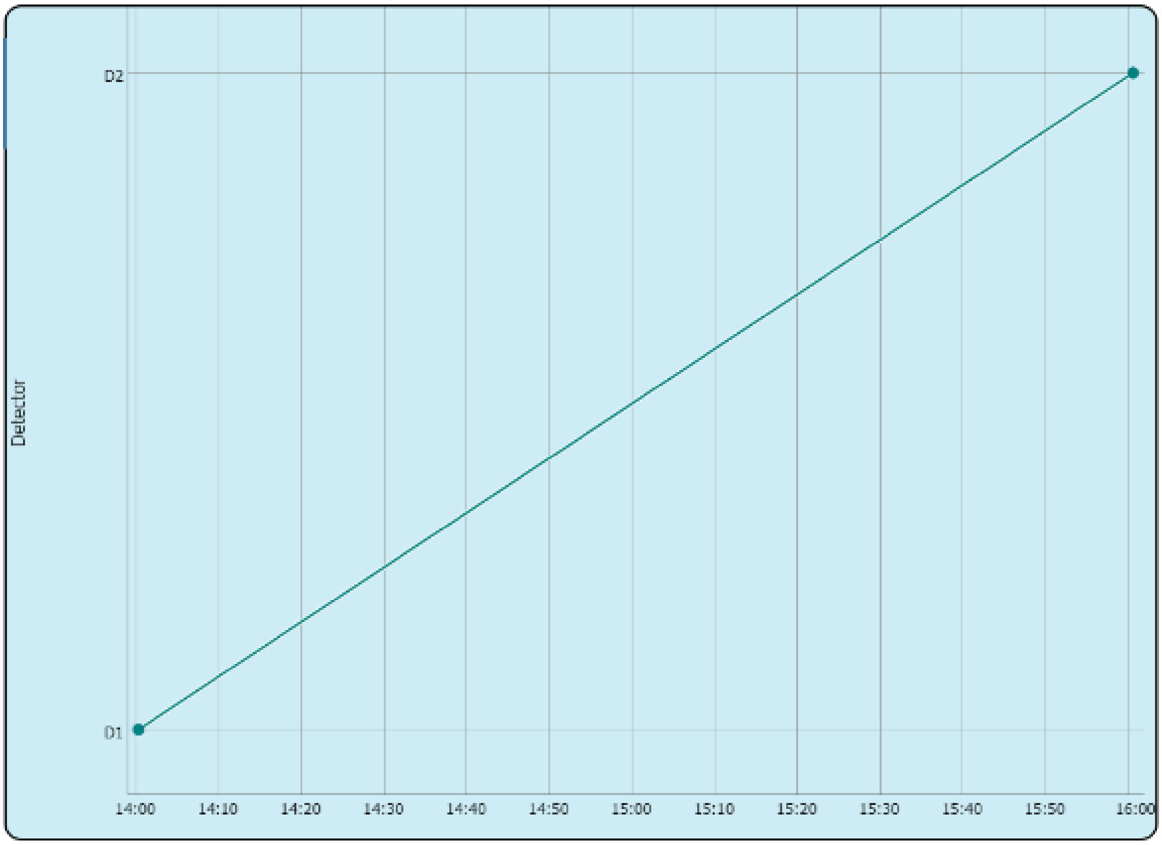


Figure 12. Example of a "simple" ascent for a Pa Mang. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

The data suggests that most species are easily ascending the fish pass itself. Many are detected at the entrance and then again at the exit shortly after. They appear to be able to navigate the internal flows and slots easily and many are ascending in a few hours. But the fish making complex ascents are more difficult to understand. They are either using the fish pass channel as a place of residency and the repeat up and down movements could be related to feeding on other fish in the channel. Alternatively, they may be having some difficulty ascending through the fish lock.

There is evidence of complex ascent behaviour from many species. Fish are frequently observed ascending the fish pass between the two antennas (entrance and exit) before descending again. Some fish then, presumably, leave the fish pass before returning after a period and attempting again. These ascents are generally considered “unsuccessful” (Figure 13). But it is difficult to determine the reasoning for this behaviour and warrants further investigation. It could be because of fish pass operation or it could be biological.

One line of investigation would be to correlate the periods of fish ascent with fishlock operation. If the fish ascend through the fish pass but reach the fishlock when it is not in attraction phase, then successful passage would not be possible or the fish could be delayed. Alternatively, there have been some periods where the fishlock has been inoperable and this could have prevented passage. Some species are known to quickly descend fish passes if there is no obvious passage and will attempt to try again via another route. But the only way fishlock synchronicity can be determined is by obtaining fish lock operation records and comparing to fish ascent data.

Obtaining fish lock operations data, and comparing with PIT system detections should be a key priority for the team in 2021. Noting that most of the unsuccessful ascents are likely to be related to fish lock operations, resolving these issues will be critical to increase passage efficiency and optimise operations.

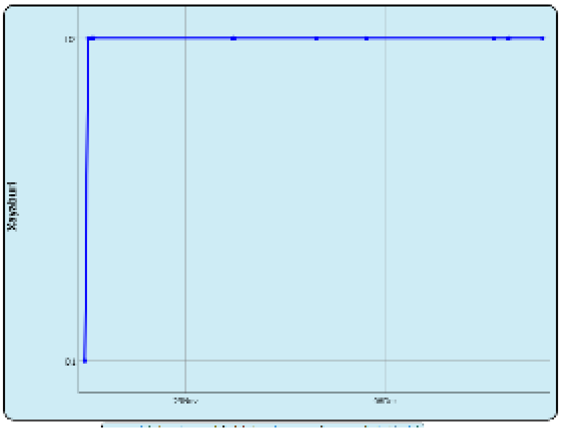
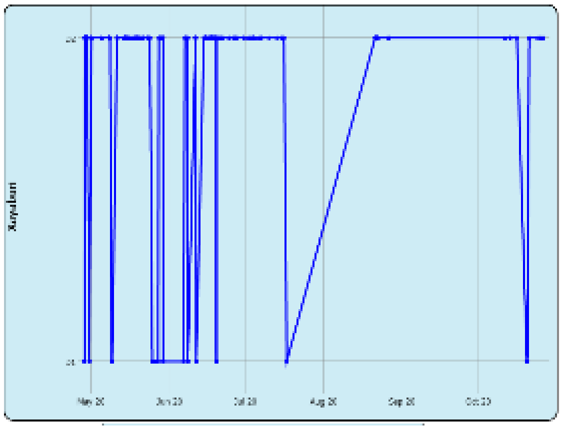
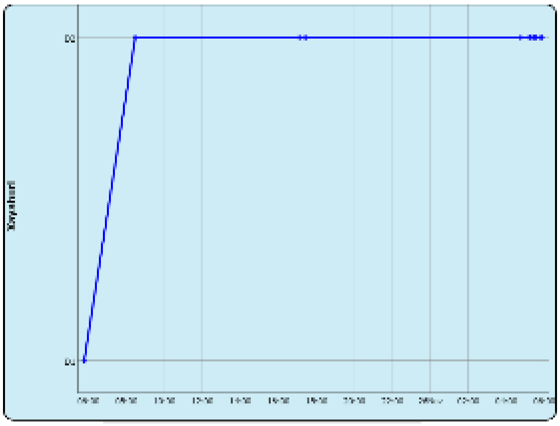
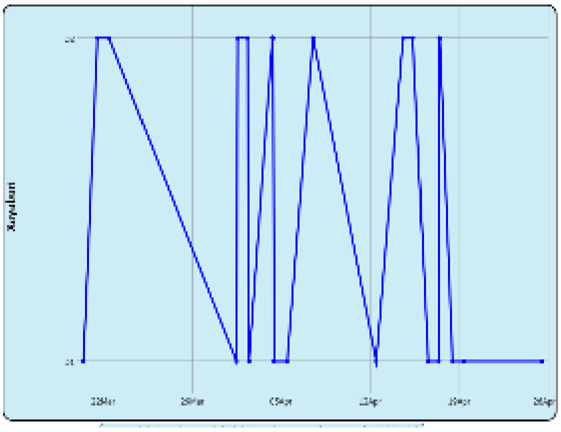
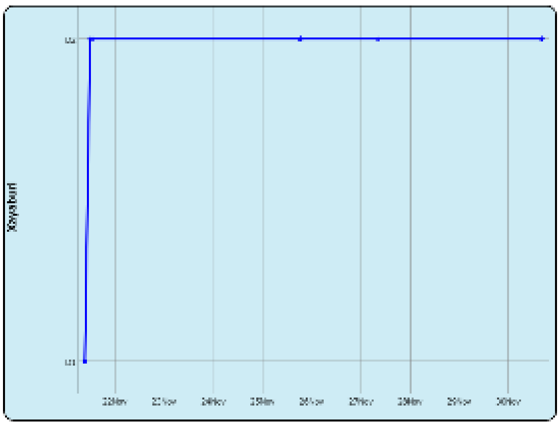
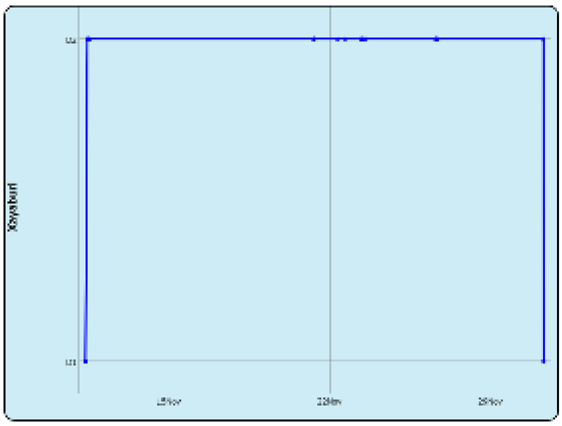
Successful ascent examples	Unsuccessful ascent / resident examples
Pa kod-Reung, tagged 24th November 	**Pa kod-Reung, tagged 1st March** 
Pa Saee, tagged 6th August 	**Pa Keng; tagged 1st March** 
Pa koh, tagged 10th June 	**Pa pak, tagged 5th August** 

Figure 13. Examples of fish ascent data through the fish pass. Y-axis depicts the antenna (D1 – entrance; D2 – exit). X-axis depicts time since tagging. These fish were selected as examples of fish displaying complex behaviour within the fish pass. Far more detailed analysis is planned across all 83 fish detected so far to identify any trends and patterns

4 Training activities

The following training activities were undertaken during 2019-20:

PIT system design

- The further training provided to NUOL, LARReC and XPCL staff on PIT tagging systems during the 2020 field trip.
- There have been ongoing online tutorials for database mining and fish data interpretation. These have been taking place as part of regular monthly meetings.

PIT tag retention trials

- The training provided to XPCL staff on conducting PIT tag retention trials during the February, June, August, October, and December 2020 field trips.
- The PIT tagging instructional movies developed by CSU for Lao-based staff. Funds were also obtained from the Crawford Fund to add Lao translations to the videos to assist with broader interpretation of the videos.

Boat electrofishing

- The boat handling and electrofishing training provided to XPCL, LARReC and NUOL staff during the February and June 2020 field trips (Figure 14).

Sensor Fish

- The team is preparing to film some instructional movies for using Sensor Fish to assess the physical conditions imposed upon fish passing Xayaburi. It is anticipated that these movies will be filmed in February 2021 and then shared with the in-country team members.

ACIAR Internship

- The team were able to assist Vietnamese HDR candidate (Vu Vi An) by collecting some otoliths from migratory species on his behalf. This data will be analysed and presented to the team in early 2021.

Figure 14. XPCL, LARREC, NUOL and other government officials being briefed on the PIT tagging and boat electrofishing procedures during the February 2020 field trip (source: unknown).

5 Intellectual property

Intellectual property matters are unchanged from the project proposal. CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties. But for now, the team are still in the data collection and optimisation phase and this will continue for 2021 and no major publications are envisaged for the next 12 months.

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[redacted].

[redacted]

[redacted]

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7 Variations to personnel

Dr Wayne Robinson is helping to coordinate in-country activities. He was “stranded” in Lao PDR due to COVID-19 travel restrictions and is temporarily unable to be repatriated to Australia.

Wayne was initially in Lao PDR undertaking field work for ACIAR project FIS/2014/041 (Variation 3) immediately prior to the introduction of the COVID-19 travel restrictions, and fortuitously made the decision to stay on in Lao PDR to maintain an in-country presence for both FIS/2014/041 (Variation 3) and FIS/2017/017 (and now FIS/2018/153).

Kyle Weatherman has stepped in to fill Jarrod McPherson’s technical role while Jarrod is away on paternity leave from October 2020 to February 2021.

8 Problems and opportunities

Problems

1. In addition to the initial nine-month delay experienced during the SRA project (see Section 6 for details), the COVID-19 travel restrictions and border closures have prevented the CSU team from travelling to Lao PDR since the February-March 2020 trip.

2. There has been no ongoing practical training for boat electrofishing for the XPCL staff. COVID-19 travel restrictions have prevented experienced electrofishing boat operators from CSU and USA travelling to Xayaburi and providing ongoing practical training and guidance. This has been an issue since the borders closed in March-April 2020.

3. XPCL staff have not been able to operate the electrofishing boat since July 2020. One of the outboard motors has experienced mechanical issues. It has proven difficult for a qualified marine mechanic from Thailand to access the Xayaburi site due to the strict COVID-19 travel restrictions.

4. The issue with the electrofishing boat has reduced the ability of the team to capture wild Mekong fish. It was intended that the electrofishing boat would be the main capture method of fish for the PIT tag retention trials, since boat electrofishing causes the least stress and injury to the fish.

5. The PIT monitoring system installed on the Xayaburi fish pass has experienced occasional communications loss. This communication loss has been caused by issues with the Lao mobile phone network and power outages at the site. The team continue to work to resolve these issues.

6. The fisheries research centre at Xayaburi has been supplied with highly turbid water during the wet season. The high sediment load within the water has proven extremely difficult for staff to observe the fish within the tanks as part of the PIT tag retention trials. The turbid water is additionally having an impact on fish health as staff are unable to closely monitor fish behaviour and condition without having to net individual fish from the tank and therefore cause more stress to the fish. It is also making it difficult to collect dead fish and/or tags that have been shed.

To mitigate the impacts of high turbidity during the wet season, (1) the current storage, inlet pipes and drainage lines will be thoroughly cleaned, and (2) a filtration system will be installed during this dry season. The filtration system will consist of a small sand filter on the delivery valve for each tank and a large carbon filter on the inlet from the river to the storage tank. Both filter types will need regular cleaning throughout the wet season, sometimes daily.

7. Some fish species did not feed well after being moved to the fish research centre, resulting in impacts on their health. We are working with the in-country staff to run some feeding trials between now and the next wet season to determine appropriate food sources for these species, so that we will have better success with these species next wet season.

8. The COVID-travel restrictions have meant that the project governance committee have been unable to meet, on-site, and deliberate over project progress. This has been unfortunate as the project is generating fantastic data and progressing well despite COVID. A virtual meeting will be scheduled for early 2021 for the group to meet and discuss potential plans for travel in later 2021 (or early 2022).

9. A community liaison program has commenced to inform the local villagers about the use of PIT tags in the fish captured at the dam site. There is concern that locals may ingest microchips if not properly informed about the program. Large-scale PIT tagging will commence once the community liaison program has been completed.

Opportunities

1. Fortuitously, Dr Wayne Robinson was already in Lao PDR when the borders closed and he decided to stay on. This has meant that he and Garry Thorncraft (who was already based at NUOL) have been able to continue undertaking site field visits to provide guidance with the PIT tag retention experiments, as initially planned for the year.

2. The CSU team has also adopted some new remote-working approaches to ensure that the project continues to progress. This has included:

- The initiation of the regular online meetings and a shared Dropbox folder with the in-country staff to follow progress, share results and other information, and resolve any issues arising.
- The CSU team developing the short instructional films to guide the in-country staff in undertaking PIT tagging experiments and fish husbandry (see 1.2).
- Further utilizing in-country resources such as the LARReC technical staff and fish hatchery manager. The LARReC hatchery manager travelled to the Xayaburi fish research Centre with Garry Thorncraft and Wayne Robinson in October 2020, to provide expert advice to the XPCL staff on general fish husbandry and how improvements could be made to the facility to reduce the sediment loads within the water supply.

The combination of these new remote-working approaches, and having staff in-country, has enabled the project to remain on schedule in meeting all its milestones throughout the pandemic.

3. The upside to being able to capture fish from the lock during 2020 is that it will assist us in managing the 2021 catch. We have learnt a considerable amount in terms of transportation requirements, stocking densities, tank sharing, feeding requirements and disease management. The team is currently developing care management plans for most of the expected species in 2021.

4. The XPCL and CSU team have been unable, so far, to compare fish movement information with fish lock operations. Obtaining the fish lock operational data, including the cycle times will be paramount for optimising fish pass operations into the future. This is a significant opportunity for collaboration in 2021.

5. Australia Award student, Vu Vi An, was assisted by the project team to collect some fish otoliths from Luang Prabang and downstream of the Xayaburi site. He is investigating the breeding location of several Mekong species and was missing data from the Mekong upstream of Vientiane. He is now able to complete his dataset thanks to assistance from the team and additional support from the project team.

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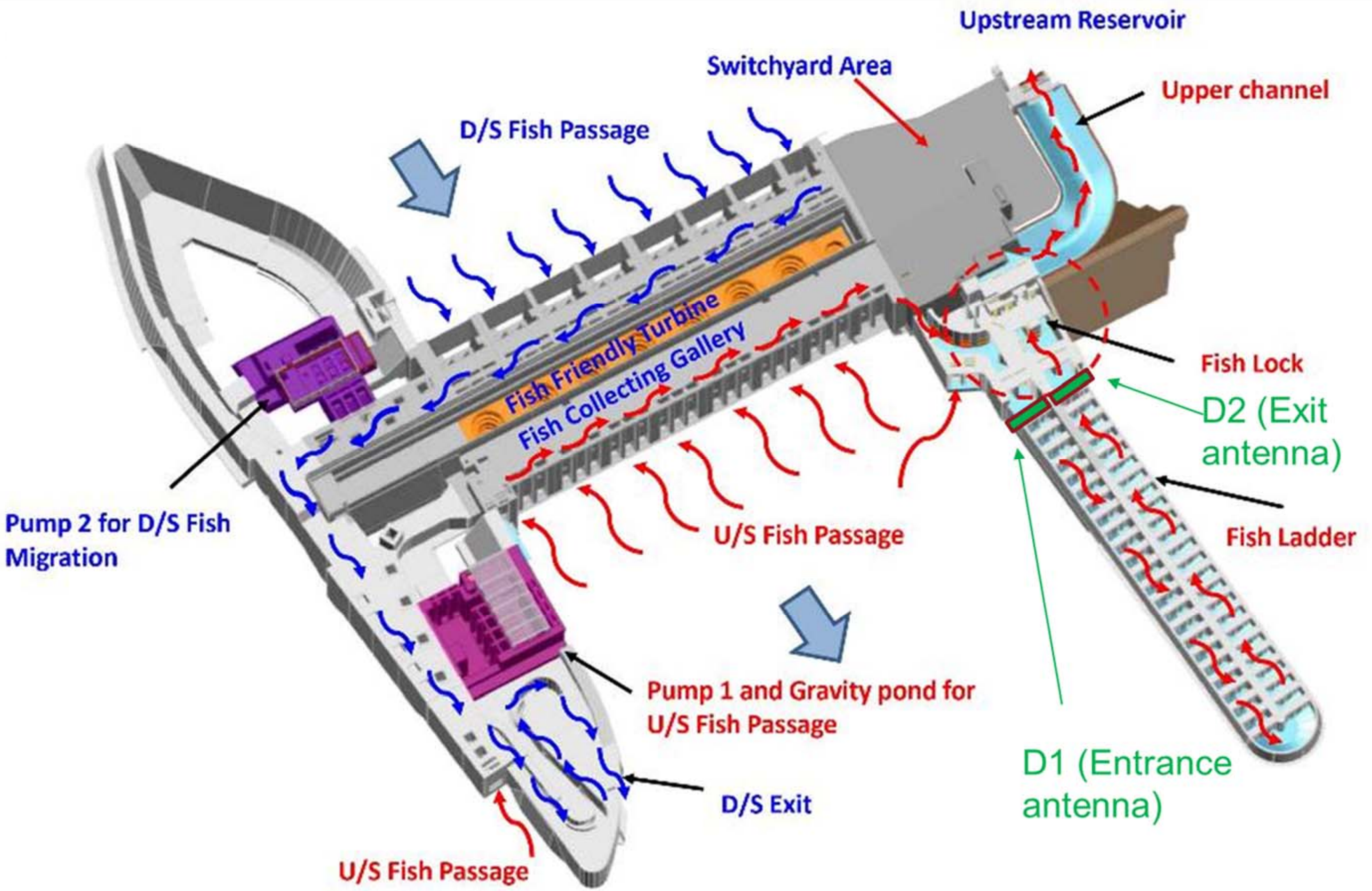
10 Appendices

Appendix I: Publications record (see the separate Microsoft Excel document)

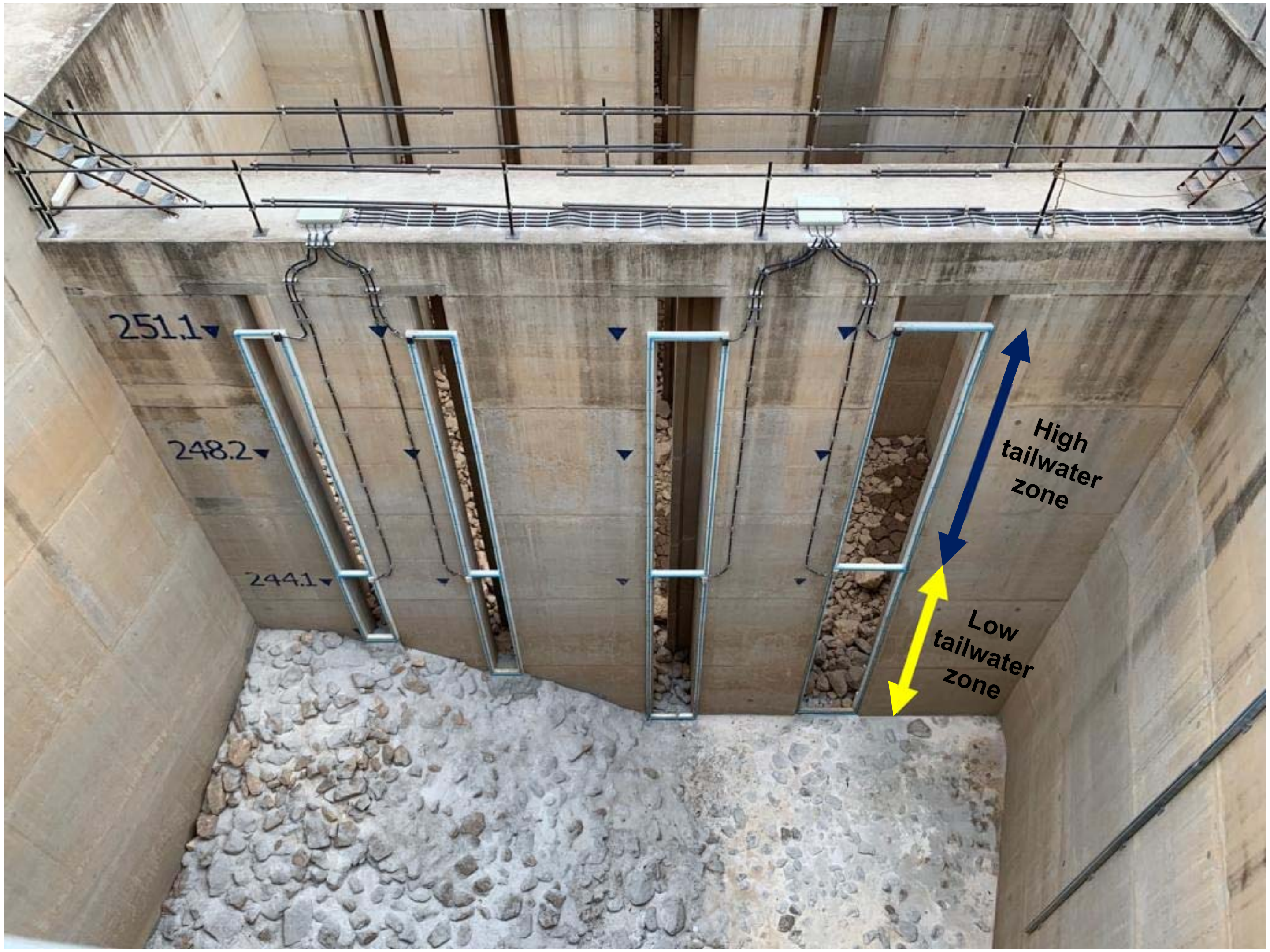
Appendix II: Papers proposed:

1. Factors influencing PIT antenna efficiency at high fish passes.
2. PIT tag retention and mortality in key Lower Mekong Basin species
3. Monitoring the effectiveness of fish migration in tropical rivers
4. Optimising electrofishing for deployment in the Lower Mekong Basin
5. Nutritional benefits from restoring fish passage

Appendix III: Existing location of PIT antennas in relation to the fish pass facilities at Xayaburi. Green areas depict the location of the existing entrance (D1) and exit (D2) antennas.



Appendix IV: **Configuration of the existing antenna detection systems. The antenna systems operate as two independent "banks". The bottom "bank" (yellow zone) operates year-round. The top "bank" (blue zone) is manually activated when the tailwater increases during the rainy season. It is <u>essential</u> that KarlTek Pty Ltd is notified when the water overtops the bottom bank so that the upper antennas can be activated. Otherwise, fish may be undetected as they ascend the fishway.**



Australian Government

Australian Centre for International Agricultural Research

DRAFT: Annual report

project	**Assessing fisheries mitigation measures at Xayaburi Hydropower project in Lao PDR**
project number	FIS-2017-017
period of report	1st January 2021 – 31st December 2021
date due	31st December 2021
date submitted	3/12/2021
prepared by	Lee Baumgartner, Charles Sturt University
co-authors/ contributors/ collaborators	Chris Barlow, Fish Matters IP Khampheng Homsombath, Douangkham Singhanouvong, LARReC Nathan Ning, Wayne Robinson, Kyle Weatherman, Charles Sturt University Thanasak Poomchaivej, Michael Raeder, Xayaburi Power Company Limited Oudom Phonekhampheng, Garry Thorncraft, National University of Laos Karl Pomorin, KarlTek Pty Ltd
approved by	Dr Ann Fleming

Contents

1 Progress summary

The site of the world's most productive inland fishery — the Lower Mekong Basin (LMB) — is currently experiencing development of rivers for hydropower generation. There are currently 11 hydropower projects scheduled for the main Mekong River channel, and many more on its tributaries. Without suitable fish passage consideration, these fish will be blocked from reaching crucial feeding, spawning and nursery habitat, and their populations will be greatly reduced or even potentially become locally extinct. The first hydropower project at Xayaburi, in Lao PDR, was commissioned in October 2019. A significant level of investment has been allocated to mitigating fish passage, with the purpose of setting the best-practice standard for future mainstem hydropower developments. So optimising the Xayaburi fish pass facilities is the focus of a significant public-private research program between Australia, Thailand and Lao PDR.

The main objectives of this project are to:

(1) develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB;

(2) optimise the Xayaburi fish pass facilities; and

(3) provide a standard for monitoring and constructing other fish passes in the LMB.

1.1 Research activities

1.1.1 Objective 1: To develop a suite of monitoring techniques for assessing the performance of mainstem fish passes in the LMB

<u>PIT antenna design</u>

- The PIT antenna system has continued to perform well since being commissioned in November 2019.
- The CSU team has continued to hold regular online meetings with the in-country project members (XPCL, NUOL) to progress project tasks and resolve any issues.
- The cloud-based solutions established in 2019–20 for exchanging data/information between the CSU team and in-country project members, have worked well so far.

Figure 1. Installation of the PIT antennas to the vertical slots (source: XPCL).

PIT tag retention trials

- Dr Wayne Robinson (who stayed on in Lao PDR following the COVID-19 border closures) has continued to coordinate the project from within country, with support from XPCL, NUOL and LARReC.
- Twelve tagging trials on eight different species/size combinations have been performed, with more than 1000 tags inserted to date.
- The CSU-developed instructional PIT tagging movies were well received by the in-country team members.

Electrofishing boat

- The electrofishing boat was inoperable for most of the 2020–21 financial year as one of the outboard motors experienced mechanical issues and it was difficult for a specialized marine mechanic from Thailand to access the Xayaburi site due to the strict COVID-19 travel restrictions. This is now resolved.

1.1.2 Objective 2: To scientifically optimise the Xayaburi fish pass facilities

- The monitoring and evaluation program for the Xayaburi fish pass facilities was initiated in early 2020. Almost 2000 microchipped fish have now been released into the Mekong River and more than 200,000 data points have been generated so far (as of mid-October 2021). Of the tagged and released fish, over 600 have been detected within the fish pass (see 3.5 for more details).
- Preliminary data on fish migration and fish pass optimization are being collected.
- The translation of project activities to project outputs and eventually impact outcomes, will be assessed via a range of 'success measures', including the number of fish tagged annually, percentage of tagged fish detected, and percentage of fish successfully ascending.
- CSU have procured some tagging equipment to ensure tagging can take place whilst travel to the site if limited. One thousand extra tags were purchased and delivered to Vientiane. Fish will be caught, implanted with tags, then released to the Mekong as soon as travel restrictions ease.
- We made up a series of 'dummy' Sensor Fish to practice our deployment techniques and the real Sensor Fish has been received from the manufacturer. We had planned to begin undertaking the deployment phase with the dummy Sensor Fish in April 2021, but this has been delayed because of ongoing COVID-19 lockdowns to the site in 2021. We intend to use the Sensor Fish to assess the physical conditions that fish are exposed to when moving along various pathways past the Xayaburi structure.

1.1.3 Objective 3: To provide a standard for monitoring and constructing other mainstem fish passes in the Mekong catchment

- The PIT tagging protocols and instructional movies developed for the Xayaburi project have been used to teach other Lao scientists and officials for the Joint Environmental Monitoring project, which is focused downstream in the MRB near Don Sahong.
- We also filmed a series of Sensor Fish instructional movies for the in-country project staff to use.
- An online project governance panel meeting was held in March 2021 to introduce the project to the panel members and discuss its progress. Governance panel members also participated in a high-level meeting with Ministry of Energy and Mines in November.

1.2 Overall progress

- FIS-2017-017 has again met most of its major milestones on time this year, despite another year of COVID-19 travel restrictions. This has been made possible by still having Dr Wayne Robinson and Garry Thorncraft in country; and successfully converting to regular online project meetings and using cloud-based systems to share data and information and provide training.
- We have tagged almost 2,000 tagged fish in the river with a significant detection percentage and many contributing to fish passage information
- The Sensor Fish component has been delayed by ongoing COVID-19 national restrictions, but we have prepared the equipment and protocols and filmed a series of instructional movies so that we can still efficiently deliver this component once the restrictions are eased.
- The project has continued to receive attention from the government and media, in both Lao PDR and Australia.
- We have strengthened partnerships with external agencies by maintaining online communications.
- The team has also continued to disseminate knowledge generated by the project with senior government officials and scientists at strategic workshops and NGO meetings.

2 Achievements against project activities and outputs/milestones

2.1 Achievements to date

The activities of FIS-2017-017 have been dictated by defined sequential timeframes and dependencies on one another, with the objectives having to be completed in chronological order. This order involves first constructing and optimising the PIT detection system; then completing PIT tag retention trials to confirm the applicability of PIT tagging local species; then determining a safe method for collecting fish from the wild; then PIT tagging the fish and releasing them back into the wild; and then monitoring and evaluating the PIT tagged fish traversing the fish pass to optimise the function of the fish pass. There is some flexibility around the ordering of these activities, but nevertheless there is a clear temporal hierarchy to be followed. If we commenced tagging in the river without giving due consideration to the impacts on fish welfare, it could result in a loss of data. Likewise, if we neglected to understand the optimal dimensions for PIT antenna construction at the site, the detection systems might not work effectively. Given these dependencies, the project activities and milestones are presented here in a chronological order (i.e. by year, rather than by objective). The strategic connections to project objectives are still included in the table to fulfil project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team	Completed

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualis ed	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the Xayaburi site Functional system installed Linked to cloud-based database	Completed
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas	Completed
1.4	Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised	Completed
1.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunis tically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other hydropower projects Commence dialogue with other developers in terms of applying outputs to their site	In progress. CSU has started its involvement in the JEM project. This project is testing acoustic tagging and PIT tagging at Khone Falls.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track	Cancelled due to site closure associated with a regal visit by the Thai Princess. Meeting deferred to 2021. Not COVID-related.
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing	Completed.
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	COVID has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos To minimise risk, training will continue under the instruction of Dr Wayne Robinson	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides	Ongoing. Variation funding by ACIAR provided an opportunity to develop a series of instructional videos with an expert videographer. The variation funding also permitted Dr Wayne Robinson, who is currently based in Laos, to work on the project. He has visited the site four times during the COVID lockdown, and has enabled this work to progress.

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Completed	Annual report was shifted to December 2020 to enable reporting on any COVID-delays.
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on COVID-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists	Recent progress meeting with ACIAR suggested that we shift this into a virtual mode and use it to progress a Pandemic plan. Deferred to early 2021.
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world	Completed; but also being refined as the project advances. Not impacted by COVID.
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during COVID travel restrictions	Weather permits commenceme nt All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to hydropower generation operations	Dr Wayne Robinson, along with NUOL and LARReC staff, have mapped a plan where the site can be visited every 40 days to maintain continuity of field activities.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
2.5	Update other groups	Liaise with MRC and other interested groups where work overlaps	Opportunistically	Other groups are keen to engage	Include tagging in design of other hydropower projects Commence dialogue with other developers in terms of applying outputs to their site	The team will work to demonstrate if PIT tags and acoustic tags will work at Don Sahong. The team also participated in a virtual meeting with ministry of energy and mines and DFAT. A COVID plan has been prepared to ensure no delays to this important work.
2.7	Project steering committee meeting (May need to be delayed depending on COVID-19)	Hold team meeting on site	Pushed into early 2021	All milestones are met	Project progress is on track	Have switched to virtual mode whilst travel restrictions are in place. First meeting held and written up. Commitment to discuss disseminating key messages in 2022 and beyond. The group will still play a vital role in reviewing progress even if travel to site is not possible.

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
3.1	Monitoring and evaluation continues	Regularly reporting project outcomes	Jul–Dec 2021	Weather permits commenceme nt All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible	The electrofishing vessel is now operational again. We were aiming to tag several thousand fish per year and release into the river. So far we have tagged around 2000 fish and generated nearly 250,000 data points.
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work	Based on current levels of progress; COVID will not impact the ability to publish work on this.
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted	By this stage we expect restrictions to have been lifted and travel to have resumed.
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted	By this stage we expect restrictions to have been lifted and travel to have resumed.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs	COVID-19 Response
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated	By this stage we expect restrictions to have been lifted and travel to have resumed.
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs	Despite the COVID difficulties; our existing mitigation strategies mean we will not need to alter this date.

2.2 DFAT reporting requirements

1. Establish a Reference Panel

As outlined in the full project proposal, a project reference panel was established containing the following representatives.

Name	Gender	Agency	Position at agency	Project Responsibilities
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member
Daniel Deng	M	Pacific Northwest National Laboratory		Reference panel member
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member
John Dore	M	Australian government (DFAT)	Lead Water Specialist	Reference panel member
Lao citizen representative	F	Lao government or local community	Local	Reference panel member
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member

2. Annual Meeting of Reference Panel

The project reference panel held their first meeting online in early 2021. A series of meeting cancellations and COVID-restrictions had precluded a formal face-to-face meeting. However, progress has been such that an urgent face-to-face meeting has not been warranted. To introduce members and to report on progress, a zoom meeting was held in 2021. Minutes were prepared and a subsequent meeting, with a smaller subset of members, was held with the Ministry of Energy and Mines in November 2021. Two meetings of the group are planned in 2022 in the final year of the projects.

3. Prepare an Annual Report

DFAT requires an Annual Report in March each year. CSU and ACIAR have agreed to prepare these in December each year so that they can be reviewed and submitted in line with the DFAT annual reporting cycle.

2.3 Summary of achievements to date (for ACIAR website)

Public opinion has been divided over the proposed development of eleven mainstem hydropower projects in the Mekong River Basin (MRB). Most of the public embrace hydropower construction and the opportunities it provides in supplying electricity, creating employment and improving living standards; but there are some who are concerned about the impacts on the livelihoods of people dependent on the river, and the difficulties of mitigating those impacts. The developers are investing in fish pass technologies to mitigate the impacts on the MRB's significant fisheries. Our project will assess the effectiveness of the fish pass on the Xayaburi Hydropower Project in Lao PDR — the first mainstem hydropower development in the MRB — and use the learnings to optimise fish pass mitigation measures at subsequent hydropower developments. It will do this by designing and installing a microchip detection system for migrating fish, building and assessing the performance of an electrofishing boat to safely collect fish, and commencing a microchipping study to monitor and optimise fish migrations. The project has already enhanced the technical and institutional capacity of in-country scientists, engineers, and managers, so that eventually they will be capable of autonomously monitoring fish movement at the site. A successful system has been installed and is actively scanning for fish. Nearly 2000 microchipped fish have now been released into the Mekong River and over 200,000 data points have been generated so far (see 3.5). Scientists are planning to analyse this data, across multiple species, and use it to help improve fish pass operations.

3 Impacts

3.1 Scientific impacts

Scientific advances

FIS-2017-017 will improve our understanding of fish ecology and rehabilitation techniques for restoring fish passage at hydropower projects throughout the LMB. Specifically, it will:

- Develop empirically-validated research techniques and technology for assessing the effectiveness of mainstem hydropower fishways in the LMB (e.g. the PIT antenna design experiments have resulted in an empirically-validated approach for setting up PIT antenna systems on other hydropower projects in the LMB).
- Improve our understanding of the migrations of key migratory species in the LMB, through the M&E program.
- Inform the development of a best-practice standard for monitoring and constructing other mainstem fishways in the LMB.
- Generate new knowledge on tag retention and mortality of tags within key Mekong species (see 3.5 for details on the species that have been assessed so far).

Scientific outputs

- Three reports have been produced from the SRA project (the final SRA report and two training manuals).
- PIT tag instructional movies were filmed during 2020 to assist the in-country staff (see 1.1).
- Similarly, Sensor Fish instructional movies were filmed in early 2021 to teach the in-country staff how to set them up and deploy them and download their data (see 1.1).
- Five papers are being planned for publication in international journals to scientifically validate the new techniques and technology being developed (Appendix II).
-

Figure 2. Staff training in PIT tag insertion and monitoring (source: Unknown).

3.2 Capacity impacts

Capacity impacts on government officials, scientists, and power company practitioners

FIS-2017-017 will build technical and institutional capacity within power company practitioners (Xayaburi Power Company Limited (XPCL)), government officials and scientists from countries in the LMB to better-understand the technical challenges concerning fish studies associated with hydropower production, and to provide the foundation for scientific approaches to develop and carry out fisheries monitoring and evaluation programs. This will be done by:

- working collaboratively with and mentoring XPCL staff
- co-hosting educational workshops relating to fish passage design
- inviting other hydropower developers to site and participating in MRC sustainable hydropower guidance discussions and development.

Capacity impacts on educational institutions

We will build capacity in educational institutions (1) by running targeted faculty masterclasses and implementing research projects; (2) by supporting the design of curriculums; and (3) through the delivery of a new CSU Graduate Certificate in Fisheries Ecology and Aquatic Engineering. NUOL has also been given conditional approval to host Master's students on site at Xayaburi, so such students will be considered on a case by case basis by XPCL. These students would form important components of our project team whilst gaining crucial practical experience. We will seek out the most promising graduates in educational facilities and offer them international educational opportunities (e.g. by assisting them in applying for international PhD scholarships). The capacity impacts from such arrangements are critical to alleviating the impacts of the Xayaburi Hydropower Project beyond the life of the ACIAR activity, as well as the impacts of all of the other planned hydropower projects throughout the LMB and elsewhere around the world. We expect that the larger spatial scale capacity impacts will occur within a 10-year timeframe (Category 2), although impacts at this scale will be influenced by donor body acceptance and investment.

Progress for 2020–21:

- CSU staff have continued to mentor XPCL staff in setting up aquaria, general fish husbandry, and conducting PIT tag retention trials. This was done face-to-face during field trips in February, June, August, and October 2020, and has been done via online meetings since then (due to the site being locked down throughout 2021 in response to COVID-19 restrictions). Around 2000 fish have been tagged and released (see 1.1).
- The in-country staff were given boat handling and safety training during the February and June 2020 field trips, but have been limited to online mentoring during 2021 because of the COVID-19 restrictions.
- Project staff from LARReC, NUOL and XPCL have received further training in more detailed data mining and analysis so that, over the long term, they are able to autonomously generate data summaries and reports. CSU staff will work closely with the in-country team members to ensure that all facets of data management and future use are understood and applied.
- Thanasak Poomchaivej (XPCL), has continued to progress his PhD through CSU, under the principal supervision of Prof. Lee Baumgartner.

Figure 3. XPCL staff undertaking boat electrofishing in September 2021 (source: Rohit Pothula).

3.3 Community impacts

3.3.1 Economic impacts

The LMB fishery has an annual first-sale value of around US$17 billion, and this value is even greater when other related economic benefits are included. As a result, the fishery is crucial to supporting the livelihoods of many southeast Asians, particularly those in rural areas. If the Xayaburi rehabilitation measures are found to work successfully, they will prevent fishery declines and associated adverse effects on the livelihoods of many rural citizens in the LMB. However, if the Xayaburi rehabilitation measures are found to provide sub-optimal fish passage, then we will need to redirect our research towards improving fish passage by (1) focusing on adjusting the fish pass's design features, and (2) fine-tuning and enhancing its operational processes. Those improvements should then be incorporated into engineering designs at future mainstem hydropower projects to achieve best-practice.

<u>Progress for 2020–21:</u>

The 600+ fish observed to be ascending the Xayaburi fish pass (see 1.1.2 and 3.5) so far, will economically benefit upstream fishers, both directly themselves, and by seeding reproduction and thus further productivity upstream. In fact, at least one tagged migratory fish was reported by a fisher who made a capture 80 km upstream from the study site.

3.3.2 Social impacts

If the Xayaburi fish pass is found to perform successfully, it will conserve fisheries production, and maintain food security and incomes for fishing families. Other likely benefits will include:

<u>Community cohesion:</u>

The development of a privately-managed asset can encourage local cohesion, by uniting locals in their goal to see the project succeed and express their enthusiasm to work on the project. We will replicate the successes of the Lao PDR fishway project (FIS/2014/041 (Variation 3)) by employing local staff to co-ordinate community co-management meetings and communicate information about the project throughout the community; attend workshops; and assist with fieldwork. We will seek active participation from women along with men, and these participants will be assessed on a case by case basis by XPCL.

Improved community co-management frameworks:

Villagers view floodplain capture fisheries as shared resources. There are many villages located in the Xayaburi region, at differing distances away from the fish pass site. Yet, the community generally considers that all of the villages should benefit equally from the fish pass if it operates as expected. Therefore, once the Xayaburi fish pass is operating, fish will move upstream and become more accessible to the other villages; resulting in equitable access to the fishery resource.

Progress for 2020–21:

Community engagement has occurred on two levels thus far:

(1) Community members (PAFO office) were involved in the February 2020 training exercises. Representatives from the local provincial and district fisheries offices participated in training activities and learned about the project and its objectives.

(2) XPCL have run an ongoing education program with local villages to forewarn them that some fish may contain a microchip and what to do if this occurs. These consultations have slowed due to COVID-19, but have been appreciated by local people.

3.3.3 Environmental impacts

There will be no adverse environmental impacts on the LMB fishery if the Xayaburi fish pass functions successfully. Instead, the most likely environmental outcome will be to ensure that the fishery at the Xayaburi site does not decline.

We will seek to empirically validate that, through suitable operation and integration into hydropower plant operations, the project will not result in negative environmental impacts.

Fish passes can generate detectable recovery outcomes within 12 months of construction. Quantifiable benefits for short-lived species are expected within 12 months (Category 1), and within 5 years (Category 2) for longer-lived species.

The subsequent benefits to livelihoods and nutrition will be quantifiable, and our learnings from the ACIAR Lao PDR fishway project (FIS/2014/041 (Variation 3)) indicate that these timeframes are realistic.

Progress for 2020–21:

- The community of released fish observed to be ascending the Xayaburi fish pass so far has been made up of fourteen species, confirming that a diverse range of Mekong fish have already been able to traverse the fish pass and access upstream habitats.
- We have been continuing to work with the XPCL team to ensure fish pass operations are optimized by incorporating fish pass data into fish lock operations.

3.4 Communication and dissemination activities

Meetings:

- We have continued holding regular online meetings (approximately every 4–6 weeks) among project team members progress tasks and resolve issues, while facing the COVID-19 travel restrictions.

Communication and extension activities targeted towards end users:

- CK Power has released an online video outlining how the hydropower plant, and the fish pass, operates: https://youtu.be/IslaT7L15x0
- The PIT tagging training videos have been translated into three languages (Lao, Vietnamese and Bahasa) and uploaded onto the Crawford Fund You Tube site:

https://www.youtube.com/watch?v=adz7tNNoTd8&list=PLvLMhkEc96QGDV0wKNV7hu632x2ZRu5ok

- The Sensor Fish instructional movies have also been shared with the in-country project members (see 1.1).

Hands-on training of fisheries scientists, managers and students in Asia and Australia:

- The hands-on training provided by CSU/NUOL staff to XPCL staff in conducting PIT tag retention trials during field trips in February, June, August, October, and December 2020.
- The boat handling and electrofishing training provided to XPCL, LARReC and NUOL staff during the February and June 2020 field trips.
- Further hands-on training was planned for this year, but has so far been delayed by COVID-19 travel in-country restrictions

Publications of scientific reports and manuscripts in high-impact international journals:

- The three reports produced from the Xayaburi project thus far (Appendix I).


Figure 4. Left: Mr Thonglom Phommavong from the National University of Lao releasing a PIT tagged fish back into the Mekong River (source: Jarrod McPherson). Right: XPCL staff being given hands-on electrofishing training on the Mekong River.

3.5 Key results so far

3.5.1 PIT tag retention trials

Twelve PIT tag retention/mortality trials have been completed thus far on eight different species (Table 1). These trials are focusing on key species to determine whether the tagging process needs to be refined. Ensuring that the tagging does not contribute to mortality, and that the fish do not shed tags, is essential to ensure the veracity of the data collected within the fish pass. Sound experimental design has allowed isolation of cause and effect for the results in every trial. We have thus identified and improved any issues with fish husbandry; as well as any differences in fish health, fish mortality and tag rejection rates associated with the tag insertion techniques, operators, and/or water quality in the experimental tanks.

Table 1. List of species/size combinations used in PIT retention trials to date. TBC = to be completed. ** = one of the five high priority target species for investigation in this project (FishTek performed swimming speed trials on these 'target' species and used the data to help initially design the Xayaburi fish pass).

Species	Trial	Key findings
Pa saee (*Mekongina erythrospila)*	1, 3	Susceptible to increased mortality after tagging
Pa mang (*Sikukia gudgeri*)	2	Susceptible to increased mortality after tagging
Pa pak >210 mm (*Hypsibarbus lagleri*)**	4	Very low mortality rate suitable for tag and release in the field
Pa pak 150 to 210 mm (*Hypsibarbus lagleri*)**	5	Very low mortality rate suitable for tag and release in the field
Pa pak all sizes (*Hypsibarbus lagleri*)**	6	Very low mortality rate suitable for tag and release in the field
Pa sway (*Pangasianodon hypophthalmus*)	7	Difficult to maintain in captivity. Requires better understanding of diet and habits before next trial.
Pa kot reung (*Hemibagrus filamentus*)	8	Low mortality rate suitable for tag and release in the field
Pa sakang (*Puntioplites falcifer*)**	9	Low mortality rate suitable for tag and release in the field
Pa viengfai *(Barbonymus schwanenfeldii)*	10	Very low mortality rate suitable for tag and release in the field
Pa pakpian *(Scaphognathops bandanensis)*	11	Low mortality rate suitable for tag and release in the field
Pa kott (*Hemibagrus nemurus)***	TBC	Pending
Pa ort (*Pangassius elongates)***	TBC	Pending
Pa sroi (*Henicorhynchus lobatus, H.siamensis*)**	TBC	Pending

There have been notable improvements in the tagging techniques of the local operators as they have become more experienced (Figure 5). For instance, trial's 3, 4 and 5 compared two tagging techniques — scalpel-assisted insertion and syringe-assisted insertion. Both techniques returned similar tag retention and mortality results. Syringe-assisted insertion has been used in all other trials before and since. But we found that some of the operators preferred syringe insertion methods, whilst others preferred scalpels. Several species have proven to be very well suited to PIT tagging (e.g. Pa pak, Pa sakang, Pa viengfai) and are now deemed suitable for large-scale tag and release upon collection in the field.

Figure 5. Dr Wayne Robinson using a scalpel insertion technique to PIT tag a Pa pak individual during a field visit in June 2020 (source: Thavonne Phommavong).

Some species are either sensitive to tagging or have been difficult to care for in the fish research centre. For instance, one of the migratory species commonly captured at the site, Pa saee (*Mekongina erythrospila*), experiences high mortality from handling and significantly reduced growth rates after tags are inserted (Figure 6, Figure 7). Several trials are trying to resolve these matters but it could simply be that this species in not suitable for longer term migration trials. It is important to note that this highlights the value of tag retention trials prior to large-scale tagging in the field. Ideally, once fish are tagged and released into the Mekong, they should have a high probability of retaining the tag and surviving. This is the best mechanism to gain high quality data from the PIT system.

Other species have not performed well during the trials. Declines in the health of both control (untagged) and tagged fish suggest that health issues are unrelated to tagging; rather, they are a consequence of the transition from the ‘wild’ to ‘captivity’. Some fish have failed to eat whilst being held in concrete tanks, whilst others have been injuring themselves because a rectangle-shaped tank does not suit their biology. This is new information on these species and will be transferrable to other captive-holding applications beyond this project. For the species which are most affected, the team now have management plans in place, including not being held in captivity or undergoing a feeding trial experiment to ensure good health before being used in future tagging trials.

LARReC staff are also producing natural fish food and transporting it to Xayaburi for the team to trial.

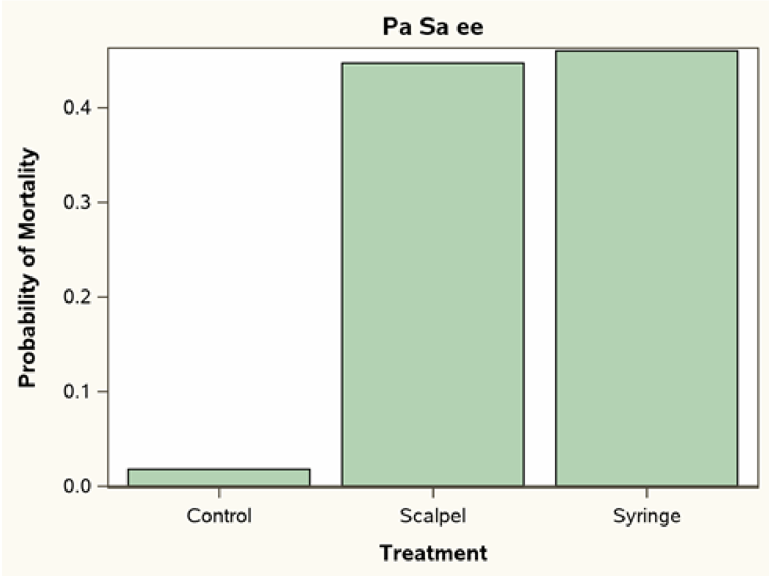


Figure 6. The probability of mortality of Pa saee (*Mekongina erythrospila*) for the three treatments tested in the PIT tag retention trial: scalpel-assisted PIT tag insertion, syringe-assisted PIT tag insertion and control (i.e. no tag). The figure demonstrates that tag insertion by either method resulted in about 40% of fish mortality.

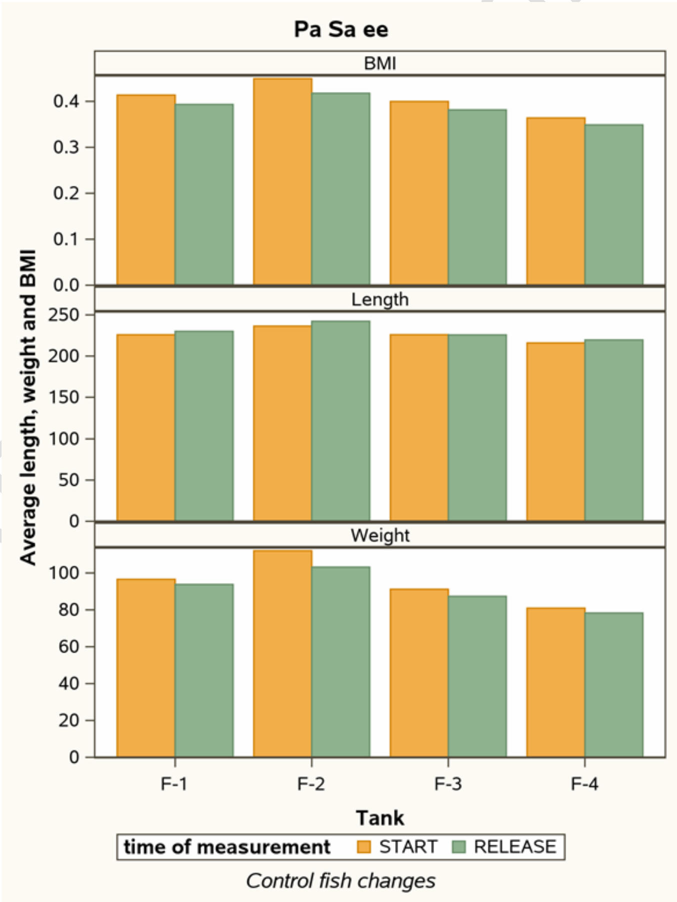


Figure 7. Changes in the length (mm), weight (g) and condition (as assessed by body mass index — BMI) of untagged (i.e. control) Pa saee in each tank (F1–F4), between the start and end (release point) of PIT tag retention trial 3. The declines in weight and body mass index during the trial indicate that even non-tagged fish of this species were not easy to husband in 2020.

3.5.2 Tag release data

To date, 1878 individual fish, from 23 species, have been tagged and released into the Mekong. Large-scale tagging has commenced, but many tag/releases have still been via the release of surviving fish at the completion of each tag retention trials, and/or by actively tagging and releasing fish into the Mekong on an opportunistic basis. The most released fish have been Pa pak and Pa sakang (Table 2). The team have attempted to tag a wide range of fish sizes. The biggest fish so far (Pa kaeng-kong) was 637 mm. There has been limited harvest of larger fish so far. But the team are on standby to tag significantly sized fish (over 1 m), given their overall social and economic value in the Mekong; and that these were a key species size upon which the fish pass was designed.

Table 2. Total number of fish tagged and released into the Mekong since training commenced in February 2020. Maximum and minimum length (mm) of each fish is also given to provide an indication of the size range released so far (* = total as of 11 October 2021). Shading indicates species caught in both years.

Detection year	Species	Min. length (mm)	Max. length (mm)	Number
2020	Hypsibarbus	145	450	2
	Pa bok	120	175	2
	Pa chaun	366	366	1
	Pa ka-soob	210	250	2
	Pa kaeng	217	230	2
	Pa ki-lam	196	196	1
	Pa kod-reung	101	350	54
	Pa koh	156	191	3
	Pa mang	116	200	19
	Pa nang-daeng	333	351	2
	Pa pak	118	469	195
	Pa pak-pian	155	279	53
	Pa phia	177	460	2
	Pa saee	179	393	29
	Pa sakang	160	285	205
	Pa sanak	238	238	1
	Pa sway	291	340	2
	Pa viengfai	150	268	64
2020 total				**639**
2021	Pa joke-gheaw	153	356	16
	Pa kaeng-kong	502	637	2
	Pa ki-leung	126	160	9
	Pa mang	95	207	251
	Pa pak	101	425	299
	Pa pak-pian	122	345	98
	Pa phia	500	632	6
	Pa saee	274	301	2
	Pa sakang	103	270	480
	Pa sood-jam	210	210	1
	Pa sway	285	350	10
	Pa viengfai	153	298	51
	Pa viengfai (altus)	126	242	14
2021 total*				**1239**
Grand total*				**1878**

3.5.3 Fish detection data

A PIT detection system has been installed to monitor both the entrance and exit fish-pass baffles. It has been fully active since November 2019. Fourteen species have been detected by the fish pass PIT system so far (with many of these involving the same fish being detected on multiple occasions). In total, across all 14 species detected, there have been more than 246,527 detections within the fish pass.

Interestingly, the detection data is providing an excellent source of continual seasonal movement data. The preliminary data collected so far is showing that some species have defined migration seasons (Figure 8). This will provide significant opportunities for fish pass optimisation into the future because entrance and flow settings could be 'manipulated', in various seasons, to maximise fish passage during peak periods.

Figure 8. Examples of migratory seasonality based on PIT detection data within the fish pass. Y-axis depicts total number of individual fish detected. X-axis provides the month detected. The six species here are showing seasonal patterns which will provide a powerful dataset when a multi-year dataset is available.

3.5.4 Additional Sensor Fish component

Given that the Sensor Fish data loggers are quite expensive and there is a high chance of losing when they are passed through the hydropower structure, we made up a series of 'dummy' Sensor Fish to practice our deployment techniques. These dummy Sensor Fish have been made similar in size, shape and buoyancy (but lacking the expensive internal electronics) to the real Sensor Fish, so as to replicate the real Sensor Fish for the deployment process.

The real Sensor Fish units have been received from the manufacturer in North America, and are being held onsite. We had planned to begin undertaking the deployment phase with the dummy Sensor Fish in April 2021. However, because of ongoing COVID-19 lockdowns at the site, our in-country team members have not been able to travel there to undertake this deployment phase.

3.5.5 Fish pass movement examples

A total of 687 unique (i.e. individual) fish were detected in the fishway. When compared with the 1878 tagged fish that have been released into the Mekong, it provides an overall 'recapture' rate of 36.6%. This is very high as most studies worldwide report values of less than 15%. The effort to refine tagging techniques, and define mortality rates, is leading to these high recapture rates.

Five-hundred-and-fifty-two (n=552) of these unique fish that were detected ultimately ascended the fishway successfully (Table 3). Therefore, 80.3% (i.e. 552) ascended the fishway from the 687 fish detected. One-hundred-and-thirty-five of the fish detected (19.7% overall), did not ascend the fish pass (Table 3).

Some species are more successful at ascending the fish pass than others. For instance, for Pa kaeng, Pa Ki Lam and Pa Ki leung – there was 100% passage success. Other species, such as Pa phia (25%) and Pa viengfai (altus; 40%) were not as successful at ascending the fishway; but the sample size of these fish is also very low. There were no fish species with a zero-passage success rate. That is, for all detected species, at least some individuals ascended the fish pass.

Of the 552 unique fish that ascended, 305 were 'simple' ascents where they were detected at the entrance, then the exit, then not again. Two-hundred-and-forty-seven were 'complex' ascents, which were detected at multiple antennas over extended periods of time, before they ultimately ascended. That is, they showed bi-directional movement before ultimately fully ascending and exiting the fish pass.

Pa kod-reung is an exemplar species with a complex ascent behaviour (Figure 7). These fish regularly move up and down within the fish pass over multiple-days and months. Their behaviour in the fish pass is consistent with residency for some individuals. The two fish that successfully ascended in Figure 11 were active within the fish pass over several months.

A Pa mang provided a good example of a 'simple' ascent. Here a single fish was detected within the fish pass on 3rd August at 1400. It ascended the fish pass in two hours and was detected at the exit at 1600 and then not again (Figure 8).

A single species, Pa koh, was recorded as 'descending' the fish pass. But the 'descent' was inconsistent with tagging data (the fish was released on the downstream side of the hydropower project in June). It is likely that this fish 'ascended' the fish pass either (a) when there was a power outage and the PIT system was down or (b) when the top antennas were not activated because of water level changes. There is the possibility that the fish ascended the navigation lock and then descended the fish pass.

Table 3. All fish that have successfully ascended the Xayaburi fish pass so far. These are fish that have been detected at both antennas and then not again for a significant period. The conclusion is that these fish have moved upstream through the fishlock, and then continued their upstream migration.

Species	Total detected (unique fish)	Ascended	Did not ascend	% passing
Pa Kaeng	2	2	0	100
Pa Ki-lam	1	1	0	100
Pa Ki-leung	2	2	0	100
Pa Kod-Reung	30	29	1	97
Pa Sa-Ee	12	11	1	92
Pa viengfai	51	47	4	92
Pa Joke-gheaw	6	5	1	83
Pa Pak	214	174	39	81
Pa Mang	91	71	20	78
Pa Sakang	233	181	52	78
Pa Pak-Pian	34	25	9	74
Pa Koh	2	1	1	50
Pa viengfai (Altus)	5	2	3	40
Pa Phia	4	1	3	25
Total	**687**	**552**	**134**	

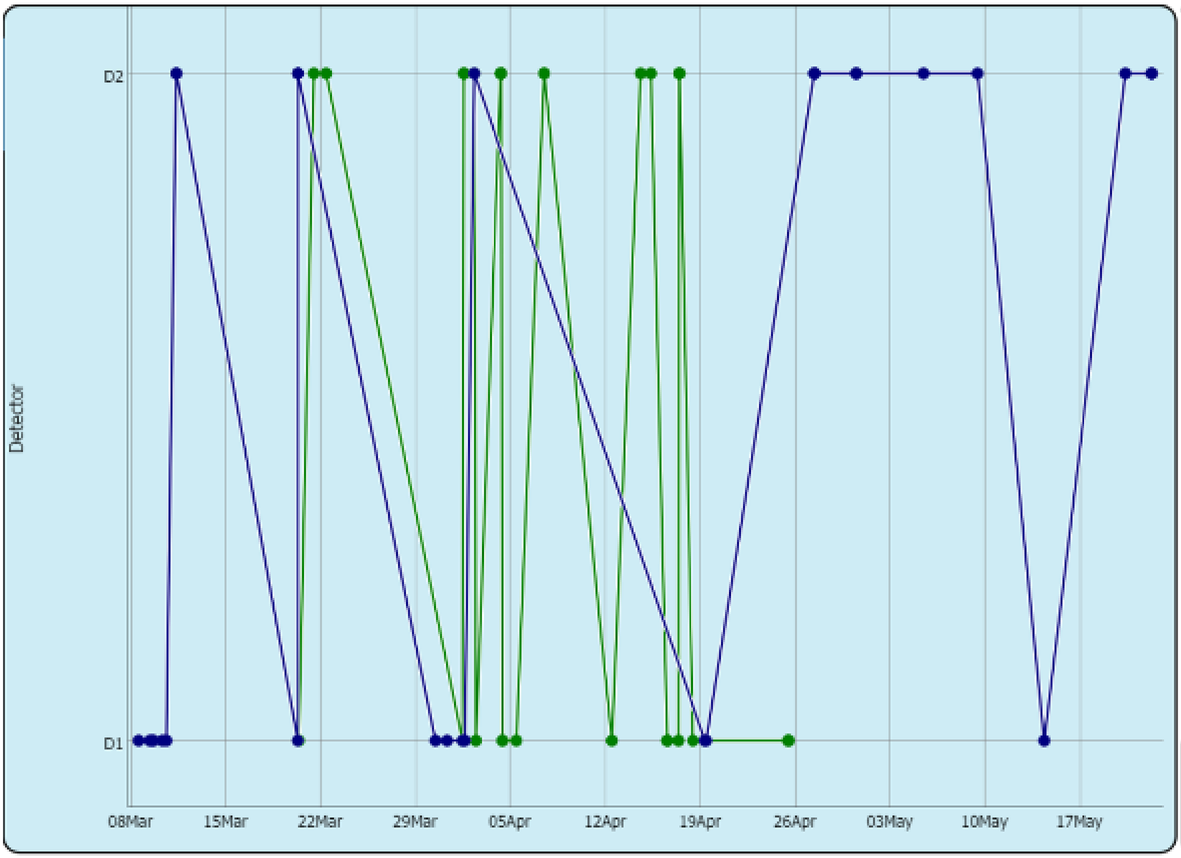


Figure 9. Example of 'complex' ascents for two Pa kod-reung. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

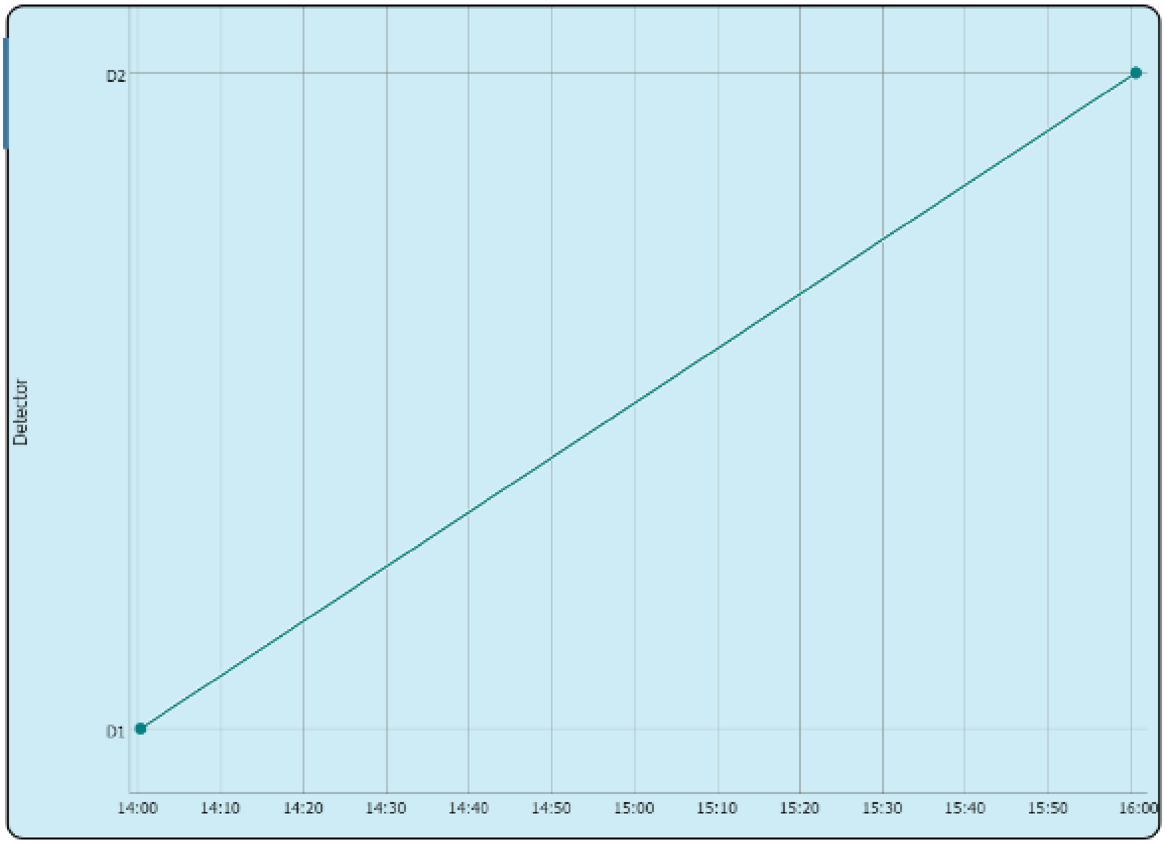


Figure 10. Example of a 'simple' ascent for a Pa mang. On the y-axis is the antennas (D1 – entrance and D2 – fish pass exit). X-axis is the time scale.

The data suggests that most species are easily ascending the fish pass. Many are detected at the entrance and then again at the exit shortly after. They appear to be able to navigate the internal flows and slots easily and many are ascending in a few hours. But the fish making complex ascents are more difficult to understand. They are either using the fish pass channel as a place of residency, possibly with the repeat up and down movements indicative of feeding on other fish in the channel. Alternatively, they may be having some difficulty ascending through the fish lock.

There is evidence of complex ascent behaviour from many species. Fish are frequently observed ascending the fish pass between the two antennas (entrance and exit) before descending again. Some fish then, presumably, leave the fish pass before returning after a period and attempting again. These ascents are generally considered 'unsuccessful'. But it is difficult to determine the reasoning for this behaviour and warrants further investigation. It could be because of fish pass operation or it could be biological.

One line of investigation would be to correlate the periods of fish ascent with fishlock operation. If the fish ascend through the fish pass but reach the fishlock when it is not in attraction phase, then successful passage would not be possible, or the fish could be delayed. Some species are known to quickly descend fish passes if there is no obvious passage and will attempt to try again via another route. But the only way fishlock synchronicity can be determined is by comparing lock operation records to fish ascent data.

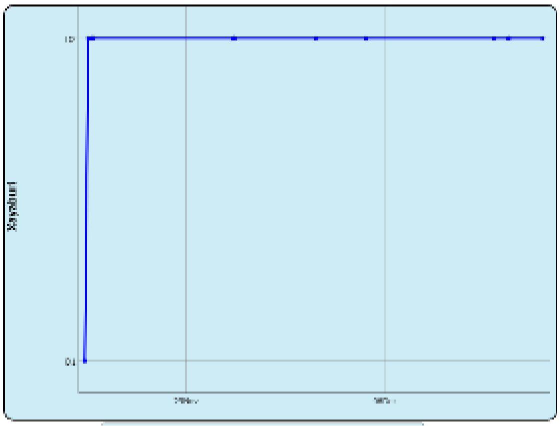
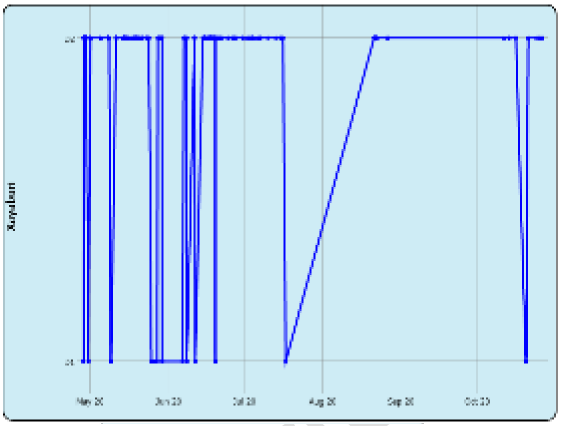
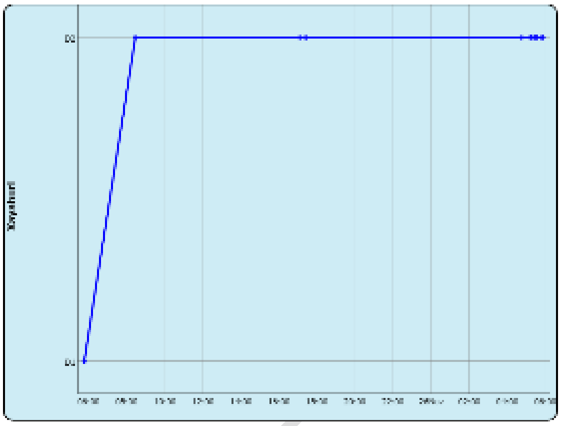
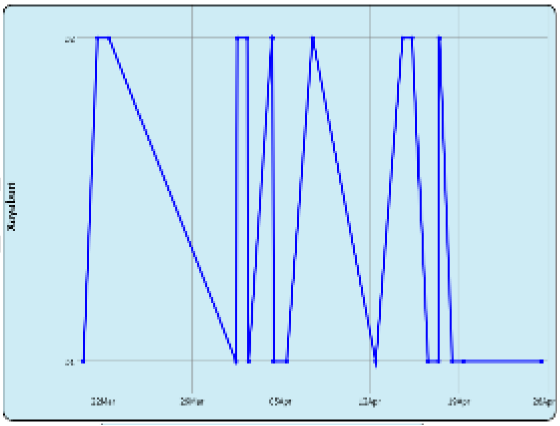
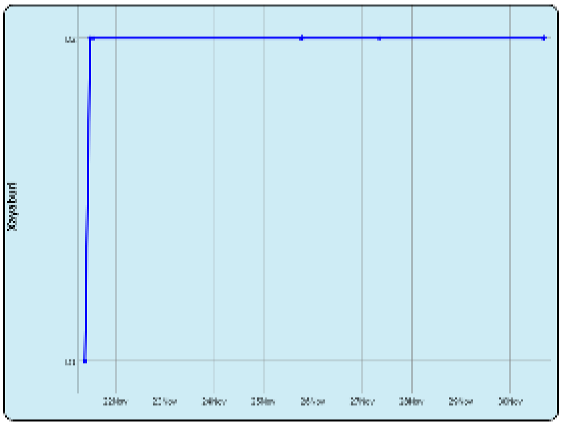
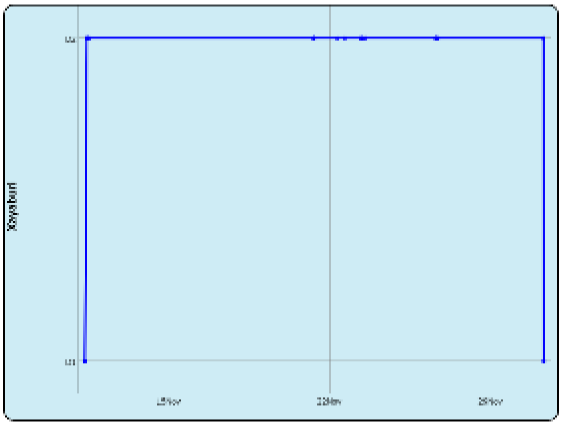
Successful ascent examples	Unsuccessful ascent / resident examples
Pa kod-reung, tagged 24th November 2020 	**Pa kod-reung, tagged 1st March 2020** 
Pa saee, tagged 6th August 2020 	**Pa keng; tagged 1st March 2020** 
Pa koh, tagged 10th June 2020 	**Pa pak, tagged 5th August 2020** 

Figure 11. Examples of fish ascent data through the fish pass. Y-axis depicts the antenna (D1 – entrance; D2 – exit). X-axis depicts time since tagging. These fish were selected as examples of fish displaying complex behaviour within the fish pass. Far more detailed analysis is planned across all fish detected so far to identify trends and patterns

4 Training activities

The following training activities were undertaken during 2020–21:

PIT system design

- The further training provided to NUOL, LARReC and XPCL staff on PIT tagging systems during the 2020 field trip.
- There have been ongoing online tutorials for database mining and fish data interpretation. These have been taking place as part of regular monthly meetings, and in lieu of our in-country team members being to travel to the study site because of the ongoing COVID-19 travel restrictions.

PIT tag retention trials

- The training provided to XPCL staff on conducting PIT tag retention trials during the February, June, August, October, and December 2020 field trips.
- The PIT tagging instructional movies developed by CSU for Lao-based staff. Funds were also obtained from the Crawford Fund to add Lao translations to the videos to assist with broader interpretation of the videos.

Boat electrofishing

- The boat handling and electrofishing training provided to XPCL, LARReC and NUOL staff during the February and June 2020 field trips. Further training is planned but has been delayed by the COVID-19 travel restrictions.

Sensor Fish

- The Sensor Fish instructional movies were shared with the in-country team members so that we can still efficiently deliver this component once the COVID-19 restrictions are eased (see 1.1).

ACIAR Internship

- The team were able to assist Vietnamese HDR candidate (Vu Vi An) by collecting some otoliths from migratory species on his behalf. This data was analyzed and presented to the team in early 2021, and An submitted his PhD for examination in August 2021.

5 Intellectual property

Intellectual property matters are unchanged from the project proposal. CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties. But for now, the team are still in the data collection and optimisation phase and this will continue for 2021. In early 2022, the governance team will reconvene and a plan for the publication and dissemination of key findings will be developed. There are some critical key learnings which can now be considered for dissemination.

6 Variations to future activities

The PIT tag trials have been progressing, but there was an initial nine-month delay in being able to commence the project due to the difficulties of working at a remote site, undertaking many tasks for the first time, and dealing with unexpected lengthy bureaucratic processes.

There have also been further delays over the last 12 months due to ongoing COVID-19 travel restrictions preventing both Australia-based and in-country staff from travelling to the study site to provide face-to face guidance and mentoring.

Consequently, progress towards the completion milestones has been delayed but the project is still essentially on-track despite COVID.

The team would like to work with XPCL to design and install an additional 'bank' of antennas that can be installed upstream of the fishlock (Figure 15; Figure 16). The proposed fishlock antenna would serve to detect the fish which have ascended the fish pass and then have passed through the fishlock and proceeded into the reservoir. Presently, a major limitation of the PIT system is its inability to detect any fish that have passed through the lock. If such an antenna system could be installed it would add significant value to the fish pass study.

Matters relating to site access have proven problematic. The Xayaburi Hydropower site is considered critical infrastructure. Any COVID-related outbreak on site could have significant implications for power generation. Hence, there are strict travel restrictions and quarantine procedures in place. The project team has been unable to gain permission to access site given the current COVID outbreak in Lao PDR. To offset this inability to travel to site, the team purchased and sent some additional tagging equipment. The idea is to continue fish tagging in the Vientiane reach and releasing to the river. If these fish are detected on the Xayaburi PIT system it will be wonderful evidence of long distance migrations.

The Sensor Fish component has been delayed by ongoing COVID-19 international and domestic travel restrictions (see 1.2). We have prepared the equipment and protocols and filmed a series of instructional movies so that we can continue with this component as soon as the domestic travel restrictions are lifted.

7 Variations to personnel

Dr Wayne Robinson is still in country, helping to coordinate project activities. He was undertaking field work in Lao PDR when the COVID-19 travel restrictions were initially enacted in early 2019 and decided to stay on.

His in-country presence has proven to be highly fortuitous, as he has been able to maintain an in-country presence for all three of our ACIAR projects — FIS/2014/041 (Variation 3), FIS/2017/017, and now FIS/2018/153.

Kyle Weatherman stepped in to fill Jarrod McPherson's technical role while Jarrod was away on paternity leave from October 2020 to February 2021. Jarrod then returned to the role, but in August 2021, he accepted another CSU role as the lab manager for the CSU Aquatic Lab. The salary dedicated to Jarrod is now being used to support Dr Wayne Robinson whilst he remains in Lao PDR.

8 Problems and opportunities

Problems

1. In addition to the initial nine-month delay experienced during the SRA project (see Section 6 for details), the COVID-19 travel restrictions and border closures have continued to prevent the CSU team from travelling to Lao PDR since the February-March 2020 trip. They have even prevented our in-country team members from travelling to the Xayaburi site for most of 2021.

2. There has still been no ongoing practical training for boat electrofishing for the XPCL staff. COVID-19 travel restrictions have prevented experienced electrofishing boat operators from CSU and USA travelling to Xayaburi and providing ongoing practical training and guidance. This has been an issue since the borders closed in March-April 2020.

3. XPCL staff were unable to operate the electrofishing boat for most of the 2019–20 financial year. One of the outboard motors had experienced mechanical issues, and it was difficult for a qualified marine mechanic from Thailand to access the Xayaburi site due to the strict COVID-19 travel restrictions. This has recently been rectified and the boat is now operating again and has done several trips in 2021.

4. The issue with the electrofishing boat reduced the ability of the team to capture wild Mekong fish during 2021. It was intended that the electrofishing boat would be the main capture method of fish for the PIT tag retention trials, since boat electrofishing causes the least stress and injury to the fish.

5. The PIT monitoring system installed on the Xayaburi fish pass has experienced occasional communications loss. This communication loss has been caused by issues with the Lao mobile phone network and power outages at the site. The team continue to work to resolve these issues.

6. The fisheries research centre at Xayaburi has been supplied with highly turbid water during the wet season. The high sediment load within the water has proven extremely difficult for staff to observe the fish within the tanks as part of the PIT tag retention trials. The turbid water is additionally having an impact on fish health as staff are unable to closely monitor fish behaviour and condition without having to net individual fish from the tank and therefore cause more stress to the fish. It is also making it difficult to collect dead fish and/or tags that have been shed.

To mitigate the impacts of high turbidity during the wet season, (1) the current storage, inlet pipes and drainage lines have been thoroughly cleaned, and (2) a filtration system has been installed. The filtration system consists of a small sand filter on the delivery valve for each tank and a large carbon filter on the inlet from the river to the storage tank. Both filter types will need regular cleaning throughout the wet season, sometimes daily.

7. Some fish species did not feed well after being moved to the fish research centre, resulting in impacts on their health. We have been working with the in-country staff to run some feeding trials determine appropriate food sources for these species.

8. The COVID-travel restrictions have meant that the project governance committee have been unable to meet, on-site, and deliberate over project progress. This has been unfortunate as the project is generating fantastic data and progressing well despite COVID. A virtual meeting was held in 2021 for the group to meet and discuss potential plans for travel in early 2022.

9. XPCL completed a community liaison program to inform the local villagers about the use of PIT tags in the fish captured at the study site. There is concern that locals may ingest microchips if not properly informed about the program. The villagers have now accepted the program and tagging is underway.

Opportunities

1. Fortunately, Dr Wayne Robinson was already in Lao PDR when the borders closed and he decided to stay on. Consequently, he and Garry Thorncraft (who was already based at NUOL) were able to continue undertaking site field visits to provide guidance with the PIT tag retention experiments (although this has been hampered in 2021 due to COVID domestic travel restrictions).

2. We have also transformed our working approaches to ensure that the project continues to progress. This has included:

- The initiation of the regular online meetings and a shared Dropbox folder with the in-country staff to follow progress, share results and other information, and resolve any issues arising.
- Us developing the short instructional films to guide the in-country staff in undertaking PIT tagging experiments and fish husbandry, and Sensor Fish trials (see 1.2).
- Further utilizing in-country resources such as the LARReC technical staff and fish hatchery manager. The LARReC hatchery manager travelled to the Xayaburi fish research Centre with Garry Thorncraft and Wayne Robinson, to provide expert advice to the XPCL staff on general fish husbandry and how improvements could be made to the facility to reduce the sediment loads within the water supply.

These new remote-working approaches, in conjunction with having staff in-country, have ensured that the project has essentially remained on schedule in meeting all its major milestones throughout the pandemic.

3. The benefit of being able to capture fish from the lock during 2020 is that it has assisted us in managing the 2021 catch. We have learnt a considerable amount in terms of transportation requirements, stocking densities, tank sharing, feeding requirements and disease management. We have also developed care management plans for most of the expected species in 2021.

4. Australia Award student, Vu Vi An, was assisted by the project team to collect some fish otoliths from Luang Prabang and downstream of the Xayaburi site. His PhD investigated the breeding location of several Mekong species and was missing data from the Mekong upstream of Vientiane. He has now been able to complete his dataset (and PhD thesis) thanks to assistance from the team and additional support from the project team.

[redacted]

[redacted]

[redacted]

[redacted].

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10 Appendices

Appendix I: Publications record (see the separate Microsoft Excel document)

Appendix II: Papers proposed:

1. Factors influencing PIT antenna efficiency at high fish passes.
2. PIT tag retention and mortality in key Lower Mekong Basin species
3. Monitoring the effectiveness of fish migration in tropical rivers
4. Optimising electrofishing for deployment in the Lower Mekong Basin
5. Nutritional benefits from restoring fish passage

Australian Government
Australian Centre for International Agricultural Research

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FIS

27 August 2019

Dr Jason White
Director, Research Office
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2678
AUSTRALIA

Dear Dr White

Project Agreement relating to ACIAR Project No. FIS/2017/017
Assessing upstream fish migration measuresat Xayaburi Dam in Lao PDR

The **Commonwealth of Australia** represented by the Australian Centre for International Agricultural Research (ACIAR) has approved the above project and now wishes to enter into an agreement (Project Agreement) with the (the Commissioned Organisation), ABN 83 878 708 551 to undertake the Project.

1. Formation of Project Agreement

The Project Agreement commences on the Commencement Date.

The documents that form the Project Agreement are:

(a) this Letter of Agreement;

(b) Attachment A - Standard Conditions; and

(c) Attachment B - Project Document (including Project Budget).

These documents constitute the entire agreement between the parties for the provision of the Services under the Project.

2. Priority of Documents

If there is inconsistency between clauses in any of the documents forming part of the Project Agreement, then the clause in the document appearing higher in the following list prevails to the extent of the inconsistency:

(a) The Letter of Agreement;

(b) Attachment A - Standard Conditions (dated September 2017) and

(c) Attachment B - Project Document (including Project Budget).

3. **Basic Definitions**

Unless the context indicates otherwise, the following words have the following meanings in this Project Agreement:

"Collaborating Institution" means:

- National University of Laos
- Living Aquatic Resources Research Centre
- Xayaburi Power Corporation Limited

"Commencement Date" means the date on which all relevant International Agreements are signed in accordance with paragraph 6 of this Letter of Agreement and:

- the Agreement comes into effect; and
- the Project is able to commence.

"Developing Country" or "Collaborating Country" means:

- Lao People's Democratic Republic

4. **Compliance with the Standard Conditions**

The terms and conditions set out in Attachment A (Standard Conditions) apply to the Project Agreement and the Commissioned Organisation must comply with Attachment A when performing the Services.

5. **Scope of Services**

The Commissioned Organisation will undertake the Services as defined in, and in accordance with, Attachment B.

6. **International Agreement**

Any international agreement that establish(es) the overseas operating framework for the Project including such matters as protocols, customs assistance, in-country security, indemnities and intellectual property rights will be signed by the parties to the Project.

The international agreement will be executed with each of the parties as identified as a Collaborating Institution in paragraph 3 (Basic Definitions) of this Letter of Agreement.

7. **Payment Schedule**

ACIAR will make payments for the Services in accordance with the Payment Schedule set out in Attachment B and the Standard Conditions.

8. **Financial Limitation**

The financial limitation of the Project Agreement i[redacted]xcluding GST). FOI Act s. 47g

Expenditure in excess of the Financial Limitation requires the prior written approval of ACIAR.

9. Duration

The services relating to the Project are to be performed from the Commencement Date with a scheduled completion date of 31 August 2022.

The Project Agreement expires on the date ACIAR receives from the Commissioned Organisation the Final Acquittal and if applicable all unexpended funds, which confirms completion of the Project and the Commissioned Organisation's performance of its obligations under the Project Agreement, unless terminated earlier in accordance with the Standard Conditions.

10. Contract Managers and Addresses for Notices

The Commonwealth's Contract Manager:

Name/position title:	The person occupying the position of Research Program Manager Fisheries, currently Dr Ann Fleming.
Postal Address:	GPO Box 1571, Canberra ACT 2601
Telephone:	[redacted]
Email Address:	[redacted]

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The Commissioned Organisation's Contract Manager:

As detailed in Attachment B.

11. Attachments

The following documents are separate but form part of this Agreement:

(a) Attachment A - Standard Conditions for Project Agreements between the Australian Centre for International Agricultural Research and the Commissioned Organisation as at September 2017; and

(b) Attachment B – Project Document including Budget for FIS/2017/017, Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR.

EXECUTED as an Agreement

If the Commissioned Organisation agrees to undertake the Services described in Project Document on the terms in this Agreement including the Standard Conditions, please indicate its acceptance by signing and dating both copies of the Agreement; retain one copy for your records and return the other to ACIAR.

Please note that until the Agreement is executed by both parties there is no legal relationship between the parties.

Signed for and on behalf of the **Commonwealth of Australia** as represented by the **Australian Centre for International Agricultural Research ABN 34 864 955 427** by its duly authorised delegate in the presence of

[redacted] ←   [redacted] ←

JULIA HELLE   Professor Andrew Campbell

Name of witness (**print**)   Name of delegate (print)

Chief Executive Officer

Position of delegate (**print**)

ON: [**insert date**] 27/8/19 ←

FOI Act s. 47

Executed by **Charles Sturt University** by its duly authorised delegate in the presence of

[redacted] ←   [redacted] ←

SHARON SANDRY   ANDREW VANN

Name of witness (**print**)   Name of delegate (print)

Professor Andrew Vann
Vice-Chancellor and President
Charles Sturt University

Position of delegate (**print**)

ON: [**insert date**] 28/10/19 ←

Australian Government

Australian Centre for International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/017
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organization, collaborating institution(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavors to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/017
Project title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Proposal stage	Full Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/09/2019
Proposed finish date	31/08/2022

Key contacts

Activity leader: Commissioned agent

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Position	Associate Research Professor (Fisheries and River Management)
Organisation	Charles Sturt University
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Fax	
Email	
Postal address	
Street address (if different to postal)	

Administrative contact: Commissioned agent

Title and name	Dr Jason White
Position	Director – Research Office
Organisation	Charles Sturt University
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Fax	
Email	
Postal address	

Collaborating scientist: Australian collaborating organisation

Title and name	Karl Pomorin
Position	Managing Director
Organisation	KarlTek Pty Ltd
Phone	[redacted]
Fax	
Email	
Postal address	
Street address	

Collaborating scientist: partner country collaborating organisation

Title and name	Mr Douangkham Singhanouvong
Position	Deputy Director
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Email	
Postal address	
Street address	

Collaborating scientist: partner country collaborating organisation

Title and name	Dr Oudom Phonekhampheng
Position	Vice President,
Organisation	National University of Laos
Phone	[redacted]
Email	
Postal address	
Street address	

Collaborating scientist: partner country collaborating organisation

Title and name	Dr Michael Raeder
Position	Owners Representative
Organisation	Xayaburi Power Company Limited
Phone	[redacted]
Email	
Street address (Lao PDR)	
Other address (Thailand)	

Collaborating partner: DFAT, Australian High Commission, Lao PDR

Title and name	Mr Dominique Vigie
Position	Manager – Greater Mekong Water Resources Program
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Other address (Postal)	

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Contents

1 Project Summary

1.1 Background and Justification

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupts access to vital spawning, nursery and feeding habitat. The LMB fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, will be operational in 2019. Xayaburi Dam blocks the entire width of the river, presenting an impassable barrier to all fish species. Significant investment (US$300M) to provide for fish passage was incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world. Nevertheless, the facilities need to be rigorously assessed to determine if they meet the design specifications.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. The dam design includes a series of 70 different moveable gates which can be configured to alter fish pass flow in order to improve passage rates for specific species and/or specific seasonal flows. The project team will be able to, within the funding envelope on offer, adaptively alter the configuration of the fishway and determine if different settings alter passage rates for particular fish species and their life stages, and for different seasonal flow rates. This will provide XPCL with operational recommendations to optimise the performance of their facilities overall. This represents a substantial challenge and the question of whether the fish passage facilities will be effective in allowing a large proportion of fish numbers and species to pass is a question that the developer, Government of Lao PDR and scientists are all keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential to be developed in regions where poor people are dependent on natural resources. The Xayaburi facilities provide an opportunity to design and commence experiments to test the efficiency of the fish passage design, and to apply/adapt learnings to other sites.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods that will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and *in situ*. These trials will be used to install a functional tag detection system which will be used. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust approaches to calculating fish pass efficiency. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Assess upstream fish passage within the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the 30-year concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). The overall project budget, excluding the SRA commitment, is split between three cash contributors [redacted] as significant additional in-kind support over the three year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defendable, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used to improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its support or publication of results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to other sites, for example, both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities and monitoring programs. The research methods developed here may lead to a new set of standards that can be applied at other sites.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams) (Commission 2010). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB (Hortle 2007, Baumgartner et al. 2016). Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein (ICEM 2010). Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction (Amornsakchai et al. 2000). The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade (Commission 2010), there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong's productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB (Orr et al. 2012). All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing a productive river fishery. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 95% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. This work was done by a US company and did not involve Australian expertise. XPCL has invested US$300 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America (Williams 2008), but where investment only targets salmon species. XPCL invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site. The purpose was to exchange information especially in relation to possible future

research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.2 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households (Hortle 2007). Most rural Asian citizens are actively involved in inland capture fisheries and river, and fishery health is crucial to securing food and income for local communities (Dugan et al. 2006, Millar et al. 2018). The Xayaburi Dam was expected to have a potential impact on upstream food resources; which is why a fish pass is being constructed. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It will also address an important planning need across the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development (Dugan et al. 2006). Irrigation development has negatively impacted inland fisheries (Dudgeon 2000). This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating positive outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing (Siason et al. 2010). Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has brought together an international team of private, developmental and governmental sectors to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to develop methods which will be available to quantify fisheries migration studies into the future.

2.3 Relationship to other ACIAR investments and other donor and partner-country activities

2.3.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (Australian Government AusAID 2012). By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies if the fish pass is effective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising female professionals to use the newly established research infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining robust fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome 'Agriculture, Fisheries and Water'. Hydropower development is one of the most significant water management issues in the LMB; and Xayaburi Dam, being the first site, is of particular significance and international interest. [redacted] Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due in December 2019. To maintain continuity for project staff, the large follow-on project must commence in August 2019.

2.3.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in researching the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies on all aspects of fish passage (upstream and downstream). XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.4 Research questions

2.4.1 Xayaburi fishpass overview

Specific design parameters were incorporated into the dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Fig. 1). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a ‘gallery’ toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) ‘choose’ to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

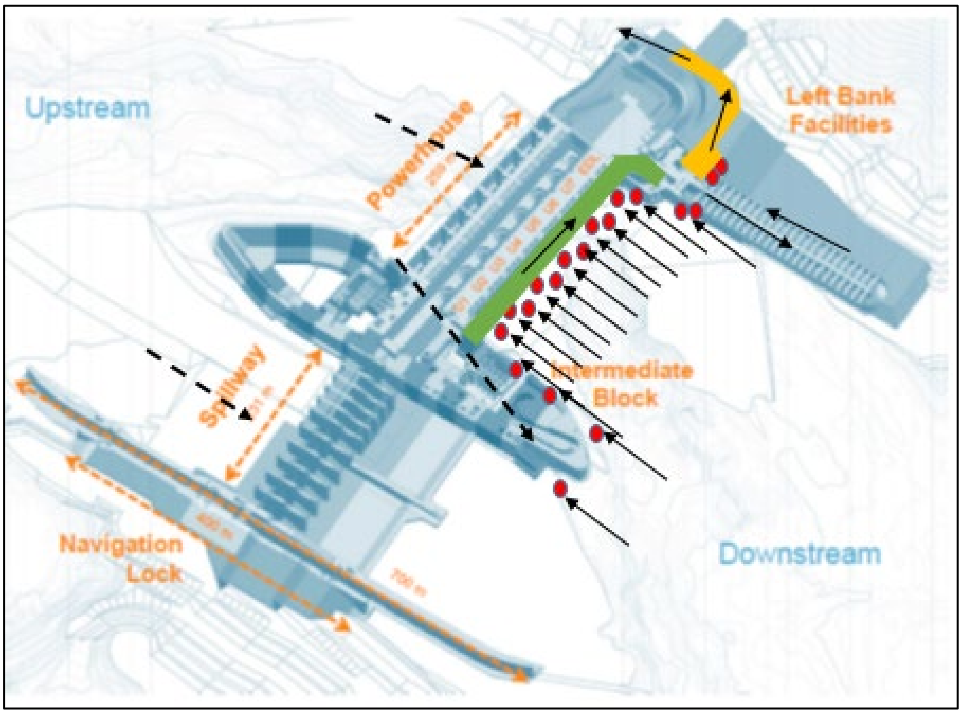


Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

2.4.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

2.4.3 Request from XPCL: Final selection of Research Questions

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, is beyond the scope of the available budget so the ACIAR/DFAT team is only focusing on methods to assess upstream fish passage at this stage. Consequently, the research questions posed are:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

2.4.4 Previous work on fish species selection for passage

There have been a number of fish studies done in the region of the dam as part of the environmental approval process, as well as earlier studies – in both the published and grey literature. These have generated a list of 308 potential adult species in the region, many of which are migratory.

Part of the GoL conditions of approval was that XPCL are required to provide for migratory fish to pass through the dam. To ensure the fish passage design catered to the slowest swimming species, FishTek, a British consulting company, performed a series of fish passage trials to identify the swimming abilities of key species. The swimming abilities of the slowest species formed the basis for the final design decisions for the fishway engineering. The GoL and XPCL agreed on a list of 26 potential migratory adult species (Table 2) that were the most important to monitor for effective passage. Their criteria for importance were based on a combination of food security and conservation significance.

XPCL contracted fishermen surveys to identify important species to the local fishers and communities (Team consulting, 2014). Using this study and others done in the region, we have highlighted in Table 2 (in bold) those species considered important for food security for local communities.

Thus, fish species selection in the project will be based on:

i) Those species that have been listed as important to pass through the fish passage by the GoL/XPCL, which includes species important to food security for local communities and conservation significance, and

ii) Those species that can be successfully tagged, released and monitored.

2.5 Gender focus

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong River bank in Xayaburi and Luang Prabang provinces, with seven of these requiring relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP has to enhance the quality of life for the project affected people (PAPs) and to minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Our research team is playing a very small, but important, role within XPCL's community consultation process. Our team will participate within the XPCL monitoring framework. In particular, we will engage with the XPCL consultation framework through our Lao government partners to ensure our decisions about fish species selection in relation to food security are endorsed by locals; including men and women. We also plan to include a Lao national on a project reference panel, so will report to them on our level of engagement with communities and inclusion of gender perspectives on key decisions, particularly regarding species selection.

Consideration of gender within the research team

Our research team consists of XPCL staff, Laos government (LARReC) and university staff (NUOL) and the Australian team. The XPCL monitoring team was selected by the company and staff were allocated to our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately, this has provided a gender structure among the project team which is predominantly male.

Outside the nominated project team in-country, the Australian team strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female Australian honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, but that the team is more balanced.

3 Research strategy and partnerships

3.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass, upstream, large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems.

The logical sequence for the proposed research is to:

1. Perform laboratory and *in situ* trials of three techniques (PIT detection antennas, electrofishing boat and a long-term tagging study) to optimise tag and recapture methods
2. Implement these methods at the dam site

3. Perform real-time monitoring of upstream fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual upstream fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, to report on the daily operation of the fish pass
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. Most of the current knowledge pertaining to the effectiveness of fishway designs has been for temperate species, and/or has come from laboratory-based trials (Mallen-Cooper 1992), whereas very little knowledge has been obtained via *in situ* field-based evaluations (Baumgartner et al. 2012). Indeed, only two *in situ* fishway evaluations have been published thus far in the LMB (Baumgartner et al. 2012, Baumgartner et al. 2018). At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defendable; and
c) When combined, provide an overall picture of upstream fish pass effectiveness.

4.1 Project aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities to move fish upstream.

The project team has been asked to provide advice on optimizing fish passage performance, not to set targets for triggering changes in operational procedures. We will select a subset of the 70 moveable gates within the fish passage design as reference points for fish pass performance. Each of these reference points will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. The results for various species, life stages and times of the year will be used to establish maximum achievable passage rates for each target species. These rates will be used to advise when and what operational changes should be made to the fishway to optimise the fishway's effectiveness for the target species, life stages and/or times of year.

The specific objectives are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

We note that passing fish downstream, including eggs and larvae, is also a significant challenge at the site. However, at this stage the team has only been asked to focus on upstream moving fish through the fish pass facilities. Downstream movement studies are equally important but, at this stage, are beyond the scope of the available budget and

request from XPCL. The team are very experienced with downstream movement work and can consider additions at a later stage if requested and appropriately resourced.

4.2 Research activities, methods and outputs

4.2.1 Monitoring upstream fish movement at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods (Williams 2008). Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters) (Williams 2008). In terms of fish monitoring research, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation, thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field

6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system), but have low overall ongoing running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely (Castro-Santos et al. 1996). At other dam sites world-wide, PIT data is being used to advise daily operations in relation to upstream migration rates. For instance, Bonneville Dam on the Columbia River (USA) has an elaborate set of fish passes and PIT systems (Williams 2008). The PIT systems report daily fish movement rates, both upstream and downstream, to a cloud-based database. Scientists monitor, in real time, passage rates and species arrivals. The PIT systems also report entrance efficiency and percentage passage rates based on pre-calculated algorithms. When different species arrive, or passage rates change, the flow rates through the dam gates or fishway channel are changed to maximise efficiency. These are ways in which PIT data can be used to provide real-time feedback between fish movement efficiency and dam operations.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

Integrity: This is the critical component of any system. A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

Veracity: It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system, a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events.

Reliability: This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency.

In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance (Castro-Santos et al. 1996). They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Selection of fish tracking technologies relevant to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL need to demonstrate through their research and monitoring program that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific upstream fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate fish are moving upstream.

PIT tags were determined to be a suitable technology upon which to base initial trials for upstream migration studies. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully (Castro-Santos et al. 1996, Baumgartner et al. 2010), (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in*

and *ex-situ*. Based on successes at other dam sites internationally (Castro-Santos et al. 1996, Baumgartner et al. 2010), PIT tagging has been identified as the most suitable technique. If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase (18 months): There is the actual testing (offsite) and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation.

(2) Operational Implementation (18 months): Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise the Xayaburi fishway's adjustable settings and integrate fish movement requirements into dam operation management.

4.2.6 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a “high dam” fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA) (Williams 2008). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System (PTAGIS) framework. PTAGIS is a large, spatially integrated upstream fish migration monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is ‘pinged’ within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement (Downing et al. 2001, Williams 2008).

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass (Barrett and Mallen-Cooper 2006). Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative

benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales) (Barrett and Mallen-Cooper 2006). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to that based on PTAGIS (See https://www.ptagis.org/). With two such systems operating successfully in cascade rivers internationally, and with a cascade proposed for the LMB, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

4.2.7 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a 'loop' that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency (K. Pomorin pers. comm.). PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway 'slots' to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions. The team have identified research questions that could be answered using a PIT system installed into the slots (of various widths) located along the length of the fish passage (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each is necessary.

Stage 2: Obtain detailed engineering drawings. The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped to identify optimal design configurations.

Stage 3: **Construct prototype antennas and set up 'in the dry'.** KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions; Figure 2). The antennas, as indicated in the options diagrams over page, will be constructed. The efficiency tests will be performed scientifically. Antennas will be tested for a range of width's and length's and two tag sizes will be assessed (23 mm tag and 12mm tag). The 12 mm tag is preferable as it is much smaller and produces a lower "tag burden" on fish. However, it has a smaller read-range

than the 23mm tag. Determining if 12 mm tags will perform efficiently with large antennas is essential. The approach will be to construct and establish each antenna, take five tag readings (each of a 12 mm and 23 mm tag) and record the read distances (in cm). These readings will be plotted to provide an efficiency map for each antenna morphology. This approach is considered world-standard for antenna efficiency tests.

Figure 2. Slots where antennas are proposed to be installed and possible configurations.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the *ex situ* test in stage four in terms of percent number of tagged fish detected (See Table 3 for list of fish passage criteria to be assessed), we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these *in situ* tests will then advise the locations where fixed antennas should be located.

Additionally, and based on *ex situ* testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway. Here we will initially focus on the entrance and exit locations of the fishway. A 'bank' of antennas will be fitted to the entrance slots; a second 'bank' will be fitted to the exit slots.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

4.2.8 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable

because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others) (Thorstad et al. 2013). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

<u>*Research activities*</u>

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 300 migratory species at the Xayaburi site and at least 26 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Two previous fish studies have been conducted at the site. The first, by “Team Consulting”, and the second by “FishTek”. These studies firstly, quantified the species present on site and, secondly, determined the swimming ability of these species to inform fishway design. These data, along with information from the community consultations as to which species are important food sources, was used to generate a shortlist of potential priority species for fish passage. (Table 2). The fish pass infrastructure was designed specifically to accommodate these species. What is unknown is whether these species are optimal candidates for PIT tagging. It is proposed, to test the efficacy of PIT tagging for each species under laboratory conditions.

Stage 2: Construct a fish hatchery facility to house the wild caught fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction is due for completion in June 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial ACIAR-funded work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish (Grieve et al. 2018a). So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days (Grieve et al. 2018a). However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the batch of tagged fish to inform on fishway operation.

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

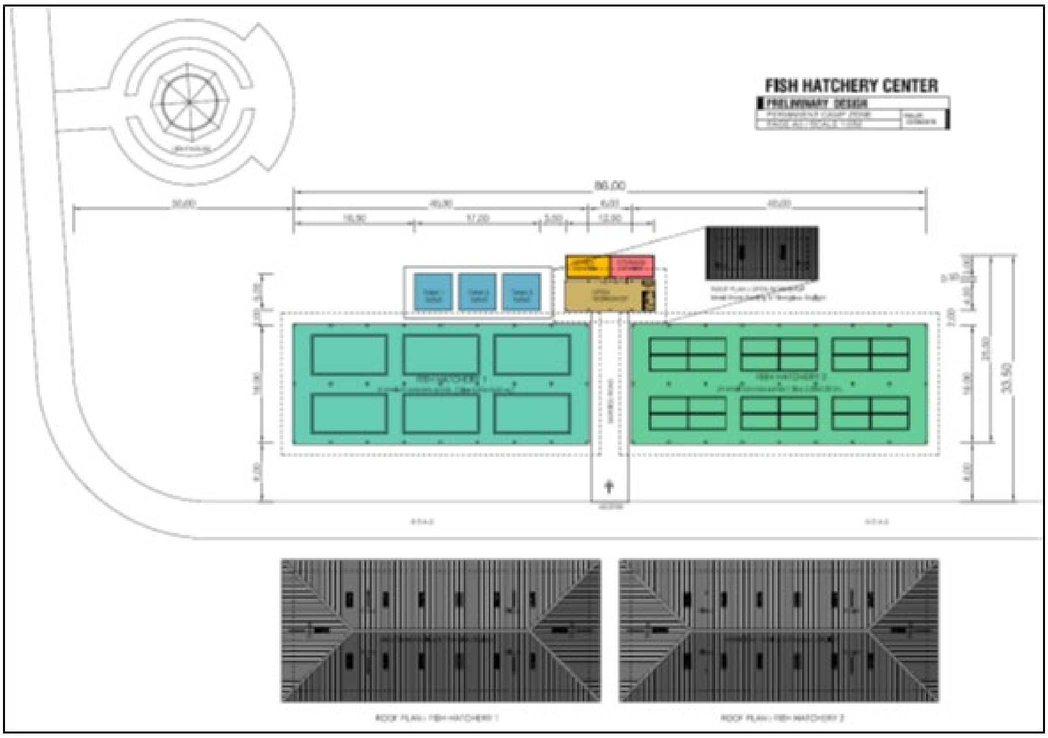
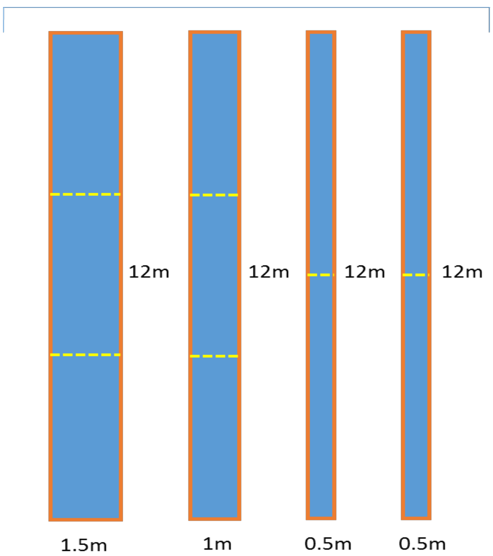


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

<table>
<tr><th>Antenna design</th><th>Diagram</th></tr>
<tr><td>Maximum predicted number of antennas for each width of fish slot in the fish passage: three antennas for the wider slots (1.5 and 1m), and two for the two narrower slots (0.5 m).

antenna fitted into the 12m high fish slots.

Number of slots to be fitted = 8.</td><td>
</td></tr>
</table>

4.2.9 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. However, gill netting is a harsh technique that can cause stress and, in extreme cases, impact survival. Tagging a fish that has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish (Sigourney et al. 2005). It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a ‘research exemption’ from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL has provided all funds to purchase the vessel and will allocate contractors to fit out the vessel. This was on the basis that CSU can guide operation and train Lao government, University and XPCL staff in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish (Bohlin et al. 1989). It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival (Burkhardt and Gutreuter 1995). It is widely used in Australia, and Charles Sturt University will run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river; therefore, combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. There are two commonly applied approaches to electrofishing; the “grunt method” and the “power transfer” method.

For the “grunt” method, the boat is started and the voltage settings gradually raised until the generator is significantly working to input electricity into the water. It is the most commonly applied approach in Australia.

For the “power transfer method”, the electrofisher settings are optimised to the water conductivity. “Power transfer theory” predicts that electrofishing will be optimised when the conductivity of the fish matches that of the water. As such, voltage and amperage settings can be optimised depending on the water conductivity in order to match, as closely as possible, the target species.

For this research component, we will compare the “grunt” and “power transfer” fishing methods. We will need to firstly determine the “conductivity” of the target species. This is achieved by using a multimeter to measure the conductivity of target fish. Then we will manipulate the voltage settings of the electrofishing unit (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong. For each electrofishing "shot" all species will be collected, measured and weighed. Statistical analyses will be performed to determine if any differences exist between the two methods.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into the Mekong River Commission Design Guidelines for Mainstem Dams.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

Table 2. List of migratory adult species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Green indicates the upstream migration season and yellow the downstream migration season. Imp column indicates the primary importance of the species whether for food, conservation or income.

Species	Imp	Local name	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Cyclocheilichthys enoplos	F	Pa Joke												
Cyclocheilichthys repasson	F	Pa Joke-sai												
Henicorhynchus lobatus	F	Pa Sroi												
Labeo chrysophekadion	F, I	Pa Pia												
Hemibagrus nemurus	F, C, I	Pa Kod												
Mekongina erythospila	F	Pa Sa-ee												
Sikukia gudgeri	F	Pa Mang												
Chitala sp.	F, I	Pa Tong												
Pangasius macronema	F, C, I	Pa Yorn												
Hemisilurus mekongensis	F, C, I	Pa Dangdaeng												
Phalacronotus apogon	F, I	Pa Sa-ngua												
Bagarius suchus	F, I	Pa Khae												
Paralaubuca typus	F	Pa Teab												
Tenulosa thibaudeaui	F	Pa Mak-pang												
Pangasianodon hypophthalmus	F, C, I	Pa Sway												
Cyprinus carpio carpio	F, I	Pa Nai												
Yasuhikotia modesta	C	Pa Kiaw-Gai												
Macrochirichthys macrochirus	F	Pa Fak-pa												
Pristolepis fasciata	F, C	Pa Chang-yeab												
Pangasius bocourti	F, C, I	Pa Phor												
Pangasius conchophilus	F, C, I	Pa Mong												
Pangasius larnaudii	F, C, I	Pa Thay-po												
Phalacronnotus bleekeri	F, C, I	Pa Sa-ngua												
Wallago attu	F, C, I	Pa Kaow												
Hemibagrus filamentus	F, C, I	Pa Kod-rueng												
Pangasianodon gigas	C	Pa Buek												

4.2.10 Research component 4: Measuring upstream fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study the project team were to use PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations which are all being applied to the work at Xayaburi. So the team are starting from a strong knowledge and experience base.

For application at Xayaburi there is a defined chronological sequence that needs to be completed in order to arrive at this research component. For example, the antennas must be installed, then it will be possible to use the PIT system to determine the overall efficiency of the fish pass. The tag validation trials must have been completed, and we must be able to collect sufficient sample sizes of fish. Some of this is seasonal and some will vary annually. So the proposed species list will need to be revised on an opportunistic basis.

Once all stages are completed, and if the PIT tag system reveals that the fish pass is demonstrated to be sub-optimal (for one or more species), then the dam constructors have incorporated a series of 70 different moveable gates which can be configured to alter fish pass flow in order to determine if improved passage has been achieved. So the project team will be able to adaptively alter the configuration of the fishway and determine if different settings alter passage rates.

It is important to emphasise here that optimal passage rates are difficult to set at this fish pass facility. Our approach will be to record the current rates, seek to understand where design points could be improved and manipulate the adjustable gates to optimise passage rates. So our aim is to achieve a change in percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation (using methods developed in research component 2). Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will shed tags, there will be a need to re-tag fish in every year to maintain a sufficient sized pool of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating at maximum efficiency.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	Conclude tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunis tically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track
2.2	Organise a reference panel discussion about technical aspects	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
2.7	Project steering committee meeting	Hold team meeting on site	Nov 2020	All milestones are met	Project progress is on track

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	Aug 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are four main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission and community beneficiaries.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway for upstream migrants.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.

The Mekong River Commission (MRC) is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “Mainstem Dam Hydropower Guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a “Joint Environmental Monitoring Initiative” (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. There is some overlap between the

JEM initiative and the proposed research plan. Where overlap exists, then is an opportunity to ensure that so that results can inform the environmental monitoring requirements and standards for future dams. We will also be the first to have trialled many of these technologies on the Mekong. So there is significant interest from the JEM team, where there is obvious mutual interests, to integrate their training of local staff with the technologies being implemented on site. Of prime importance is that the process of fish selection for testing considers the food security needs of impacted communities. The interests of community beneficiaries will be considered by inclusion of a civil society representative on the Advisory Panel.

Project extension and communication

Project extension and communication will be promoted to the extent agreed by project partners, and by the terms negotiated through the reference panel. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam and it is important research results are presented in a defendable manner. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect these items and is unwilling for the technical details of its product to enter the public domain during the research phase. XPCL also have commercial-in-confidence considerations. With these issues in mind, the project team has entered into a confidentiality arrangement where no public project messaging will be made without the approval of all parties. Thus, extension and outreach will need to be carefully managed throughout project implementation.

4.4.2 Capacity building

Partner countries
Fish passage technology and implementation, as pertaining to hydropower dams, will provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL has a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from our research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Australian team
Australian researchers will benefit from involvement in the project. The tropical rivers of South East Asia offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes than they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with future hydropower development activities.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, there is potential to link with the Mekong River Commission's JEM initiative and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Action Plans', which take the activities and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These annual plans are devised before each New Year, and assessed at the end. These Action Plans then inform Progress Reports.

Medium-term cycles

The yearly reports and a forum, will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year, and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program

- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai (XPCL employed) scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) Factors influencing PIT antenna efficiency at high dam fishways
  (b) Tag retention and mortality in key Lower Mekong Basin species
  (c) Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers
  (d) Optimising electrofishing for deployment in the Lower Mekong Basin
- A project final report
- Abstracts published in conference proceedings

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.6 Intellectual property and other regulatory compliance

See Section 7. Appendix A.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site, and the overall fish pass performance has implications at a site, national and international level. Site based impacts relate to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and the development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam’s day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we plan to influence the design and construction of other dams into the future (Figure 5).

Importantly, our team focusing on upstream migration only will limit the extend of applicability to other dams. It is important to note that, if the majority of fish are migrating upstream to recolonize habitat, or to spawn, it follows that these fish may need to move downstream at a later date to complete important life history stages. Focusing on upstream migration, at least initially, effectively mitigates a series of risks because our team is only focusing on one aspect initially. Thus, the political pressure to provide answers to <u>all</u> migration questions is significantly reduced by this focused scope.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The “gold standard” Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs.

Long term (strategic):

1) PIT tagging incorporated into the Mekong River Commission Design Guidelines for Mainstem Dams
2) PIT tag systems installed at other mainstem dam sites
3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key South East Asian economies on a common issue.

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across South East Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

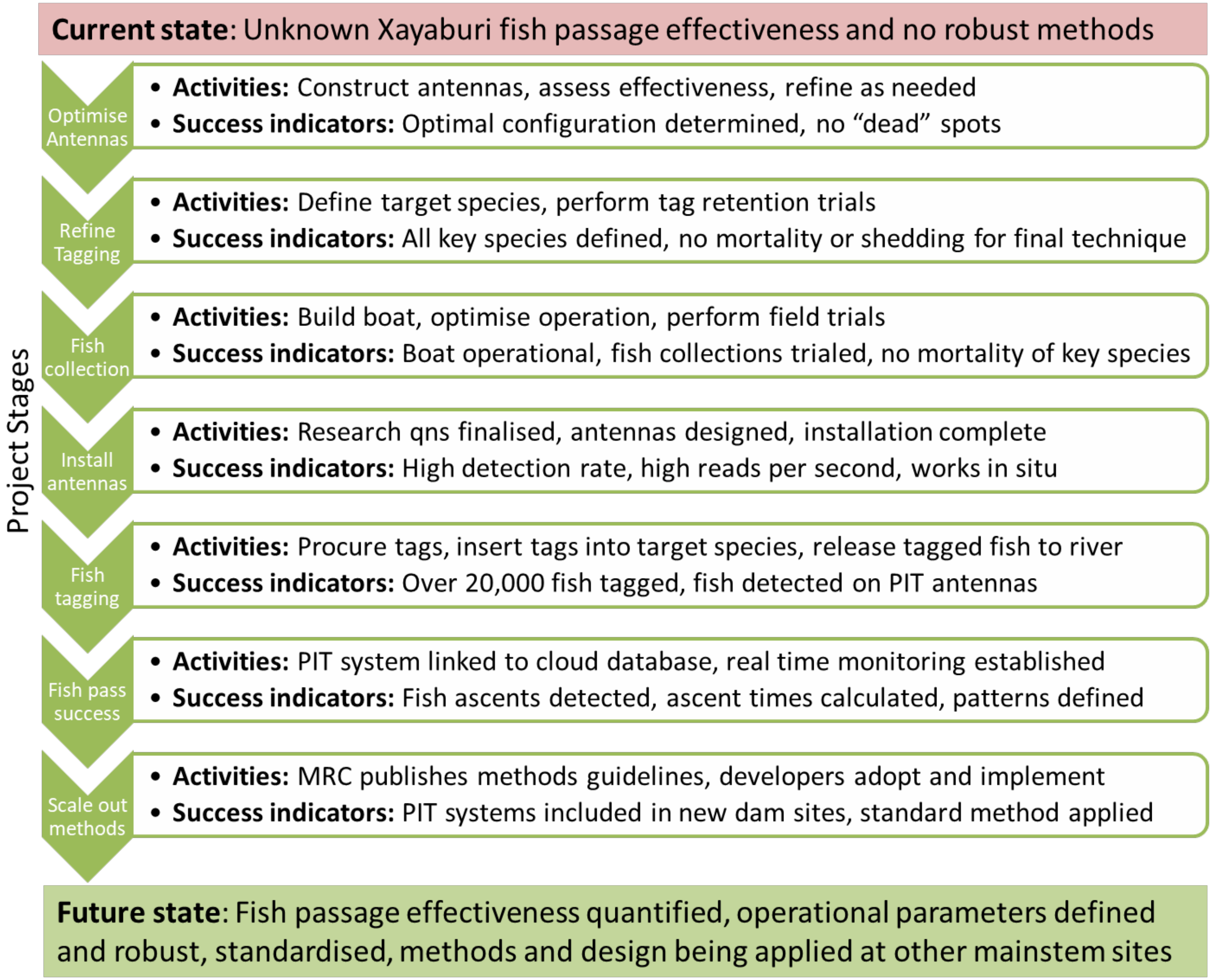


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the LMB and globally. It is important to note that the methods being developed will be applied in the LMB for the first time. Further, the implementation is occurring at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground, but we recognise that there are many assumptions and challenges that may lead to compromised data and outputs. To mitigate this risk, we have consulted with a biostatistician experienced in the Australian hydroelectric research field to advise on how to ensure statistically robust methods in the event of each possible failure point.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring upstream movement using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility for their research and monitoring program, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. PIT tagging: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. Electrofishing: A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating masters students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have conditional approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is imported from outside over the short term and built through a steady stream of learned graduates over the longer term.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hands-on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.4 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by participating in MRC dam guidance discussions and development where appropriate. An important platform for these discussions will be through the reference panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4 Community impacts

The science justifying fish passage implementation is sound (Williams 2008, Baumgartner et al. 2016). Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an "impact investment". That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems. The research impact of this project is within the footprint of the Xayaburi Dam

site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner that can influence these outcomes, particularly through the Advisory Panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards (Commission 2010). The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction cost is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $300M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year (Nam et al. 2015). Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to meet the performance specifications set by the GoL, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region, while recognising the immense technical challenges we face in realising these results.

5.4.2 Social impacts

It is expected that effective fishway construction on mainstem dams will ultimately maintain fisheries productivity, although many technical and operational challenges must be overcome before this is verified through the project. The local benefits to communities from this research are maintained food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls in decision-making (Siason et al. 2010, Baumgartner et al. 2016)

Local communities will directly benefit through unchanged access to fish for food and income if the Xayaburi facilities are demonstrated to work. Nonetheless, if the Xayaburi facilities are demonstrated to not work effectively, this research will be critical to informing XPCL's business decisions about which aspects of the fish pass to target for maximising improvements to triple bottom line outcomes.

Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed and operated, any fish that move upstream through the dam will become accessible to the upstream villages, thus creating an equitable access to the resource. However, there are likely to be considerable negative social impacts as there are numerous unknowns about the design and function of the fish passage infrastructure. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative social impact, considering the reliance of the capture fishery of the LMB for food security and income (Nam et al. 2015). Apart from those adverse effects due to dam construction and forced relocation, is the likely overall reduction, to some extent, in fish passage compared to pre-dam conditions, leading to a reduced abundance and range of fish species accessible to fishers. The project is likely to indirectly improve social benefits by minimising this negative impact - through advice to XPCL on operational management to optimizing fish passage at the Xayaburi Dam, and more broadly to the GoL on standardised tools and protocols for fish tagging and monitoring, and improvements in fish passage design for future hydropower development.

Therefore, demonstrating fish passage functionality through robust research is very important for XPCL to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The Xayaburi fish pass facilities were constructed to ensure fish are able to pass the dam. The overall aim is to demonstrate, through sound operation and integration into dam operations, fish pass effectiveness. The overall aim is to ensure fish communities upstream of the dam do not decline. The flow on effects to livelihoods and nutrition are being measured through the XPCL community program.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the region can be measured by the ability to influence Mekong River Commission mainstem dam guidelines, ensuring new dams include functional fish passes, as well as adopt standard monitoring methods.

6 Project management

6.1 Management aspects

6.1.1 Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be

responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work. A recommendation from these consultations was to establish a Project Reference Panel consisting of the major stakeholders that would be regularly briefed and consulted regarding project progress and outcomes.

Under the contract terms of the first phase of research (the SRA), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated the panel meet on an annual basis, at the dam site.

The Project Reference Panel will have advisory status, and consist of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited plus representation of Lao nationals (Figure 2).

They will conduct their business in confidence which will be defined by a terms of reference will be established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly-funded data must be openly available according to ACIAR’s contractual requirements, and also that that some IP will be required to remain commercial-in-confidence.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. We need to respect that our research team are invited ‘guests’ on the project site. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support.

The data sharing and publication arrangements therefore need to be carefully considered and discussed and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

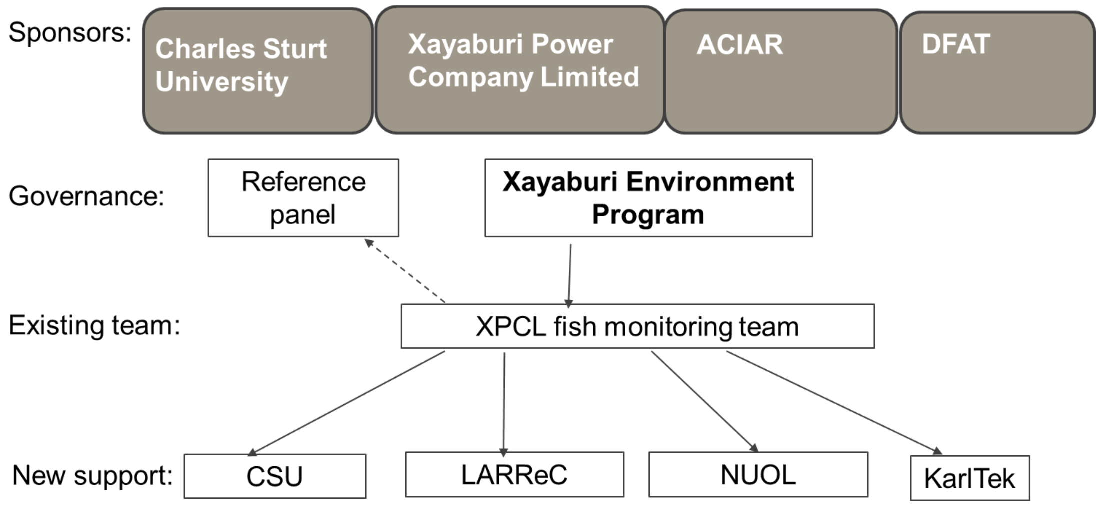


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will integrate within existing governance arrangements.

6.1.2 Mid and final project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR "mid-project review" (after 18 months) and "end of project review" processes.

6.1.4 Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role on-ground in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Douangkham Singhanouvong (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Coordinator and Government rep	
Douangkham Singhanouvong	M	Living Aquatic Resources Research Centre	Deputy Director	Coordinator and Government rep	
Thonglom Phommavong	M	National University of Laos	Research Associate	Collaborating scientists	
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	
Phousone Vorsane	M	National University of Laos	Research Associate	Field technical support	
Saleumphone Chantavong	M	Living Aquatic Resources Research Centre	Research Associate	Field technical support	
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	
Michael Raeder	M	Xayaburi Power	Owner Representative	Owner representative	
Dominique Vigie	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	
Casual Staff	TBA	Charles Sturt University	TBA	Assistance with fieldwork or other project requirements	
Lauren Withers	F	Australian Volunteers	Volunteer	Project support	
Garry Thorncraft	M	National University of Laos	Research Associate	Collaborating Scientist	
Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental Monitoring	Project support	
Jarrod McPherson	M	Charles Sturt University	Research assistant	Field support and coordination	
Nathan Ning	M	Charles Sturt University	Scientist	Manuscript preparation and writing	

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Chris Barlow	M	IP Matters	Director	High level support and writing	

6.3 Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

Name	Gender	Agency	Position at agency	Project Responsibilities	% on Project	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	1.0	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	1.0	
Jürgen Geist	M	Technical University of Munich	Chair of Aquatic Systems and Director of FITHydro initiative	Reference panel member	1.0	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	1.0	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	1.0	
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member	1.0	
Dominique Vigie	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Reference panel member	1.0	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	40	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required.

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

6.4 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	
Jarrod McPherson Charles Sturt University	
Thanasak Poomchaivej Xayaburi Power Company	
Dr Michael Raeder Xayaburi Power Company Limited	
Garry Thorncraft National University of Laos	

Name	[redacted]
Dr Oudom Phonekhampheng National University of Laos	[redacted]
Douangkham Sinhanouvong Living Aquatic Resources Research Centre	[redacted]
Karl Pomorin KarlTek Pty Ltd	[redacted]
Dr Nathan Ning Charles Sturt University	[redacted]
Dr Chris Barlow Fish Matters IP	[redacted]
Lauren Withers (and others) Australian Volunteer	[redacted]

Name	[redacted]
Phousone Vorsane (NUOL) and Saleumphone Chantavong (LARReC)	
Thonglom Phommavong (NUOL) Khampheng Homsombath (LARReC)	

6.5 Summary details of proposed reference panel participants

Name	[redacted]
Jody Swirepik (chair) Australian Government	
Dr Elizabeth Pope Snowy Hydro	
Prof Jürgen Geist Technical University of Munich	
Dr Michael Raeder XPCL	

Name	[redacted]
Lao citizen representative TBA	
Dr Ann Fleming ACIAR	
Dominique Vigie DFAT	

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6.6 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR. CSU has extensive experience with PIT system data analysis and installations throughout Australia and has extensively collaborated with researchers and the Australian government on the installation of fish monitoring systems since 2001. There are no other universities in Australia with such extensive experience and networks for fishway monitoring.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (HDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

7 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

7.1 Administrative details

[redacted]

7.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

[redacted]

If “yes” to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	Details of plant or animal germplasm exchange

Proprietary materials, techniques and information

[redacted]

“Data” means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

7.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If "yes", for each applicable country provide brief details.

[redacted]

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Australian Government

Australian Centre for International Agricultural Research

Full Project Proposal

ACIAR Program(s) area	Fisheries
Project Title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Project Number	FIS/2023/133
prepared by	Lee Baumgartner and Nathan Ning
ACIAR Research Program Manager	Dr Chris Cvitanovic

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Summary Information

Version # and date of this document	August 2023
Project number	FIS/2023/133
Full project title	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods
Budget ($)	$5,700,000
Commissioned Organisation	Charles Sturt University
Project Leader	Dr Lee Baumgartner
Country 1 Coordinator	Dr Oudom Phonekhampheng (NUOL)
Country 2 Coordinator	Dr Michael Raeder (XPCL)
Proposed start date	1/07/2024
Proposed end date	30/06/2029

Contents

1. Project justification

1.1 Project aim

This project aims to minimise the potentially harmful impacts of hydropower dams on the productive fisheries, and the people who depend upon them, in the Lower Mekong Basin.

1.2 Development issue and research opportunity

Development issue

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively and severely impacted if all planned large-scale mainstem hydropower dams are completed without appropriate consideration for the impacts on fish migration and people who depend upon migratory fish. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The dams have divided public opinion. The Mekong region fishery has been estimated to be worth US$4-7 billion annually (Nam et al. 2018), but dams are expected to reduce, by more than half, this important source of food and income for many people (ICEM 2010).

Hydropower development (HPD) on the Mekong River is expected to aggravate food insecurity and poverty in the region (MRC, 2018). Thailand is expected to suffer the most economically and ecologically, and full dam development will decrease GDP growth for LMB countries by US$29 billion (MRC, 2018). Native fish stocks will be particularly impacted, with more than 900,000 tonnes of fish biomass, worth US$4.3 billion (Figure 1), predicted to disappear by 2040 because of dams. Thailand (55%) would have the highest rate of fish loss, followed by Lao PDR (50%), Cambodia (35%) and Vietnam (30%).

Social impacts are also expected, such as livelihood and food insecurity reductions, and will largely affect riparian communities. Environmental issues of reduced water quality decreased fish quantity and unstable water flow will exacerbate these losses (Soukhaphon et al. 2022). Loss of livelihood is expected to be cumulative and become increasingly significant as more dams are constructed along the Mekong River. Issues of food and livelihood security are also faced by those relocated and not provided appropriate compensation. Dam proponents suggest that these impacts can be minimised through the application of technical solutions, such as fish passes (Baumgartner et al. 2018; Baumgartner et al. 2012).

The first LMB mainstream dam, at Xayaburi, in Lao PDR was completed in late 2018 (Figure 1). Xayaburi Dam blocks the entire width of the river with a dam wall more than 30 m high, presenting an impassable barrier to all fish species (Orr et al. 2012). Significant investment (US$380M) to provide for fish passage was incorporated into the final designs to minimise impacts on fisheries. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical world. However, at the time of construction, there were no data available globally to inform the likely success, or otherwise, of such an investment in a river system with a highly diverse fish community like the Mekong. The success of this structure was the focus of FIS/2017/017.

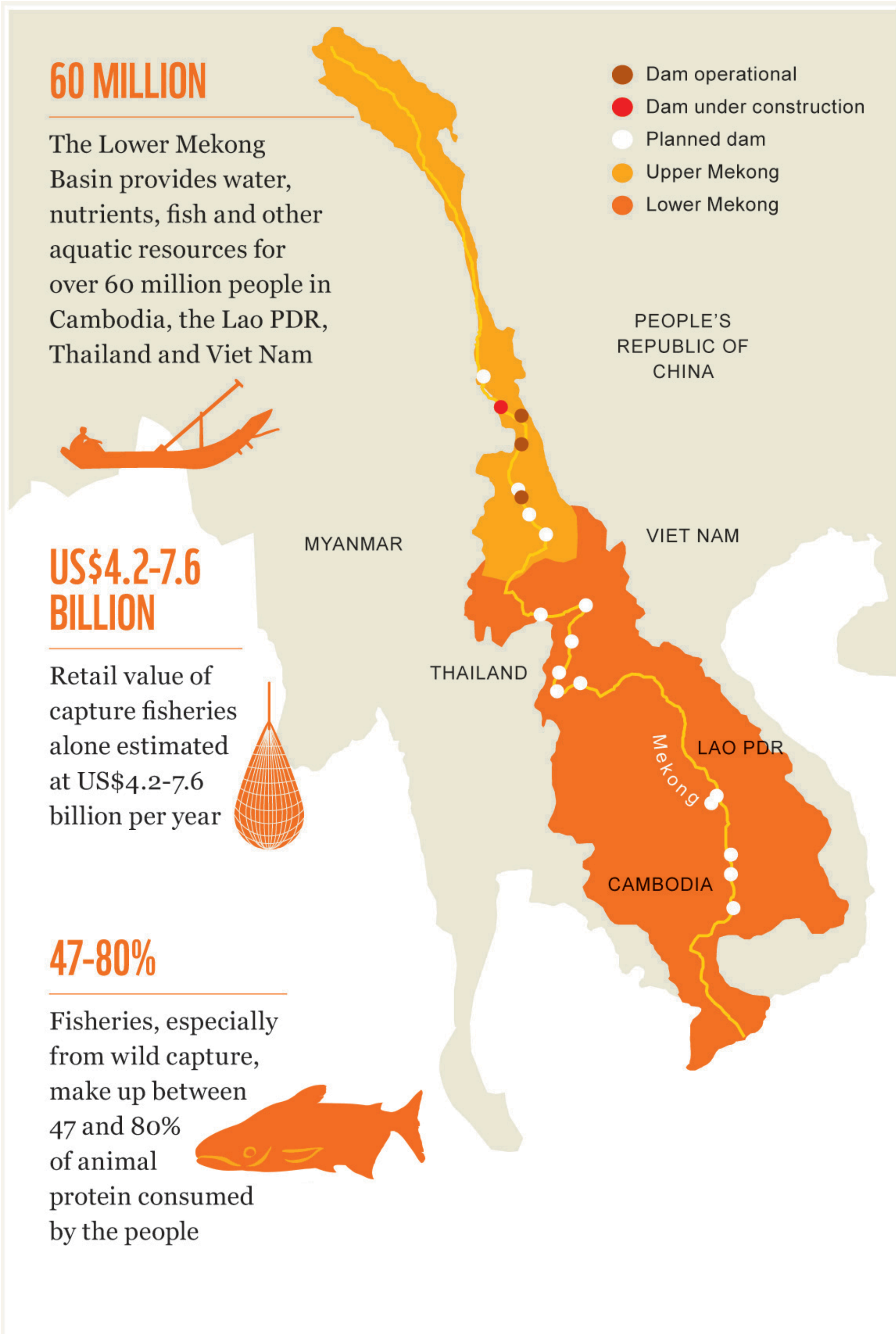

Figure 1. Infographic of hydropower development in the Mekong and the link to fish-dependent livelihoods (source: WWF Freshwater Program).

What do we already know?

ACIAR/DFAT and Charles Sturt University partnered with the dam proponents to answer the question of whether the upstream fish passage facilities were effective in passing a large proportion of fish numbers and species. A structured research program was initiated (FIS/2017/017), which focused on the effectiveness of the upstream fish pass within a limited line of inquiry (focused largely on the fish pass effectiveness for fish migrating upstream). Nevertheless, initial results are very promising, demonstrating that large numbers of many species are moving upstream with a >80% efficiency (unpublished data, FIS/2017/017).

This initial work was, deliberately, technically focused. The monitoring technology needed to measure fish pass effectiveness had never been used before in SE Asia, nor at a dam of this size. So, the methods needed to be validated (methods included microchipping and electrofishing). Secondly, efficiency trials had never been completed for such a diverse tropical ecosystem. Methods were therefore needed to be refined for a significant number of Mekong fish. Thirdly, the study represented the first time that fisher-independent data had been generated in the Lower Mekong Basin. Therefore, the mechanisms to analyse and interpret such data needed to be developed. These were all achieved as part of FIS/2017/017, which concludes in June 2024. The project has significantly advanced knowledge generation to inform the development agenda. However, several knowledge gaps remain.

What is the current stage of the development cycle?

The Mekong River Commission (MRC) coordinates a ‘prior consultation’ process under the Procedures for Notification, Prior Consultation and Agreement (PNPCA). This represents an opportunity for MRC Member Countries and other stakeholders to discuss and review benefits and risks of any water-use project proposed for the mainstream, which may have potential significant cross-border impacts on the Mekong River flow regimes, water quality and other environmental and socio-economic conditions (Table 1). This is a highly public, open and transparent process, by which developers submit their plans for hydropower projects and these then become subject to national and international scrutiny. The MRC has concluded prior consultations for five hydropower projects: Xayaburi, Don Sahong, Pak Beng, Pak Lay and Luang Prabang, and is carrying out the consultations for the Sanakham project (Table 1; Figure 1). The outcomes of these PNPCA processes were that the proposed fisheries mitigation strategies, as submitted, were likely to be insufficient and that the developers needed to work harder to identify sustainable solutions.

Xayaburi, Don Sahong and Luang Prabang altered their plans because of the PNPCA and proposed solutions that were otherwise untested in the region. Other developers (for Pak Lay and Pak Beng) are now actively working to amend their submissions in response to PNPCA feedback. The Mekong River Commission are subsequently seeking evidence and data to support these re-designs. The main point here is that there are few new hydropower plants currently under construction; most are in the design, or redesign phase. Those that are already operating have a significant opportunity to influence those about to be designed, or those that are being re-designed (Table 1).

Therefore, there is an extremely limited, but time bound, opportunity to influence the design of future dams provided that (a) evidence and learnings from existing sites, in terms of fisheries productivity and livelihood protection, can be disseminated; (b) dam proponents agree to share and incorporate data into new designs; and (c) the need to protect fisheries and livelihoods is accepted and actioned by developers.

Table 1. Expected completion dates for hydropower dams in the Lower Mekong.

Hydropower project	PNPCA date	Expected commissioning year	Installed capacity (MW)	Mean annual energy (GWh)	Height (m)	Crest length (m)	Max reservoir area (km²)
Ban Kum	TBD	Beyond 2030	1,872	8,434	53	780	132.5
Latsua	TBD	2029	800	3,504	22	1,300	13
Luang Prabang	2019	2030	1,200	6,500	57.5	318	72.4
Pak Beng	2018	2029	912	4,846	85	943	87
Pak Lay	2018	2030	1,320	4,252	35	630	108
Sanakham	2020	2028	700	5,015	25	1,144	81
Santhong-Pakchom	TBD	Planned. COD Unknown.	1,079	5,052	55	1,200	80.3
Stung Treng	TBD	Planned. COD unknown.	980	4,870	22	10,884	211

Knowledge gaps in the 'sustainable hydropower' research for development framework

There is insufficient evidence available, in the public domain, or otherwise, for developers to adequately address PNPCA concerns. There remains significant debate as to what the 'minimum' requirement would be to define a hydropower project as 'sustainable' and there is virtually no data/evidence available, from existing sites, which demonstrate 'best practice standards'. The Mekong River Commission recently released the 'MRC Hydropower Mitigation Guidelines' (MRC 2020), which steps through the key considerations for developers. However, the document lacks local evidence and examples in the guidance are largely from other regions (North and South America). In fact, the only data that currently exists regarding mitigating fish migration outcomes in the LMB has been solely generated by FIS/2017/017 at Xayaburi Dam. Nonetheless, that project was limited in scope and identified several key knowledge gaps that require further investigation, and dissemination, in a 'research for development' sense. Indeed, that work, once disseminated will necessitate an update to the MRC document.

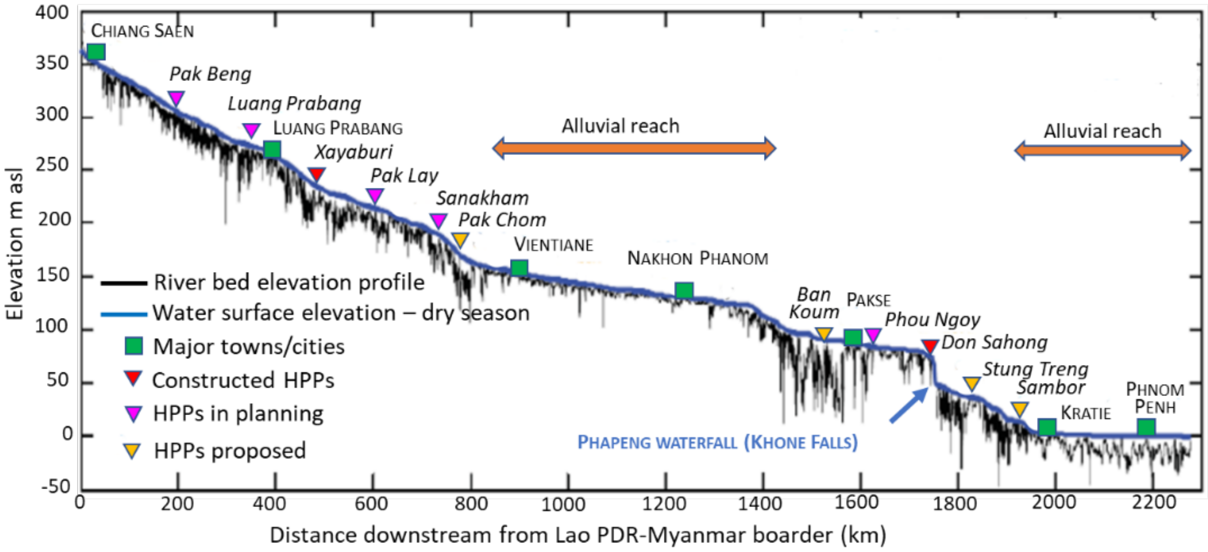

Figure 2. Cross section of hydropower construction along the Mekong.

Progress so far

Following FIS/2017/017 a knowledge gap workshop was held, comprising of a team with developers, the Lao government, and Charles Sturt University academics. The workshop participants identified scalability of existing results, and any knowledge gaps that remained, to influence the policy and activities of other hydropower planners and developers in the region.

The co-design workshop revealed that:

- The Charles Sturt team is presently the only research group with established relationships, and an active program of work, at all existing mainstem hydropower dams (Don Sahong, Xayaburi and Luang Prabang).
- The team has long-standing (since 2007) and functional links with the Lao government (Ministry of Energy and Mines, Ministry of Agriculture and Forestry and National University of Laos). Additionally, the team actively works with major river development initiatives in association with the Mekong River Commission, the Asian Development Bank and the World Bank.
- The existing project (FIS/2017/017) successfully demonstrated new technology and established trust among partners.
- The existing project only focused on upstream fish pass effectiveness using a single technology at a single site.
- In a 'research for development' sense, there is still a need to understand:
  (a) whether the downstream fish pass's are facilitating bi-directional fish movement and if upstream migrating fish are delayed (Knowledge Gap (KG) 1).
  (b) if there have been changes in river fisheries structure/yield following construction (KG1).
  (c) factors influencing migratory fish in the region, why fish are migrating, where they are migrating to, and if the dam facilities are assisting (KG1).
  (d) the long-term benefits of the existing facilities at Xayaburi (KG1).
  (e) whether livelihoods of people dependent upon fish have changed (or are unchanged from pre-dam conditions) (KG2).

(f) how best to disseminate and translate the results of the program of ACIAR/DFAT work into improved policy and decision-making outcomes (KG3).
(g) whether the learnings from Xayaburi can be directly applied to other sites, such as the next hydropower plant (Luang Prabang) and others in Table 1 (KG4).

Consolidating the workshop outcomes into the new activity yielded four focus areas linked to the requirements of the ACIAR project design brief:

<u>KG 1: Fish pass facility effectiveness.</u> The FIS/2017/017 assessment of the fish passage facilities at Xayaburi focused entirely on the fish ladder itself and only on upstream migration. This was urgently needed and filled an important knowledge gap. However, this alone is insufficient to demonstrate that a hydropower project has mitigated its environmental impacts. For instance, there is a need to understand if migratory fish are delayed 'outside' the fish pass and cannot enter the fish pass at all. Fish also need to migrate downstream, but there have been no studies on downstream passage efficiency at any hydropower project site along the Mekong. There is, therefore, an urgent need to document whether fish can pass both upstream and downstream at Xayaburi. There is also a need to determine if fish approaching the dam are delayed, or unable to locate the fish pass entrance at all. These questions are equally relevant to the next dam scheduled for construction, Luang Prabang, and there remains significant international demand for this evidence to be generated. The data then needs to be transferred to other sites.

<u>KG 2: Social benefits arising from fish pass construction.</u> The degree to which the level of investment ($US300m in fish pass facilities) has brought about positive benefits to the lives of fishers, and those in the fisheries value chain, remains unknown. During the construction process, some villagers were resettled, and some fishers were transitioned to other industries. Some fishers also persisted with fishing and, presumably, all households still have a dependency on fish as a major source of protein and micronutrients. There is a need to demonstrate whether the investment in fish pass construction has effectively sustained opportunities for locals to keep fishing. If so, this evidence needs to be disseminated to other sites.

<u>KG 3: 'Who is who' in the sustainable hydropower space:</u> The information on fish pass success and livelihoods (viz. KG1 and KG2) needs to be disseminated among developers and decision makers to ensure uptake and translation of results (into policy and practice). However, there is a poor understanding of the network of stakeholders involved in the overall hydropower development process across the LMB. This lack of cohesion, and a general lack of data sharing, has been propagated by some developers as a reason to proceed with sub-optimal mitigation strategies incorporated into dam planning (i.e. until the knowledge is generated, projects are proceeding). Consequently, while the dissemination pathways and key actors are unknown, it will be difficult to ensure this evidence and data are disseminated.

<u>KG 4: Designing effective dissemination pathways.</u> Given that the dissemination pathways and various actors remain unknown, the best mode of dissemination, to maximise policy and practice change, also remains unknown. Therefore, the information generated (in point 1 and 2 above) on social and fisheries outcomes needs to be disseminated (to the actors defined in point three) in the most appropriate format (to be determined here in point 4).

These knowledge gaps form the central concepts needed to close out an adaptive management theory of change. In this instance, an intervention has been designed and data has been gathered on its performance. Future interventions now need to be improved based on this information. So far, only limited information on KG1 has been generated by FIS/2017/017. KG2, KG3 and KG4 require urgent resolution to influence the next dams, which are scheduled for construction over the next seven years. Filling these essential knowledge gaps, and disseminating the data, remain the most significant barriers to the sustainable hydropower movement in the Lower Mekong Basin.

Novelty and timeliness of this research

There are presently no other efforts underway to address these research priorities in the Mekong region. All learnings from this research are novel, and crucial for providing a standard for dam construction and fish pass monitoring at other dam sites in the LMB. Plans to construct eight other mainstem dams on the Lower Mekong are at various stages of development. The next dam, Luang Prabang, will be operational in seven years. Additional sites at Pak Beng and Pak Lay will follow and are presently progressing through concept design review. Each dam will add cumulative impacts on fish migratory ecology (Halls and Kshatriya 2009), but there is little to no practical understanding or anticipation of these compounded impacts in the region; in fact, our team is the custodian of the only practical dataset, which is in significant demand by consent authorities and donor agencies and could realistically influence this agenda.

There remain critical knowledge gaps – across ecological management, policy influence and technical interventions – to achieve outcomes at a whole-of-region scale. Continuing the existing research program (from the ACIAR-DFAT co-funded FIS/2017/017 project) is required to assess the quantum and species mix of fish that are passing at fully operational hydropower sites, both up- and downstream. Furthermore, there is an increasing and immediate requirement to disseminate the data to a broader audience and to communicate the human/social issues. These are urgently needed if sustainable practices are to be incorporated into future hydroelectric power development programs.

There is a time-limited opportunity to develop critical knowledge, which can be translated into actions at these new sites. The research outcomes from this proposal could positively influence development at the remaining sites, by building on a solid foundation of industry-relevant research, and an effective policy influence framework for decision makers.

1.3 Partner country and Australian research and development priorities

Country/regional priorities and commitments

Protecting migratory fish from hydropower infrastructure impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to international conservation advocacy groups. The overarching need for this work is largely driven by the 1995 Mekong Agreement, which explicitly requires Lower Mekong Basin countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). It is also driven by the commitment of the XPLC to set the standard for fish pass infrastructure design and fish pass monitoring in the region.

For hydropower dams in Lao PDR, the Lao government (through the Ministry of Natural Resources and Environment - MONRE, and the Ministry of Energy and Mines - MEM) enter into 30-year concession agreements with power companies. During this period, the company owns and operates the site, after which ownership transfers to the Government of Lao PDR.

Dam proponents are required, via approval processes managed by MEM, to take substantial steps to minimise environmental impacts at the dam site, including providing successful passage for fish species. MEM is currently the only agency with an outward facing discussion with all proponents of mainstem hydropower dams. Their role in approving dam projects includes reviewing the design of the fish pass component. MEM officials recognise their engineers are not equipped to do this work and have sought to engage with FIS/2017/017, requesting that their staff are trained in sustainable fish pass techniques. The new project will bring MEM into the centre of its strategic partnership engagements, given their influence in effecting change in dam design in PDR of Laos. At a recent co-design process with the project team and stakeholders, MEM officials identified that gaining access to critical skills and data is needed to make more informed choices when decision-makers are given consent for future projects.

Australian Aid and/or Foreign Affairs Agenda

DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (DFAT 2017; DFAT 2020a; DFAT 2020b).

This activity is therefore directly related to DFAT's strategic outcome ‘Agriculture, Fisheries and Water’. Hydropower development is the most significant water management issue in the Lower Mekong Basin. The Xayaburi Dam, being the first site, remains of particular interest and significance internationally.

This project is directly related to Australian Aid’s strategic outcome ‘Agriculture, Fisheries and Water’. There are also important links with ‘Education and Health’ and ‘Gender Equality and Empowering Women and Girls’, and alignment with ‘Building Resilience’ and ‘Acquiring Critical Infrastructure’ in the fisheries field.

The use of research and innovation to achieve strategic objectives underpins ‘Agriculture, Fisheries and Water’. The two objectives our activity most closely aligns with are:

a) Increasing incomes of poor people: using strategic applied policy research to improve water policy to prevent a major decline in income for those directly employed in fishing-related market chains; and

b) Enhancing food, nutrition and water security: empowering government agencies and private industries to understand, and develop strategies to mitigate, potential development impacts.

Protecting migratory fish from dam impacts is a priority for all SE Asian countries and is recognised by many foreign aid agencies. Our team members work with ACIAR on fishery-related research in Lao PDR (through active projects FIS/2006/183, FIS/2009/041, FIS/2012/100). Likewise, the recently completed CGIAR Challenge Program on Water and Food commissioned several projects on hydropower sustainability. In addition, USAID have an active program, which has identified fisheries sustainability as a priority area for SE Asian countries.

Until the mid-2010s, these programs were largely unilateral, focusing on individual countries, rather than taking a regional collaborative approach as will be the case in this project. USAID recently committed $US600,000 towards an initiative to extend fish passage outcomes (from ACIAR investments FIS/2006/183, FIS/2009/041, FIS/2012/100) to Vietnam, Cambodia and Myanmar. It was agreed that USAID funding would be used to progress initiatives in Cambodia and Vietnam until 2020. ACIAR funding (this proposal) is anticipated to be used to progress initiatives in Lao PDR, Indonesia, Cambodia and Myanmar. However, as momentum and outcomes grow from this program, so do the demands on project team members' time and expertise.

Relevance to ACIAR 10-year strategy

Food security and poverty reduction

SE Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural people are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities.

Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in SE Asia because hard research data does not exist. This project will identify and bridge information gaps, drawing upon data from fishway projects across the region shaping more effective management strategies. Indeed, the knowledge generated from this project will be crucial for sustainably managing SE Asian fisheries in the face of increasing human development and changing climatic conditions.

Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. River development has negatively impacted inland fisheries. This project aims to redress this imbalance and broker win-win scientific solutions so modern river development projects support the sustainable production of fish, rice and energy.

Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. Research has found that women can occupy half of the harvest and post-harvest workforce, and selling fish can provide extra income and offset household needs, and provide extra nutrition with by-catch for the immediate family. This project will document this participation and champion the need to recognise the important role of women and girls in fisheries value chains benefitted by fishway construction (see Section 2.5).

Value chains and private sector engagement

Hydropower modernisation is generally the domain of developers under development bank, or investor, supervision and generally contracting local companies for construction, though local village coordination and then accepting final ownership. The sector is increasingly receptive to considering fish passage during planning and construction activities and is looking to external and private sector experts for assistance. But often solutions that are developed are sub-optimal and based on experiences from outside the LMB. The private sector also plays a key role in shaping government regional decisions and policies. This project will bring both private, developmental and governmental sectors together to recognise the value of fisheries resources and to determine how to maximise those resource returns in sympathy with future growth across the hydropower sector.

Building capacity (individual and institutional)[1]

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner with regional governments, multilateral development banks, regional agencies, and capacity building experts to equip these organisations with capacity to address fish migration challenges beyond the lifespan of the project.

1.4 Relationship to other ACIAR investments and other donor activities

Existing/previous ACIAR work on hydropower sustainability

This research follows on and extends a body of ACIAR research that has developed and tested techniques to assess the performance of the fish pass at Xayaburi – and, to an extent, other future mainstem dams in the LMB (ACIAR FIS/2017-016 and FIS/2017/017). It also addresses DFAT's Mekong Australia Partnership – Water Energy Climate (MAP-WEC) goal of strengthening the environmental resilience of countries in the Mekong subregion (Cambodia, Laos, Myanmar, Thailand, and Vietnam). FIS/2017/017 engaged with both technical and policy influence change pathways. The project progressed despite COVID-19, but there remains a significant challenge in providing a rigorous validation of the technical aspects of Mekong hydropower fish passes. There also remains a significant challenge to build local capacity in the design of fish pass infrastructure for environmentally sustainable hydropower and influencing decision making to adopt best practice sustainable fish pass technologies. Furthermore, significant research for development challenges remain, as the team in conjunction with management agencies in the Mekong need to find effective processes for translating research findings into improved decision-making, dam design and management practices.

We learnt in FIS/2017/017 that there is a significant political challenge in influencing change. We recognised that the Mekong River Commission guidelines are not the final adoption point for sustainable technology; in the first instance this is the Government of Laos. Second, the project only focused on upstream fish pass investigations. There remain significant gaps in terms of downstream migration, and, more broadly at the ecosystem scale. Third, the team has not yet explored social dimensions (whether the dam is influencing re-settled and other communities' fisheries-based livelihoods and food/nutrition security). Fourth, the most appropriate dissemination and influencing mechanisms, for each key next user, are yet to be understood.

Further, this project adds to (1) SSS/2020/142, which explores the policy impact in Lao PDR and the transition from research to practice, and (2) the (almost finalised) impact evaluation work conducted by ACIAR on the 'Research-Policy Interface: Lessons from Lao PDR'.

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[1] relates to components to be funded by ACIAR's Capacity Building section under FIS/2018/153.

Activities of other actors/donors

Substantial investments have been made by ACIAR, DFAT and XPCL in researching the required infrastructure to build effective fish passage systems and in developing new technologies to assess fish pass rates when the hydropower facility is operating. Now further research is needed to scale up and scale out the ecological learnings from the Xayaburi Dam site; as well as to better understand the cumulative impacts of the Xayaburi and Laung Prabang damsites on the livelihoods of local communities; and to translate the research outcomes from the Xayaburi and Laung Prabang dam sites into policy. The main additional actors to be brought into this initiative are (a) Lao Ministry of Energy and Mines (as a central partner as opposed to a reference group member like they were in FIS/2017/017), and (b) other hydropower developers who are proposing mainstem dams. The Mekong River Commission is also charged with developing a regional ‘Sustainable Hydropower Guidance’ document and data generated by the team will be highly relevant to future iterations of that document.

A significant feature of the proposed activity will be to ‘map’ actors which have been ‘missing’ from our collaboration network (KG 3). Critical to this process will be building on our existing collaborations with the Mekong River Commission and making strategic connections to dam developers relevant to other projects. The Mekong River Commission has already indicated that they are very motivated to see the outcomes of FIS/2017/017 translated and transferred to other projects. So, there can be an immediate suite of information transfer which can take place whilst other knowledge gaps are advanced.

2. Project Theory of Change (i.e. program logic)

2.1 Overview

Adaptive management is the most appropriate theory of change mechanism applying to ‘sustainable hydropower’ in the LMB. In this context, adaptive management is described as (Bunnefield, 2015):

“a structured, iterative process for making decisions in ‘response to changes in context and new information that promotes intentional learning and minimizes the obstacles to modifying programs.”

Relevant to the agenda ‘Sustainable Hydropower’, adaptive management is fundamentally dependent upon the injection of empirical knowledge and learning at critical phases of the project or programme cycle (Figure’s 3 and 4). This would most notably occur during the design and planning phase (to ensure that plans reflect the environment in which they are located, that objectives are relevant and realistic, and that the proposed interventions are feasible and appropriate) and then subsequently during implementation to ensure that experience and lessons are captured and fed back into the next hydropower project, informing adjustments to implementation as required. With respect to fish pass criteria, results determined from FIS/2017/017 could now be, theoretically, directly applied to improve the criteria for fish pass design at the next dam, Luang Prabang then the following one at Pak Beng; and so forth. In essence this is occurring, but is also straightforward, because the Luang Prabang dam is owned by the same developer (Xayaburi Power Company Limited). The challenge is establishing dialogue with the other developers and transferring research findings to them in a manner which influences practice change. In this context, we define long term ‘practice change’ as when a developer proposes a dam which contains a mitigation strategy that is most likely to pass fish, both upstream and downstream, with minimal (or no) impact on fish-dependent livelihoods. We suggest that the ability to do so requires:

(a) technical solutions which are based on robust evidence in the local context.
(b) knowledge of the solutions and how to apply them.
(c) a willingness to adopt, and invest in, the solutions.
(d) a commitment to monitor, evaluate, learn, and apply improved solutions to future situations.

Our Theory of Change (TOC) approach outlines a specific process and approach to incorporate learning and information into new and ongoing hydropower development activities. In adaptive management frameworks, the TOC needs to be seen as dynamic, allowing stakeholders to review and adapt whenever there is new evidence, or when there are changes in the context that affect assumptions or hypothesized pathways of change. The hydropower agenda in the LMB is dynamic. It is influenced by changes in institutional leadership, investors, developers, ministerial portfolios, government priority setting, and international technology advancements among many factors. Therefore, should a theory of change have been developed in 1995, when the Mekong Agreement was signed, it would have needed revision, over the past 30 years, in response to changing regional and international priorities, technological changes and environmental changes (such as climate change). The TOC presented here reflects our current understanding of the sustainable hydropower development agenda, but should be reviewed annually as the project progresses or whenever political, economic, social, technological, legal or environmental factors significantly change.

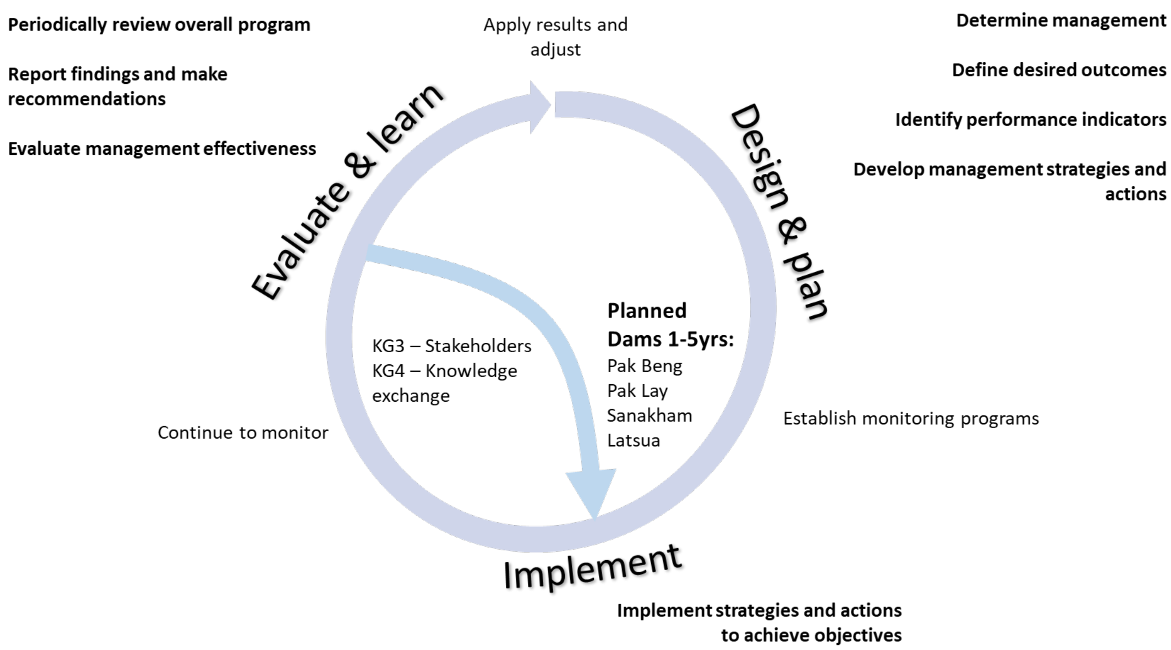

Figure 3. Theoretical adaptive management framework pathways relevant to sustainable hydropower in the LMB.

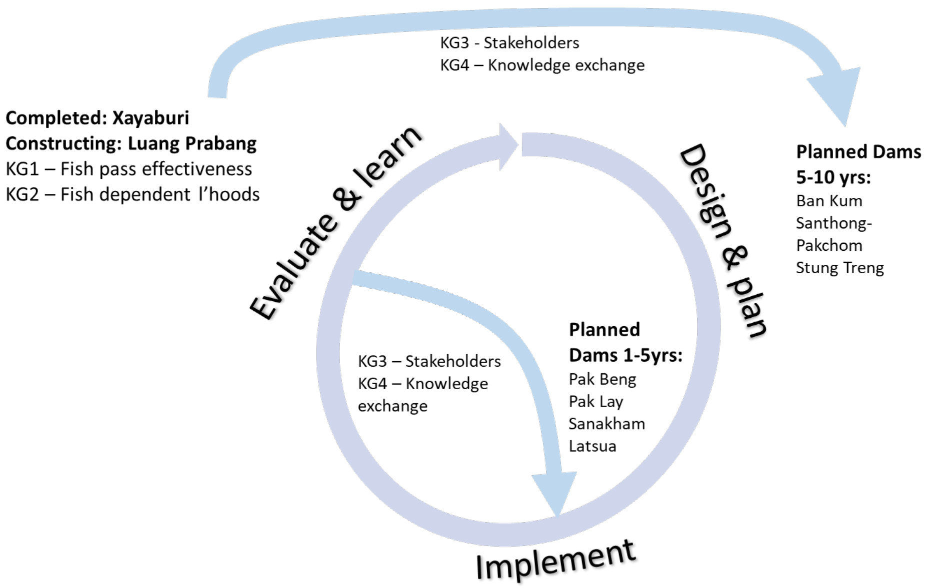

Figure 4. Theoretical adaptive management framework pathways considering the dams scheduled for design/construction commencement within the next five years (the term of this proposed project activity), with key knowledge gaps (KG's) shown as enablers into a 1-10 year impact pathway. Initially the focus will be on dams scheduled to commence in the next 1-5yrs; with knowledge brokering required for dams on the 5-10 year horizon.

End-of-Project-Outcomes

The overall goal of the ACIAR Fisheries Program is 'to improve fisheries ecosystem health under climate change. It takes a human rights-based approach to development and aims to improve the lives of aquatic resource-dependent rural people. It does this by investing in R4D that aims to improve the health of the aquatic ecosystems and resources that rural people depend upon' (ACIAR Research Design Brief). FIS/2023/133 will contribute to the overall goal of the ACIAR Fisheries Program by achieving three End-of-Project-Outcome's (EoPO's) (Figure's 7 and 8), which explicitly link identified knowledge gaps with hydropower project construction schedules in an adaptive management sense. The main focus here is research for development. This is time-bound as the ability to influence hydropower projects, until the sector enters the 'development' stage, is within the next five years.

Consistent with the goals of the ACIAR Fisheries program, our overarching development goal for this activity is: *'To ensure that hydropower does not negatively impact fish and fish-dependent livelihoods'*.

To achieve that objective, there are four primary EOPO's that the activity is targeting. The first two focus on expanding the evidence base on technical solution effectiveness to inform the sustainable hydropower agenda. The second two focus on transferring, and translating, that evidence base into improved policy, decision making and implementation.

- EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).
- EoPO 2: Social and economic dimensions of hydropower and fisheries interactions are better-defined.
- EoPO 3: High level stakeholders advocate for and support sharing information and participating in a process for evidence-based decision making.
- EoPO 4: Technical staff in relevant government agencies and hydropower companies have capacity to make informed decisions.

Links between the EoPO's

The technical fish passage (EoPO1) and socio-economic research (EoPO2) evidence will establish the evidence base that is needed to guide the design and planning for the remaining dams (but currently missing from the MRC PNPCA process). Absence of evidence is presently being propagated, by some developers, as a reason to proceed with sub-optimal technical solutions. EoPO3 is required to effectively 'map' the hydropower development stakeholder system to understand who key evidence needs to be disseminated to, in order to facilitate policy and practice change to influence the adaptive management cycle. EoPO4 seeks to design and evaluate the performance of dissemination/policy framework to ensure that the evidence base (EoPO 1 and 2) is disseminated to the identified stakeholders (EoPO4). There are functional and structural links between each of the EoPO's. The dissemination, policy adoption and capacity building frameworks will subsequently link to meet our overarching development objective of protecting fish-dependent livelihoods.

'Impact pathways' in the theory of change/program logic

The program logic will follow the sequence of undertaking 'Foundational' and subsequent 'Influencing Activities', to achieve 'Immediate' and successive 'Intermediate Outcomes' that eventually result in the 'EoPO's'. These are summarised in Figure 8.

EoPO 1

The Foundational Activity for EoPO 1 will involve documenting the effectiveness of the fish pass operations at Xayaburi and Luang Prabang. This Foundational Activity will underpin the Influencing Activity of generating empirical evidence to support the inclusion of fish passage in hydropower developments. The Immediate Outcome will be that hydropower companies and investment decision makers in central government both understand the business case for investing in fish friendly hydropower development. This should subsequently translate into the corresponding Intermediate Outcome. That is, hydropower companies and government investment decision maker criteria requiring hydropower developments to be fish friendly.

EoPO 2

The Foundational Activity for EoPO 2 involves making the 'human' case for investing in technical solutions. Specifically, research will be undertaken to understand socio-economic impacts of dam and fish pass operations at Xayaburi and Luang Prabang. Across the Mekong, fish remain the most important source of protein and micronutrients for over 60 million people (Hortle et al. 2017). It is widely accepted that dams will reduce this resource base unless suitable technical solutions are applied. Now that several dams are operational, with technical solutions applied, there is an opportunity to understand if the investment is generating the intended benefit to fish-related livelihoods (i.e. no net reduction). The Influencing Activity for EoPO 2 will involve generating empirical evidence to understand the community impacts of dam and fish pass operations at Xayaburi and Luang Prabang. A series of social surveys will be conducted in areas around constructed dams (with and without technical solutions) to triangulate information on livelihood benefits/disbenefits following construction. The Influencing Activity should lead to the Immediate Outcome of hydropower companies and investment decision makers in central government both understanding the business case for investing in socio-economically responsible hydropower development. This will involve building a solid evidence base on the state of livelihoods before and after construction. The Immediate Outcome is expected to subsequently translate into the Intermediate Outcome of hydropower company and government investment decision maker criteria requiring hydropower developments to be socio-economically responsible and inclusive. This outcome cannot be met without scientifically robust data on the effectiveness of existing solutions at mitigating impacts on fish, and will apply that data to improved fish-related outcomes at future dams. For instance, if livelihoods have declined following construction, and that is due to insufficient efficiency of technical solutions, then improved interventions need to be designed. If livelihoods are unaffected, that may indicate that the technical design of existing interventions is sufficient and should be replicated at other sites.

EoPO 3

The Foundational Activity for EoPO 3 will involve key informant interviews among owners, the Mekong River Commission and the Lao government to effectively 'snowball' a ranked path analysis (to track their power and influence), and then a social network analysis to understand the key influencers for each hydropower project. The Influencing Activity will be most prominent in the early stages when high-level stakeholders are engaged, although the success of achieving this outcome will depend upon their willingness to share information and engage in a process for evidence-based decision making. The Immediate Outcome will be that the various high-level stakeholders are willing to engage and share information. This will be a two-way process, with the project team sharing information on technical solution performance, and the stakeholders willing to share their networks. The Immediate Outcome should subsequently translate into the Intermediate Outcome of broader connections with key influencers across the social network. The further the network is explored, the better key influencers and decision makers will be understood. Once defined, appropriate dissemination pathways will then be designed, preferably, as a co-designed activity.

EoPO 4

Foundational Activities for EoPO 4 will involve developing a context-specific knowledge management system to ensure adoption of project outcomes beyond the life of the project, and disseminating (knowledge brokering) the improved knowledge on the effectiveness of technical solutions to industry and government. Influencing activities will involve targeted education and dissemination through seminars, workshops, face-to-face meetings, conferences or more formal masterclasses or courses to support fish friendly hydropower development based on value-for-money and social impact. It is important that these activities are targeted towards key stakeholders identified as part of our work addressing EoPO 3. This will lead to the Immediate Outcomes of increased individual and institutional capacity to apply technical solutions while also ensuring that outcomes from EoPO 1 and EoPO 2 are socialised and made publicly available. The subsequent Intermediate Outcome will be that individuals are capable of actively applying these outcomes to on-ground projects, and that developers and the MRC provide responsible and appropriate decision-making regarding hydropower sustainability.

The Foundational Activities, Influencing Activities, Immediate Outcomes and Intermediate Outcomes for each EoPO will be used as progress markers for these EoPO's.

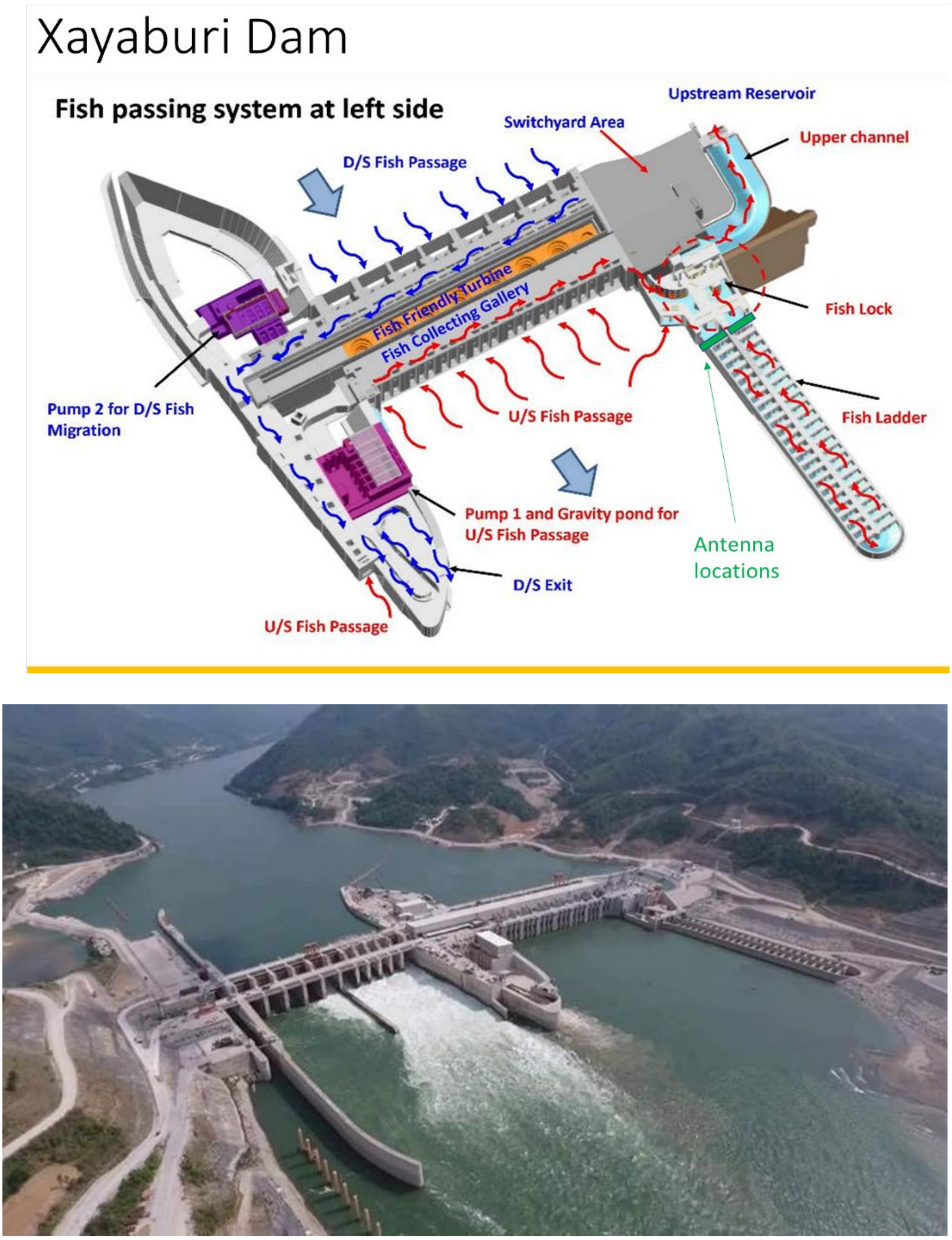

Figure 5. Schematic of the fish pass facilities at Xayaburi Dam (top) and an actual aerial photo of the site (bottom) (source: XPCL). In terms of technical data, FIS/2017/017 yielded excellent research data on the upstream fish pass. Matters of downstream migration, delay and turbine passage are still unresolved and are built into FIS/2023/133.

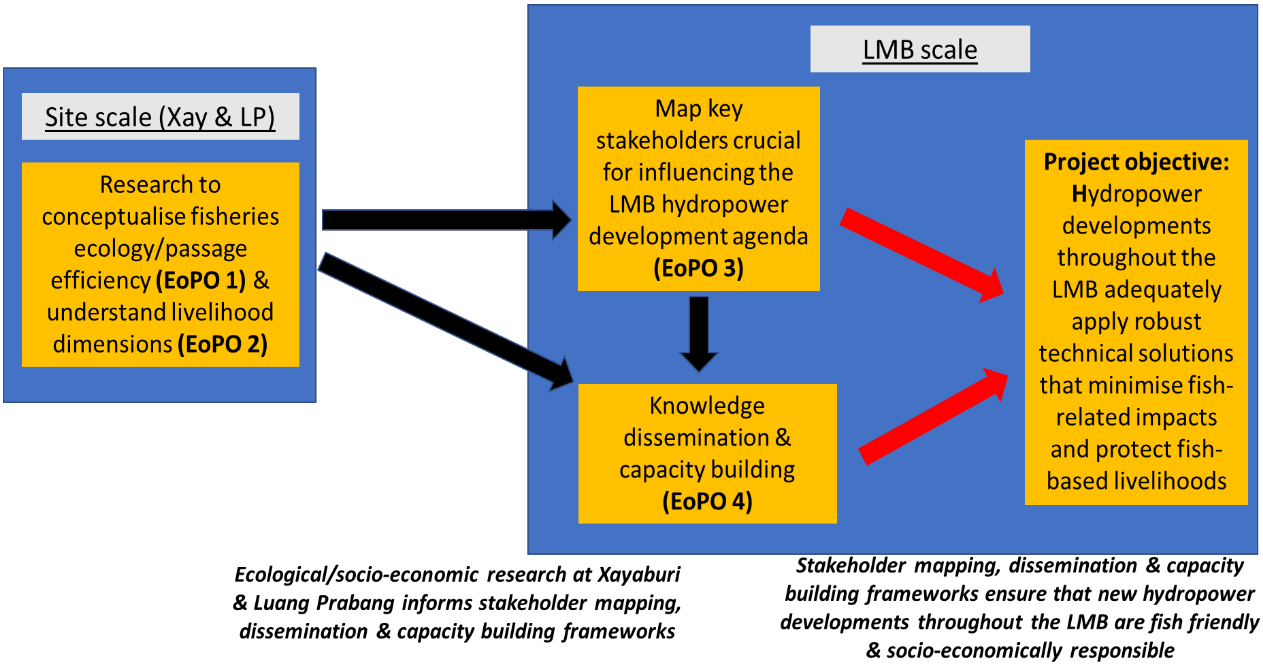

Figure 6. Functional links between EoPO's and the overall development outcome. The activities for EoPO 1 and EoPO 2 will be conducted at the site scale (at Xayaburi and Luang Prabang), but all four project outcomes will transpire at the LMB scale.

Table 2. Impact pathways and functional links to EoPO's.

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).	Access to XPCL and other facilities Fisheries researchers	Activity 1.1. Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions Fish pass monitoring at Xayaburi Dam Acoustic fish tracking at Xayaburi Dam Downstream fish monitoring at Xayaburi Dam	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings)	Evidence base is developed Implemented the fish pass to enhance aquatic biodiversity and ecological sustainability Technical solutions have been internationally and independently assessed	Locally-developed data which is of relevance to other developers Addresses international requests for data Demonstration of sustainable hydropower development, aligning with government/regional goals
EoPO 2: Social and economic dimensions of hydropower and fisheries interactions are better-defined (linked to KG2).		Activity 2.1. Research to understand socio-economic impacts of dam & fish pass operations Activity 2.2.1 Gather social-based data on villages at/near hydropower projects Activity 2.2.2. GEDSI disaggregate social data to investigate inclusivity dimensions	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings)	Assess the socio-economic effects of hydropower dams on local communities Highlighting benefits and challenges to inform balanced policy decisions	Enable evidence-based policy formulation that improves lives and fish-dependent livelihoods in tandem with hydropower development

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 3: Stakeholders advocate for and support sharing information & participating in a process for evidence-based decision making (links KG1 and KG2 to KG3).	Social scientists Connections with developers Connections with MRC Connections with government Ability to travel Willingness to share information	Activity 3.1. Stakeholder mapping Activity 3.2. Key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers	Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	Identify key stakeholders for effective information dissemination Share insights with stakeholders to influence hydropower development agenda	Forge collaborative partnerships with stakeholders, shaping development strategies in line with governmental and regional priorities Developers are connected with researchers
EoPO 4: Technical staff in relevant government agencies & hydropower companies have capacity to make informed decisions (links KG1, KG2 and KG3 to KG4).	Educators Development of curriculum / masterclasses Travel budgets Operational costs	Activity 4.1.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 4.1.2. Deliver capacity building activities Activity 4.2.1. Targeted knowledge brokering activities and learning opportunities Activity 4.2.2. Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	Proposed and future hydropower projects have better technical solutions for fisheries sustainability Fisheries and fish-dependent livelihoods are not negatively impacted

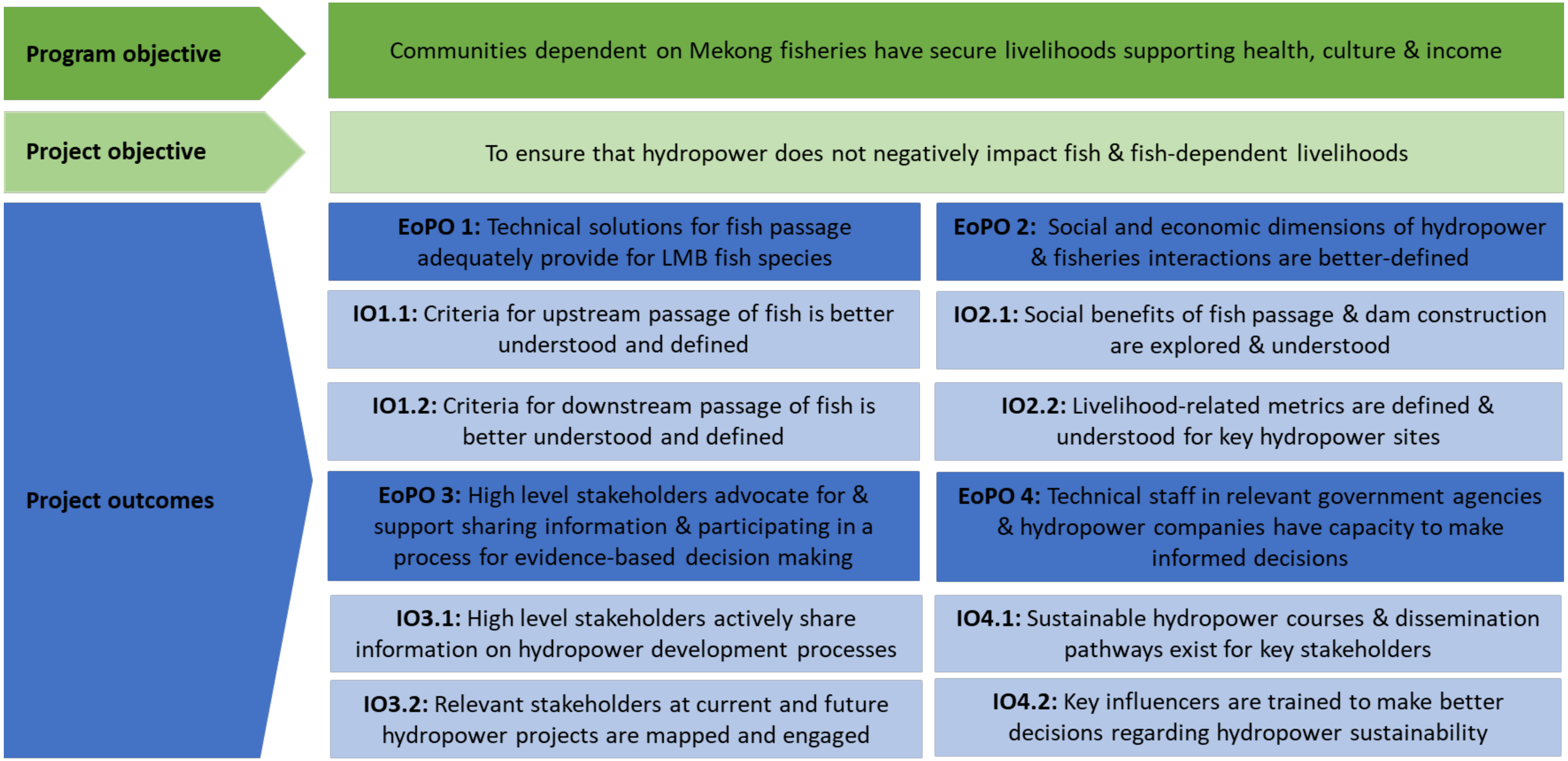

Figure 7. Conceptual overview of End-of-Project-Outcome's (EoPO's) and Intermediate Outcomes (IO's).

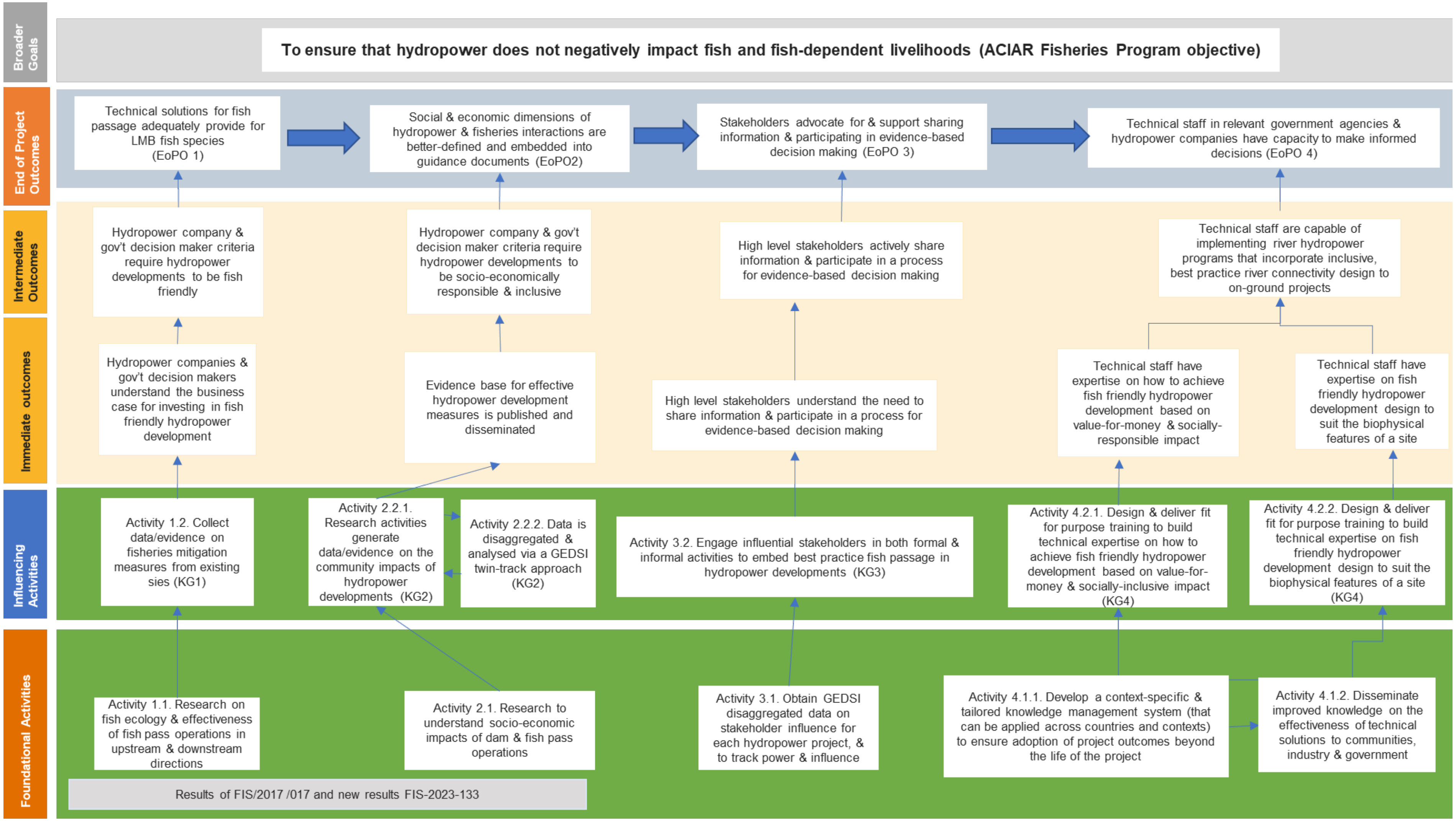

Figure 8. Program logic for FIS/2023/133, showing the impact pathways from the Foundational Acitivities to each End-of-Project-Outcome. Foundational Activities and Influencing Activities are detailed in section 2.6.

Key assumptions

Table 3. Key assumptions underpinning each activity.

EoPO	Activities	Assumptions
EoPO 1: Technical solutions for fish passage adequately provide for LMB fish species (linked to KG1).	Activity 1.1. Research on fish pass operations in upstream & downstream directions Fish pass monitoring at Xayaburi Dam Acoustic fish tracking at Xayaburi Dam Downstream fish monitoring at Xayaburi Dam	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained
EoPO 2: Social & economic dimensions of hydropower & fisheries interactions are better-defined and embedded into guidance documents (linked to KG2).	Activity 2.1. Social surveys and interactions with local communities Activity 2.2.1 Gather social-based data on villages at/near hydropower projects Activity 2.2.2. GEDSI disaggregate social data to investigate inclusivity dimensions	Access to local villagers is possible Developers agree to surveys taking place Human ethics committee permission is obtained Lao government approves, and facilitates, access to villagers
EoPO 3: Stakeholders advocate for and support sharing information & participating in a process for evidence-based decision making (links KG1 and KG2 to KG3).	Activity 3.1. Stakeholder mapping Activity 3.2. Key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared
EoPO 4: Technical staff in relevant government agencies & hydropower companies have capacity to make informed decisions (links KG1, KG2 and KG3 to KG4).	Activity 4.1.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 4.1.2. Deliver capacity building Activity 4.2.1. Targeted knowledge brokering activities and learning Activity 4.2.2. Policy brief development Update to MRC guidance document Research dissemination think tanks / dissemination events	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments

Time horizon

The team anticipate this being a 10-year program of work; but with the most urgent need to influence developers between 2023 and 2029. We will apply a theory of change framework (Olsen, 2003; UNEP/GPA, 2006) that can guide project governance and management responses based on sound research and improved capacity, and provide a pathway for change, through the uptake of knowledge and technologies. This framework will set out four 'orders' of outcomes (over a 10-year period) in the fishway program responses to changing societal, economic and environmental conditions, leading to the ultimate long-term goal of sustainable forms of energy development.

The first order outcomes (1–4 years) will involve the creation of the enabling conditions for a fish passage governance/policy initiative by linking key stakeholders, performing key research, and policy advances. This will be completely evidence-based. The team will complete the technical investigations at Xayaburi, preliminary investigations at Luang Prabang, and develop a resource base for dissemination to other developers involved with Pak Beng, Pay Lay, Sanakham and Latsua.

The second order outcomes (2–6 years) will involve changed behaviour of resource users and key institutions based on uptake of research outcomes. We will be specifically targeting the hydropower dams, which have been through PNPCA but have been required to make changes to their designs to meet sustainability guidelines.

The third order outcomes (4–10 years) will involve an increasing adoption of fish-friendly practices, aimed at livelihood protection, at other sites in the Mekong. These will focus on the dams with a longer time horizon for design and construction (Ban Kum, Santhong-Pakchom and Stung Treng).

The fourth order outcomes (1–10 years) will lead to a more sustainable and resilient inland capture fishery, with fisheries and livelihood considerations being integrated into new and existing infrastructure projects; and any future projects that may be considered.

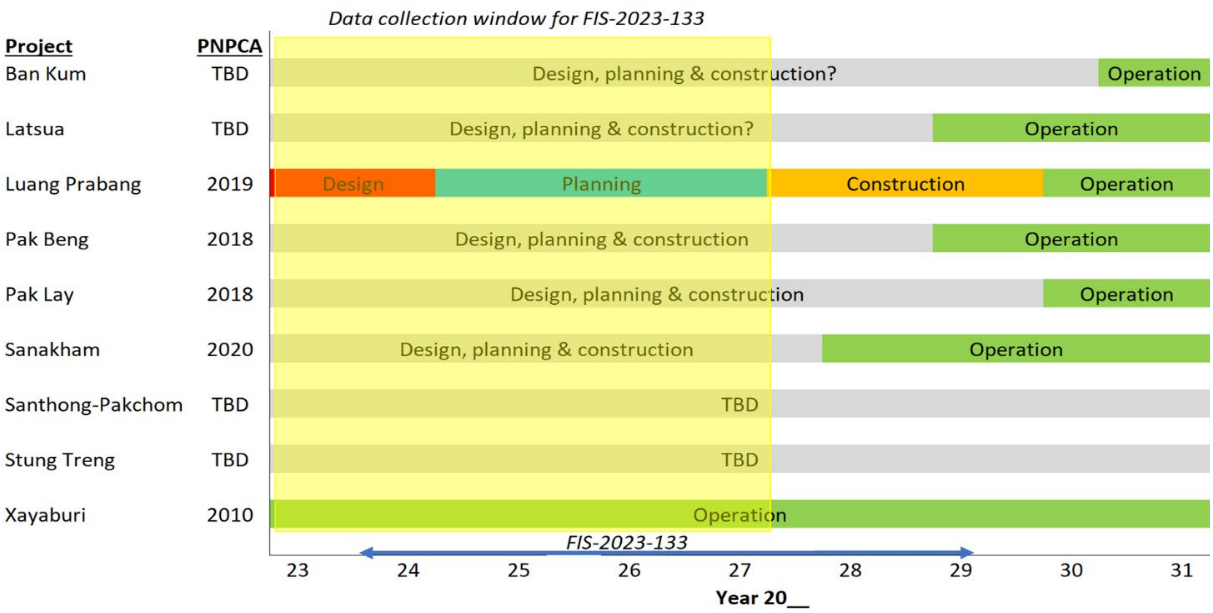

Figure 9. Construction timelines for the nine hydropower dams being built. There is a significant, time-bound opportunity to drive sustainable outcomes if research can be disseminated to the correct stakeholders.

2.2 Research strategy

2.2.1 Research questions

Question: How can improved knowledge on fisheries migration and on the Xayaburi fish pass efficiency be used to leverage improved outcomes at other planned dam sites on the Mekong River? (EoPO 1; KG 1).

Question: How can we better understand the cumulative effects of multiple dams on fisheries migratory ecology? (EoPO 1; KG 1).

Question: How has the Xayaburi site influenced local communities' fisheries livelihoods? (EoPO 2; KG 2).

Question: What are the most influential actors and mechanisms to translate the research outcomes from the Xayaburi and Luang Prabang dam sites into future dam policy? (EoPO 3; KG3).

Question: What is the most effective capacity building program to build in-country individual and institutional proficiency to make improved policy and decision making for hydropower? (EoPO 4; KG 4).

2.2.2 Addressing research questions

EoPO 1: Research to conceptualise the fish ecology and passage effectiveness (technical research)

Specific design parameters were incorporated into the Xayaburi Dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Figure 10). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Figure 10),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Figure 10),
(c) they then enter a large fish pass facility (left-bank facilities, Figure 10) and
(d) then proceed through a locking system into the weir pool (orange shading, Figure 10); or
(e) alternatively, they can move through the navigation lock.

It is important that fish can successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

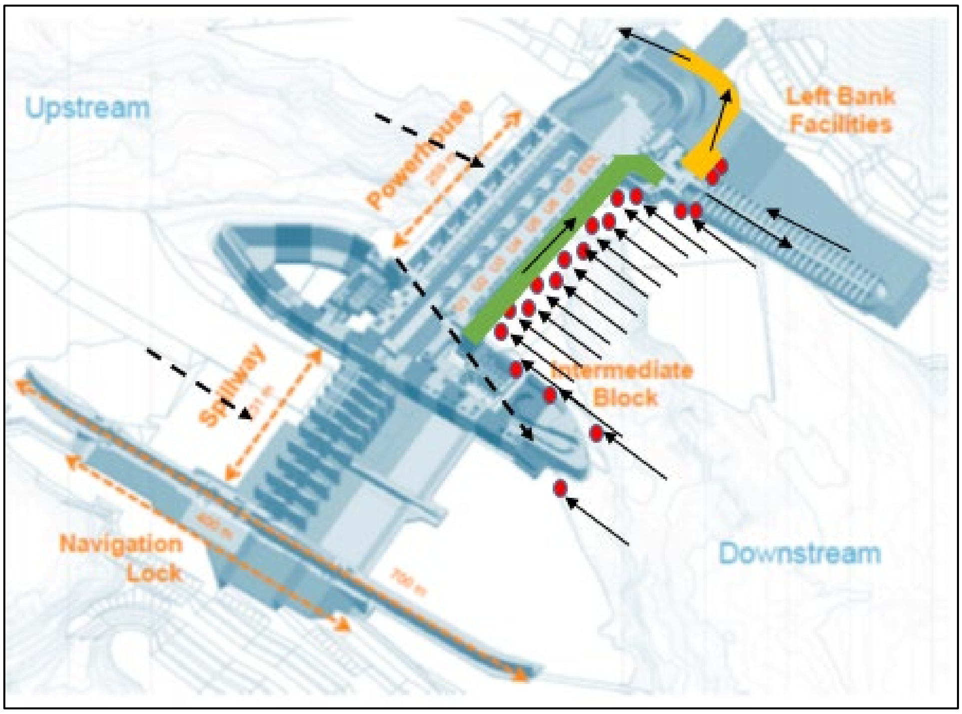

Figure 10. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green, and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

Terms of reference / research questions

A team of Australian, Lao and US fisheries scientists (fish experts) in collaboration with XPCL scoped several key research questions to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

Request from XPCL: FIS/2017/017

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was initially requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, was beyond the scope of the available budget so the ACIAR/DFAT team only focused on methods to assess upstream fish passage for FIS/2017/017.

Consequently, the initial research questions posed were:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

The result of this was that so far there has been no attempt to address the research questions regarding downstream passage, nor about what fish are approaching the dam. These questions are extremely important, both at Xayaburi and Luang Prabang, and the other dams under design and planning; and FIS/2023/133 will seek to progress.

PIT tag systems (extension of FIS/2017/017)

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970’s and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations. Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23 mm or 12 mm long; half or full duplex), which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage, which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date, or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hours a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems were assessed as part of FIS/2017/017 and have proven to be an effective method for assessing upstream fish pass effectiveness. The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It now provides a complete system, which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a webpage. Ensuring a standard tagging system is installed at multiple sites will guarantee that fish tagged in other parts of the LMB, can be detected anywhere. The system is online, active and contributing usable data. The team are tracking 4,500 fish so far (but the target was 10,000 to provide statistically meaningful results). The team will continue the existing work and build a longitudinal dataset on fish migration and fish pass efficiency. This data will be directly transferrable to other sites and, if other developers adopt and install this technology, would be the main mechanism for monitoring fish movements once (if) the hydropower cascade is completed. It will provide the largest and most comprehensive transboundary dataset on fish migration in the entire Mekong.

Rationale

FIS/2017/017 provided: (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study, the project team were tasked with using PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations, which are all being applied to the work at Xayaburi. So, the team are starting from a strong knowledge and experience base. Our aim is to achieve an increase percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Undertake large-scale tagging to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, we will continue to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 2,000 fish annually (300 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate. We can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will migrate, shed tags or be harvested, there will be a need to tag new fish in every year to maintain a sufficient sized pool of tagged fish. The team will use a model that was developed for FIS/2017/017, to estimate the number of fish that need to be tagged every year to maintain target populations of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating efficiently.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fish pass operation and XPCL fish passage efficiency reporting requirements back to the government of Laos. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power. This will be achieved by further developing long-term PIT tagging requirement models for the key species.

Stage 5: Publication, reporting and reporting to other developers and the MRC. Including further development of the MRC hydropower guidance document.

Acoustic systems

Rationale

PIT systems will only be suitable for documenting upstream migration rates through the fish pass. Acoustic systems are more flexible than PIT systems in that their listening stations can detect tagged fish from much further away, and do not require a narrow channel to steer the fish past the detection (antenna) system. Nonetheless, they are more expensive than PIT systems, require more maintenance (e.g. they require a battery), and are constrained by the landscapes in which they can be deployed.

Activities

Acoustic systems will be used either instead of (or in conjunction with) PIT tag systems to determine: (a) what fish are approaching the dam (for both up-and downstream passage), (b) what influences which route is taken (spillway, fish collector or turbines), (c) whether there is migratory delay downstream of the structure, or (d) whether fish survive downstream migration in general.

Sensor Fish and turbine Injury

Rationale

Sensor Fish are robotic data logging fish that can assess the hydraulic conditions fish may potentially be exposed to while passing through hydropower turbines. A series of Sensor Fish instructional movies were developed as part of FIS/2017/017 by the team during the COVID-19 pandemic, and shared with the in-country project partners. The in-country staff were then later given face-to-face training on the use of Sensor Fish at Xayaburi Dam in October 2022, once XPCL eased their COVID-site access restrictions. The training was provided Dr Daniel Deng (a Pacific Northwest National Laboratory (PNNL) engineer who developed the Sensor Fish) and the CSU team. The in-country staff then assisted in undertaking actual trials with dummy Sensor Fish to apply their learnings.

Activities

Sensor Fish trials will be undertaken to further empirically quantify the hydraulic conditions associated with the hydropower turbines to add a range of approach conditions (fish swimming depth) to the initial trials. Turbine-specific pressure change results will be simulated in laboratory conditions, using a barotrauma chamber, to examine the impact of turbine-related pressure changes on fish survival. These comprehensive experiments will include several target Mekong species and at various life stages. The Sensor Fish data will also be used to model the impacts of turbine-related blade strike on fish survival. The information provided by the Sensor Fish will therefore enable us to validate the ‘fish-friendliness’ of the hydropower turbines and their associated hydraulic conditions. We will compare the measurements of the hydraulic situation to 'dose rate' information from actual Mekong River fish. Linking these together gives an overall indication of survival rates through turbines.

Furthermore, there are no data yet documented for fish using the other downstream passage routes including: the downstream fish passage channel, the spillway, and the navigation lock. We will use the Sensor Fish technology and actual fish to assess the stresses faced by fish in those routes, including barometric trauma, impact trauma and fluid shear stress, which are all important factors that potentially affect downstream migrating fish survival.

EoPO 2: Research to understand the social dimensions (social science mixed methods approach)

Rationale

This EoPO seeks to determine livelihood dimensions regarding dam construction. There is a strong desire for qualitative/quantitative data documenting that the investment in technical solutions (which will be studied in-depth as part of EoPO1) is justified by fish-dependent livelihood outcomes. However, is the intervention having the desired impact on social dimensions? For instance, are fishers no 'worse-off' because of the dam? Has the fishery changed? These social dimensions are very important to transfer to the public domain, and to other developers (and the MRC for inclusion into hydropower guidelines).

Approach

We will adopt an approach taken by the FishTech (FIS/2018/153) team which recently applied an exploratory mixed-method sequential design, bringing together qualitative and quantitative datasets (Creswell & Clark, 2011), to assess the impacts of Perjaya Dam on fisheries, and fish-dependent livelihoods in Indonesia.

Data collection will be divided into a two-stage process starting with interviewing key informants using semi-structured interviews, followed by a questionnaire survey with household respondents. Key informant interviews will aim to elicit key themes and understand changes, if any, in various metrics pre- and post-dam construction. Findings from the key informant interview data will be used to guide the development of the questionnaire survey, and to get local, national, and regional contexts on hydropower development and the importance of fisheries. We plan to interview people in resettled/unsettled regions upstream and downstream of hydropower sites. Female perspectives, and those of social minorities, will be purposively sought so that data can be disaggregated by gender and/or social status.

The purposive recruitment process will be undertaken with initial guidance from local government officers and/or village chiefs. Snowballing will then be applied, either during the interview process (Kirchherr & Charles, 2018), or where government and NGO staff may contact the potential key informant themselves, prior to connecting them with our researchers. All participants will be provided an information sheet, which will be verbally explained. The information generated by the interviews will relate to:

(a) the general conditions of changes (if any) in the river and fisheries;
(b) inland fisheries production;
(c) the value of fish caught;
(d) household income;
(e) and species captured, including various details regarding perceptions of the dam on fish migration.

All interviews will be either in English or Lao, depending on respondent's language preferences.

A questionnaire survey will be designed after data analysis of the key informant interviews once the first round of fieldwork has been completed. Based on our previous experience at Perjaya Dam (Indonesia), we expect the questionnaire may include sections relating to:

(a) the value of fish for fishers;
(b) where they fish;

(c) how they utilise fish;
(d) changes in fisheries because of the fishway and dam construction;
(e) any impacts (or otherwise) on fish migration;
(f) their opinion regarding fisheries governance and management.

Questionnaire participants will be recruited using random sampling, after stratification by location and time living and fishing in the area (fishing more than 30 years in their location). This time stratification will be followed to several locations (0–5 km upstream, 0–5 km downstream, 5–10 km upstream, 5–10 km downstream, 10–20 km upstream and 10–20 km downstream from the dam).

A list of households in these areas will be obtained from the local niban/government office in line with ethics approval. From the list, equal numbers of fishers fishing for more than 30 years, and less than 30 years will be randomly selected to participate in the survey utilizing random function '=RAND' available in Microsoft Excel. In total, we aim to survey a minimum of 60 respondents with more than 30 years of fishing experience and 60 respondents with less than 30 years of fishing experience as an aspirational baseline for these surveys. This random sampling allows for male and female, and both poor and rich fishers, with and without disabilities to be included in the study. For interviews occurring with family households, the questionnaire survey will be undertaken with both members of the couple where possible to allow for both women's and men's input into the data.

Additional quantitative strategies will also be considered we will seek to partner with staff within the National University of Laos from the Faculty of Social Science and the School of Economics. We will make use of an existing Lao Expenditure and Consumption (LECS) survey data to quantify differences before and after construction. This is extremely important to form a "before" baseline and dates back to 1992. We'll consult villages which have formed part if this longitudinal survey and compare quantitative metrics within and outside the dam footprint. It will be important to establish a robust network of reference/control sites in order to determine if sites within the footprint of the dam significantly differ, across various metrics, to those outside. In addition, we will consult the LSIS (Lao Social Survey Indicator) dataset to perform before and after comparisons of livelihood status. There will be a significant challenge to disentangle impacts of the dam from other indicators of social change occurring in Lao PDR independent of hydropower development. To address this the team will use a multiple-lines-of-evidence approach with a triangulation strategy.

EoPO 3: Knowledge exchange and policy adoption (social science knowledge brokering and social network approach)

Rationale

Hydropower development involves managing a network of diverse stakeholders. As a construction project takes place in a non-linear, complex and interactive environment, efficient inter-organizational links are vital for delivering projects successfully and meeting stakeholder expectations. Essentially, cooperation with stakeholders and efficient inter-organizational linking can help owner improve social capital that arises from their stakeholder networks. The ability for a hydropower project to be designed, implemented and operated in a way which minimises environmental impact is the sum-total of the knowledge, capacity and willingness of all stakeholders to work towards that goal.

Approach

Most direction in establishing hydropower projects starts with the owners. Owners need to establish cooperation with stakeholders for a project to succeed. The owner generally would interact with (adapted from Wang et al. 2018):

- A designer which plays a role similar to that of the architect/engineer

- An owner representative who acts as agent of owner in conveying the owner's orders to contractors, and as certifier for issuing certificates regarding project cost, quality and time
- Contractors who execute and complete the works to meet the requirements of specified standards
- Suppliers who provide the owner with equipment and materials
- Local residents, who are those people who are influenced by the development
- The government, who deals with the issues regarding approval for the project, use of lands, environmental protection and relocation of migrants
- Power grid corporations, who become buyers of the electricity generated by the hydropower
- Consulting companies, which may be used to help the owners with deciding on key strategies and solving technical problems in developing hydropower projects.

In the LMB, there is a complex transboundary environment where the owners also need to manage neighbouring governments and their needs. This is generally facilitated by the Mekong River Commission through the PNPCA process. Thus, to access the social network responsible for influencing the design, construction and operation of a project; the owner and the MRC are critical, influential, stakeholders along with the Lao government as the consent authority.

Whilst the general network of stakeholders in a project is known, what is unknown, is whether these stakeholders differ among remaining projects and which actors in this complex network of stakeholders yield the biggest influence over the design and construction of mitigation measures for environmental impacts, with respect to fisheries mitigation strategies. We propose a path analysis and social network analysis to identify the role played by each stakeholder, and their overall influence, on the decision-making process.

An et al. (2022) identified that the stakeholders identified by Wang et al. (2018) can be grouped five types of influencers within hydropower projects with respect to decision making (coordinators, consultants, gatekeepers, representatives and liaison officers). Defining the sphere of influence (or power) is important when identifying their role in design and planning.

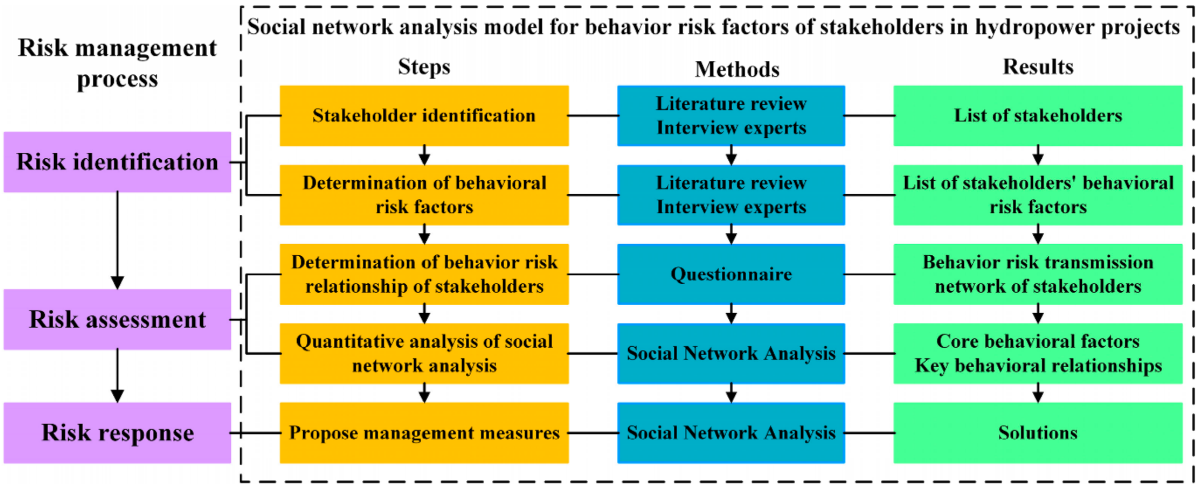

Figure 11. Framework for addressing risk, and stakeholder engagement in hydropower projects (An et al. 2022). The risk framework will be developed further and applied to fisheries mitigation in the LMB as part of FIS/2023/133.

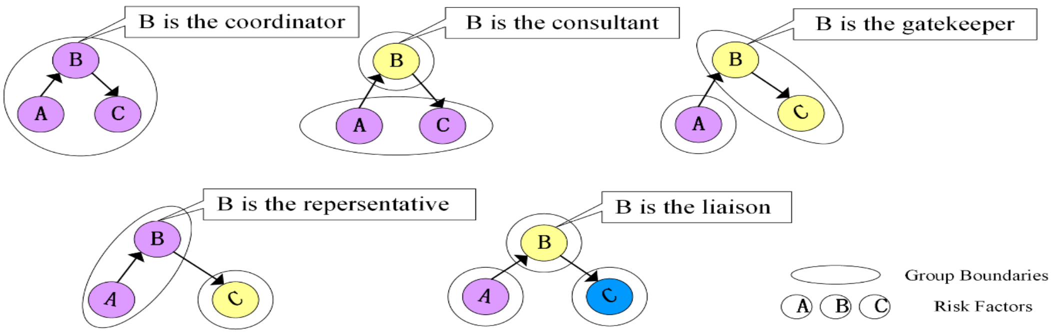

Figure 12. Role of different 'influencers' in mitigating risks associated with hydropower projects and their theoretical sphere of influence.

Commencing with the MRC, dam owner(s) and Lao government, we will hold key informant interviews to unpack the social networks associated with the decision-making process for each hydropower project including stakeholder identification, classification, influence, and overall ability to facilitate solutions. This will require a triangulated 'snowballing' strategy to understand the network of 'actors' and 'stakeholders' at various project stages. All data will be disaggregated by gender and social status to better-understand biases in the power dynamics of influential partnerships and allow GEDSI-based analyses. The general idea is to test cause-effect relationships related to decision making at key stages of the design and construct process.

The general approach will require:

1. Ranking; to demonstrate the importance and performance of relationships among stakeholders
2. Path analysis; to validate the relationships and cooperation among stakeholders at various stages
3. Social network analysis (SNA); to determine the simultaneous influence of key stakeholders in a multiple stakeholder environment.

As each construction project is essentially a combination of social interaction and collaboration, SNA is being increasingly applied into the stakeholder research in construction management discipline, where resources flow among network members through inter-organizational linking which is constrained by the network structure. Essentially, this will enable us to determine who is making key decisions, when, and why – as these will be the key stakeholders that the outcomes of EoPO1 and EoPO2 need to be communicated to. The learnings from the research into fish ecology/passage (EoPO 1) and socio-economic dimensions (EoPO 2) will inform the strategies to support stakeholder engagement and attain project outcomes and impacts across spatial and temporal scales, and stakeholder groups. A context-specific and tailored knowledge management system (that can be applied across countries and contexts) will then be developed to ensure continued policy uptake and adoption of project outcomes following project completion. Such analysis has never been completed before in the Mekong and may explain why the current approach to hydropower development is somewhat isolated, disparate and project specific.

EoPO 4: Capacity building (capacity building and knowledge brokering approach)

Rationale

Sustainable hydropower is quite a technical field. It is very difficult to explain concepts using theoretical means, and it is far more effective involving staff in on-ground research in a 'learning by doing' environment. Consequently, it is expected that the SNA will yield a list of key capacity requirements of stakeholders associated with hydropower projects. These key requirements will underpin targeted capacity building activities implemented through a capacity building through research (CBTR) approach. We need to ensure that the technical data (EoPO 1 and EoPO 2) is transferred to the most appropriate and influential stakeholders (EoPO 3) through targeted knowledge brokering and capacity building (EoPO 4).

Approach

We envisage this may comprise three levels of training:

1. **Formally recognised international courses.** In preparation for this project, Charles Sturt University has approved, for entry from second semester 2020, a Graduate Certificate in Fisheries Conservation. This has been developed as an in-kind contribution and will be specifically targeted as a training opportunity for international staff from developing countries. The course comprises two core subjects (BIO 403 – Fisheries Conservation and BIO 405 – Fish Movement and Management). Fish movement and management (BIO405) has been based on course material which was developed as part of FIS/2014/041 – Crawford Fund Masterclass in Fish Passage Engineering (Baumgartner et al. 2019). The course has been designed to comprise four subjects with intensive residential schools, meaning it can be taken 6 months full time (four subjects per semester), or 12 months part time (two subjects per semester). The curriculum for this course is flexible and bespoke. The content could be adjusted for a hydropower-focused cohort. We will enrol key staff, from each partner country, into this course to facilitate training and development over the course of the next four years. It will be impossible to export significant numbers of students for overseas training in Australia. So, this training will focus on university academics and mid-high-level officials based within fisheries and energy departments, with adequate English skills and Bachelor-level training. The focus will be on training graduates with potential to be future decision and policy makers.
2. **Targeted and specific short courses.** A key outcome from previous ACIAR FOI Act s. 47f investments (FIS/2014/041) was to develop a masterclass in 'Fish Passage Engineering'. The course is focused on in-country learning. It is targeted at in-country fisheries and engineering staff (at the federal, district and provincial level). It is taught by a series of international experts in fish passage and has a practical focus. Each student works in a team equally comprised of engineers and fish biologists and over the course of four days, they are required to develop a working concept for a fish pass at a real-world structure. They then develop a research and monitoring program to measure success. The course has been delivered in both Bangkok (to 60 high level professionals from all Mekong countries) and in Myanmar (to federal, district and provincial level staff). The outcomes of these courses have led to on-ground fish passage implementation in a range of Lower Mekong countries, including Myanmar, Lao PDR, Thailand and Cambodia. An outcome of the co-design workshop was to establish a 'Sustainable Hydropower' masterclass, which could focus on optimising fisheries solutions.

3. **National University of Laos Curriculum Improvement.** A key discussion point at the co-design workshop was that the existing course offerings at the National university of Laos (the major education institution in Lao PDR) does not have any subject offerings for hydropower nor sustainable hydropower. The Lao government officials suggested that this would be a useful focus of any extended project to ensure that future generations of managers and technical staff seeking an interest in the hydropower industry would be able to gain a grounding in based concepts relevant to sustainability in the industry.

<u>Analysis</u>

The research aspect of this component is important. There are existing frameworks in place to track career trajectories of Alumni following training activities. For (1) and (2) we will apply a system analogous to the Australia Award Alumni Tracer Facility. The Australia Award Tracer performs annual research which:

- conducts an Annual Survey, with online and telephone collection of the views and experiences of Alumni from a range of countries;
- identifies a series of case-studies, involving in-depth interviews with Alumni, employers and other stakeholders;
- collects and updates contact information for Alumni.

For the duration of our project, we will maintain contact with training Alumni and investigate benefits that have accrued. We will hold annual structured surveys which focus on understanding elements like (i) retention of technical information, (ii) technical involvement in development bank projects which have incorporated fish passage, (iii) development of new projects incorporating fish passage, and (iv) extension of training outcomes to other staff and a qualitative assessment of benefits. We will also poll graduates on the learning outcomes to ensure that the course remains fit-for-purpose and industry relevant. Key success (and failure) stories will be highlighted as case studies in our annual and final reporting processes.

2.3 Gender & Social Inclusion Strategy

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong Riverbank in Xayaburi and Luang Prabang provinces. Seven of these villages have required relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects, and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP must enhance the quality of life for the project-affected people (PAPs) and minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

The degree to which other power developers have developed such action plans is unknown but will presumably be uncovered during social network analyses.

Taking a twin-track approach to GEDSI

Development practice acknowledges that GEDSI strategies are more effective when they adopt a 'twin-track' approach (DFAT 2016). This means progressing opportunities for mainstreaming consideration of GEDSI across all components of a project, alongside targeted GEDSI activities that concentrate resources and seek new knowledge to address the underlying causes of exclusion or disparities. Targeted interventions typically generate analysis and evidence, and new partnerships and networks that can benefit the overall project. ACIAR and DFAT recommend a twin-track approach in their GEDSI policy guidance.

The proposed project will incorporate GEDSI considerations right from the outset of its co-design phase, and align with the ACIAR 'Gender Equity and Social Inclusion (GESI) Strategy and Action Plan 2022–2027'.

In particular, the proposed project team recognises that although women are highly active in fishing and marketing activities – engineering, and to a lesser extent fisheries management, are traditionally male-dominated fields (noting that this is a global trend and not just within SE Asia). Yet, women who often catch fish are the ones who prepare the fish for domestic consumption and to sell at the market. Training on safe fish handling for these objectives could enhance the nutritional quality and commercial price of the fish, while lowering the likelihood of food poisoning or unnecessary wastage.

The FIS/2023/133 team will enhance opportunities for women by:

- endeavouring to ensure equal participation of men/women in project meetings and discussions (including representative groups)
- engaging women-only training events for existing experts and students, which will be conceived in collaboration with line-agencies
- incorporating gender sensitive analysis and training into the project (especially SNA and village surveys) to ensure that the roles of both men and women are captured, and by allowing the space for both men and women to make appropriate, informed and targeted policies through gender appropriate activities
- seeking to increase the participation of women in strategic decision-making roles shaping governance and policy development.

These actions will be crucial to achieving sustainable project outcomes, and equitable, diverse and inclusive input from both women and men. It is pivotal that this knowledge is used to inform policies and strategies moving forward.

The project team has been actively working in Lao PDR for over fifteen years. Therefore, the gender inclusion strategy is largely derived from (a) our lived experience working and living in the region, (b) outcomes of structured interviews convened in association with existing projects, and (c) feedback on our proposal from reviewers. The team has also been investigating broader elements of inclusivity by including disability groups.

There are high incidences of unexploded ordnance injuries in the Lower Mekong Basin, and disability groups have been established to better-cater for the needs of impacted people. Our initial stakeholder mapping activities have identified a number of these groups that we will need to involve in the co-design process.

Nonetheless, a GEDSI advisor will be appointed, and the implementation team will consider these additional initiatives as part of project design to ensure GEDSI is integrated into all levels of activity implementation. As part of the FishTech (FIS/2018/153) initiative, under the advice of a gender advisor, the team has developed and endorsed principles to make explicit a range of GEDSI values and actions. We will apply a similar mechanism to the current project because the GEDSI considerations (of hydropower and irrigation development) are relatively similar in terms of their impacts on fisheries and fish-dependent livelihoods. During the co-design phase, a gender specialist will work with the team to adopt and adapt this approach for the context of this proposed project.

2.4 Capacity building strategy

The need for this project primarily arose because Lower Mekong partners were seeking advice and skills from international professionals with demonstrated expertise in fish passage and in fisheries monitoring using novel techniques (FIS/2017/017). Project EoPO 4 was specifically designed to enhance capacity in key hydropower development stakeholders so that they can make more informed decisions around hydropower planning and implementation.

Other partners and agencies in the region have recognised the value of the information generated from FIS/2017/017 and the demand for knowledge has grown. Despite the need, there are no systemic ‘sustainable hydropower’ capacity building programs being implemented. This project aims to create a platform for such a strategically orientated program of skill development across influencing actors.

The project team will initially conduct Menti surveys to assess the nature of the skills and/or capacity problem and the institutional environment in which the project will operate.

- The team will also assess the ‘critical mass’ in terms of training needs and key skill requirements to achieve institutional capacity, by employing systematic approaches like institutional motivation-ability (MOTA) analysis.
- These findings will be used to co-design capacity-building programs with the project partners.
- The co-design approach will be critical to assist with cultivating project partners’ ownership of, and commitment to, the capacity building agenda.
- Upon running these capacity building programs, the team will conduct further Menti surveys to review the appropriateness of the skills and/or capacity building approaches, and make changes where necessary.

The project team’s capacity building approach will be tailored to strategically enhance capacity in four key stakeholders:

Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are employed to implement research and monitoring on site. FIS/2017/017 partnered with this team and built their capacity for fish collecting, tagging, tagged fish monitoring and data analysis of fish passage. This team will broaden its responsibility for generating scientific data to inform dam operations at the new dam site at Luang Prabang.

The project will build the technical capacity of the XPCL (and research personnel in the Laos government) through peer-to-peer learning with the Australian research team, and via a range of appropriate skills development approaches, such as on-site training, online training videos (as developed during COVID-19), and workshops.

Educational institutions

A recurring discussion with universities in partner countries is their limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach, resulting in poor learning outcomes for graduates. This issue has largely arisen because academics (lecturers) have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. In response to this capacity gap, we will focus on educating these lecturers and researchers by delivering a master program through CSU (as done in FIS/2017/017 for fish pass design courses targeted at engineers in government and in donor agencies). We anticipate that, over the longer-term, some will potentially take up an international PhD (via CSU scholarships or the Australia Award platform).

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop CSU’s newly developed Master's program on fish pass design. Our project team members will then help build capacity (1) through support in designing curriculums in the tertiary sector; (2) by holding targeted faculty masterclasses in Lao PDR and implementing research projects focusing on sustainable hydropower; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host Masters’ students as part of the on-site project team. These local students, and their embeddedness within our project team, will be an important capacity-building strategy.

Government departments

A flow-on effect from poor educational institution capacity is that graduates entering the public sector have a poor capacity to effectively engage with fish passage issues in their professional life as public servants. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, there is little historical institutional capacity and no mentoring opportunities for graduates. This results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the contemporary approaches and learnings on fish passage in a hands-on way. Staff will be trained on-site at dam locations both in Lao PDR and Australia. The second approach will be targeted and opportunistic, by focusing on the most promising graduates within Lao PDR educational settings and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

Other developers

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity of, many developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this proactively by building on our trusted relationship with the Ministry of Energy and Mines, whilst engaging with key developers in the region as required. The MEM and hydropower developers both play key roles in influencing the decision making for dam designs. We have a highly effective masterclass approach to training such stakeholders. This has led to direct outcomes for fish passage design in their institutions when they return and apply their learnings to the dam construction projects under consideration.

2.5 Knowledge exchange strategy

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team, which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and developers
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool, which could be applied across the Lower Mekong Basin
- Capacity building of developers into sustainable hydropower practices
- Training of Lao and Thai scientists and managers.

The project outputs will include:

- Publications in high-ranking journals; the team anticipates ;
  (a) Modelling numbers of refresh fish for PIT tagging required in long-term fish migration monitoring programs

(b) Behaviour of Mekong River fish when approaching a hydropower plant (swimming depts, movement types, etc).
c) The effectiveness of downstream fish migration facilities at a large dam in a tropical river
(d) Improved turbine design criteria for Mekong fish species and fish friendly turbines in the LMB
(e) Social network analysis of hydropower stakeholders in the Lower Mekong Basin
(f) Socio-economic factors associated with dam construction in the Lower Mekong Basin

- A project final report
- Abstracts published in conference proceedings
- A series of online instructional videos
- Submitted manuscripts based on the findings
- Minutes and action plans formulated by the project advisory reference group
- Final report to ACIAR.

Intellectual property and other regulatory compliance

The key stakeholders and end-users of the knowledge generated through this project will consist of the XPCL, educational institutions (e.g. NUOL and CSU), government departments and other hydropower dam developers.

XPCL, educational institutions and government departments will be engaged during the project inception stage, while the project is being co-designed.

Other developers will be engaged later during the project at targeted knowledge exchange events.

Table 4. Success indicators linked to the long-term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Develop guidelines for acoustic or radio tracking at LMB HPP Revised criteria for fish friendly turbine pressure changes based on Mekong species tolerances Methodology for assessing downstream migration by fish at a large tropical river dam	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	Criteria accepted by MRC and used by other HPD (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Sensor fish trials Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified in upstream and downstream directions Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

2.6 Research activities, approaches, and outputs

EoPO 1

No.	Activity		Output(s)	Milestone date of output(s)
1.1	Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions		Data and knowledge to inform fish-friendly hydropower development	2024 - 2027
	Approach	Fish pass monitoring at Xayaburi Dam in upstream and downstream directions Acoustic fish tracking above and below Xayaburi Dam Monitoring fish that pass through turbines, the spillway, the downstream fish pass channel or the navigation lock at Xayaburi Dam Modelling limits of tolerance of Mekong fish species to changes in pressure, blade strike and fluid shear stress hydropower plants		
	Risks/Assumptions	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
1.2	Collect data/evidence on fisheries mitigation measures from existing sies (KG1)		Manuscripts on (1) Mekong fish species behaviour at HPP, (2) PIT tag refresh rates required for Mekong species to maintaining statistically robust tagged populations (3) limits of tolerance in Mekong fish species to pressure changes and shear stress (4) Improved criteria for fish friendly turbines and spillways at LMB HPP (5) Attractiveness (% of migrating fish that find) of the upstream fish ladder and downstream fish pass at a large tropical HPP.	2024-2027
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		

EoPO 2

No.	Activity		Output(s)	Milestone date of output(s)
2.1	Research to understand socio-economic impacts of dam & fish pass operations at Xayaburi & LP		Data and knowledge to inform socio-economically responsible hydropower development	2024-2028
	Approach	Social surveys and interactions with local communities		
	Risks/Assumptions	Access to local villagers is possible Developers agree to surveys taking place Human ethics committee permission is obtained Laos government approves, and facilitates, access to villagers		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
2.2.1	Research activities generate data/evidence on the community impacts of hydropower developments (KG2)		Manuscripts on community impacts of hydropower developments	2024-2028
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		
2.2.2	Data is disaggregated & analysed via a GEDSI twin-track approach (KG2)		Manuscripts on GEDSI implications of hydropower developments	2024-2029
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		

EoPO 3

No.	Activity		Output(s)	Milestone date of output(s)
3.1	GEDSI disaggregated data on stakeholder influence for each hydropower project, & to track power & influence		Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	2025-2029
	Approach	Stakeholder mapping and key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers		
	Risks/Assumptions	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared		
	Application of outputs	Identify key stakeholders for effective information dissemination Share insights with stakeholders to influence hydropower development agenda		
3.2	Influential stakeholders become engaged in contributing to formal & informal frameworks that embed best practice fish passage in hydropower developments (KG3)		Detailed stakeholder map for each site investigated Social network map for each project Pathway analysis to understand information flows	2025-2029
	Approach	Stakeholder mapping and key informant interviews with influential stakeholders, social network analysis, knowledge brokering with industry and developers		
	Risks/Assumptions	Developers, MRC and Lao government agree to engage in the process All stakeholders willingly participate and share information freely No objections to information being publicly shared		
	Application of outputs	Forge collaborative partnerships with stakeholders, shaping development strategies in line with governmental and regional priorities Developers are connected with researchers		

EoPO 4

No.	Activity		Output(s)	Milestone date of output(s)
4.1.1	Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of project outcomes beyond the life of the project		Knowledge management system	2025-2029
	Approach	Develop a knowledge management system for stakeholders identified in 3.1.		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange		
4.1.2	Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Deliver capacity building activities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		
4.2.1	Design & deliver fit for purpose training to build technical expertise on how to achieve fish friendly hydropower development based on value-for-money & socially inclusive impact (KG4)		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Targeted knowledge brokering activities and learning opportunities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		

	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures

4.2.2	Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG4)	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2027-2029

	Approach	Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures

Cross-cutting activities

No.	Activity	Output(s)	Milestone date of output(s)
5.1	Approvals to commence	Exa MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement
	Approach	Obtain approvals to commence from relevant stakeholders	
	Risks/Assumptions	Salaries and travel secured for Australian partners	
	Application of outputs	Establish the project team	
5.2	Continue PIT tagging more fish in the wild	Increased numbers of PIT tagged fish in the Mekong	Ongoing

	Approach	Continue PIT tagging more fish in the wild using the e-fishing boat		
	Risks/Assumptions	E-fishing boat is operating without issue		
	Application of outputs	Build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements models).		
5.3	Update and exchange knowledge with other groups		Sharing of key learnings Minutes from meetings	Opportunistically
	Approach	Liaise with MRC and other interested groups where work overlaps		
	Risks/Assumptions	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers		
	Application of outputs	Knowledge sharing and influencing the design and planning of other dam developments		
5.4	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2025
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.5	Hold annual team meeting		Annual team meeting minutes	April 2025
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.6	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2025
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		

	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.7	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2026
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.8	Hold annual team meeting		Annual team meeting minutes	April 2026
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.9	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2026
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.10	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2027
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.11	Hold annual team meeting		Annual team meeting minutes	April 2027

	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.12	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2027
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.13	Annual reporting		Annual reporting to ACIAR and DFAT	30 April 2028
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
5.14	Hold annual team meeting		Annual team meeting minutes	April 2028
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
5.15	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2028
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		

	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
5.16	Final reporting		Final project report to ACIAR and DFAT	June 2029
	Approach	Final project report delivered in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Overview of final project results/outcomes and final report is accepted		
5.17	Hold project final review meeting		Meeting minutes	June 2029
	Approach	Key team members and project stakeholders meet to review final project outcomes and report		
	Risks/Assumptions	Key members can attend, and all milestones are completed		
	Application of outputs	Confirm that project has been satisfactorily completed and recommended changes made to final report		
5.18	Final manuscripts		Published papers	June 2029
	Approach	Complete and submit final manuscripts to target journals		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination of key findings to the scientific community		

3. Project management

3.1 Project performance and monitoring plan

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes foundational and intermediate activities, which take the activities and break them down into manageable sub-activities. Each activites has been included includes into the logframe (Figure 8) with defined impact pathways.

Medium-term cycles

The yearly reports and a forum will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place, which will include a facilitated lessons learned workshop, and a written final report.

Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large-scale impacts will accrue with time and may extend beyond the project funding envelope.

3.2 Management aspects

Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Under the contract terms of the first phase of research (FIS/2017/017), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated that the panel meet on an annual basis, at the dam site. The Project Reference Panel has advisory status and consists of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited, Ministry of Energy and Mining, plus representation of Lao nationals (Figure 2).

They conduct their business in confidence, which will be defined by a term of reference established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly funded data must be openly available according to ACIAR's contractual requirements, and that that some IP will be required to remain commercial-in-confidence.

Mid- and final-project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR 'mid-project review' (after 24 months) and 'end-of-project review' processes.

Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Lao PDR dating back over ten years). The team will communicate regularly:

- Through face-to-face meetings, on ground and in country visits and networking
- Using Internal information-sharing and communication strategies
- Through bi-annual face-to-face planning workshops
- By developing workplans for achieving each of the four EoPO's
- Holding regular work in progress meetings leveraging a full range of technology
- By documenting and distributing meeting minutes and action items
- Through routine monitoring and status reporting of deliverables
- Through the development of instructional videos and manuals as reference items.

Project coordination mechanisms and responsibilities

Project coordination will be undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Gulbali Institute, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations. Finally, each agency will have a nominated 'leader' who will coordinate activities and partnerships with the agency. Dr Oudom Phonekhampheng will represent the National University of Lao PDR, and Bounsong Vongvichthit will represent Living Aquatic Resources Research Centre. These officers will take on local leadership roles (including managing resourcing and project management) to ensure the project team can effectively operate within local frameworks.

3.2 Avoiding harm

The project will seek to extrapolate and adopt the principles and guidelines of International Organisation for Standardization (ISO) 31000:2018 Risk Management. Detailed risk mapping will be undertaken at the inception meeting. The main aspects of the project will be identified and related to:

- Risk mapping based on previous projects and outcomes in Lao PDR (since institutional frameworks and expectations are well-known to the project team from prior projects)
- A risk management strategy, with defined risks, treatments and mitigation measures, for each key project milestone/activity

- A routine audit of and assurance on activities, which will form a key part of project measurement and evaluation by ensuring that anticipated activities are tracking as expected
- Regular communication and sound project management.

Animal research undertaken in Lao PDR is governed by the provisions of Animal Care and Ethics under Australian Law.

Therefore, the project team will apply for, and maintain, appropriate Animal Care Authorities for the duration of the project to cover all planned animal research.

Any fish research will also be in accordance with the requirements of relevant legislation (i.e. the Environment Protection and Biodiversity Conservation Act 1999, The Australian Code for the Responsible Conduct of Research (2018), and The Australian Code for The Care and Use of Animals for Scientific Purposes 8th edition (2013)).

Likewise, all human research will be conducted in accordance with The National Statement on Ethical Conduct in Human Research (2007)—Updated 2018.

3.3 Data management plan

Research Data Management (RDM) is a recommendation of the Australian Code for Responsible Conduct of Research. To ensure Charles Sturt University researchers follow good RDM practice, Charles Sturt has established an RDM policy. This policy requires all active research projects (whether funded externally or not) to have a RDM Plan which follows a standard template, and that all researchers generating research data must perform compulsory training. The RDM Plan will be provided to ACIAR upon completion.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support. The data sharing and publication arrangements therefore need to be carefully considered, discussed, and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

In terms of ACIAR good management principles:

Findable: CSU will have cloud-based systems established for most data management. Social science data will be managed, and coded, within NVivo. Both PIT tag, and acoustic tag, data will be stored in the Cloud-based database *FishNet,* which is backed up, reliable and robust.

Accessible: Access to NVivo and FishNet is managed at a user-level. Users can be added and deleted by KarlTek Pty Ltd. We suggest that the project advisory reference group be appointed as the team that manages access.

Interoperable: The cloud-based databases can be accessed via and operating system platform from any location globally provided there is an internet connection.

Re-Usable: The databases have a set of pre-defined '*Queries'* which allow 'clickable' reports to be generated by the user at any time. The reports update whenever new data is added to the database making the data re-usable indefinitely.

3.4 Intellectual property and other regulatory compliance

CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties.

An intellectual property register will be established at the beginning of the project in accordance with ACIAR's requirements. The register will encompass foreground, background and third-party intellectual property, and will include details on proprietary materials, techniques; and other contracts, licenses or legal arrangements.

In addition, the Mid-Term Review will include a review of the use of Background IP in the project to date and any Project IP that is in development and likely to lead to IP that is protectable. The Mid-Term Review team will be tasked with recommending to ACIAR whether additional actions, beyond that defined in the Standard Conditions, are required to clearly define ownership and/or public access to Project IP, that has been funded by Australian taxpayers.

4. Resourcing

4.1 Project team and partnerships

Name	Gender	Organisation	Discipline	[redacted]
Prof. Lee Baumgartner	M	CSU	Professor in hydropower/ fisheries/ river management	[redacted]
Dr Wayne Robinson	M	CSU	Biometrician and hydropower/ fisheries/ river management	[redacted]
Dr Nathan Ning	M	CSU	Aquatic ecology and hydropower/ fisheries/ river management	[redacted]
Mr Tisi Tukuniu	M	CSU	Project co-ordination and management	[redacted]
Social scientist	F	TBD		[redacted]
Knowledge broker	M or F	TBD		[redacted]
Miss Mia Urbano	F	Alinea International	GEDSI-appropriate participatory research	[redacted]
Mr Karl Pomorin	M	KarlTek Pty Ltd	PIT tag system installation and management	[redacted]

FOI Act s. 47f

				[redacted]
Mr Garry Thorncraft	M	National University of Laos	Hydropower/ fisheries/ river management and fish passage expert	[redacted]
Dr Oudom Phonekhampheng	M	National University of Laos	Fisheries/ river management	[redacted]
Dr Bounsong Vongvichthit	M	Living Aquatic Resources Research Centre	Fisheries/ river management	[redacted]
Mrs Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Fisheries/ river management and social dimensions	[redacted]

FOI Act s. 47f

				[redacted]
Mr Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental engineering and hydropower	[redacted]
Dr Michael Raeder	M	Xayaburi Power Company	Engineering and hydropower development	[redacted]
Lamphone Dimmanivong	M	Ministry of Energy and Mines	Department of Planning Division	[redacted]

The hydropower development space is a politically challenging environment. It takes time (years) to establish relationships, trust, and demonstrate an ability to deliver on research outcomes. The FIS/2017/017 project developed trust and a highly productive working relationship among partners. The project team currently includes a private-public partnership team that now has an established track record and positive reputation in the region.

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies involved have the scientific and financial capabilities to successfully complete an international collaboration. Specifically:

Charles Sturt University: Has a long history with ACIAR and in working in the SE Asian region and will lead the project. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. CSU has extensive experience with PIT system data analysis and installations. We also have extensive experience with social research. There are no other universities in Australia with such extensive experience and networks for fishway design and monitoring.

Xayaburi Power Company: Owns and operates the hydropower projects (Xayaburi and Luang Prabang, the latter of which is currently under construction). They will own the facilities for the next 30 years under a concession agreement. Their fish monitoring researchers will partner with the CSU team to conduct on-site project activities.

KarlTek Pty Ltd: Is a Melbourne-based, 100% Australian owned and operated company that provides PIT tag-based solutions to a wide range of wildlife monitoring applications. Set up the PIT database for Xayaburi and will continue to manage this PIT database and advise on any new PIT installation works at the new dam site. Has >20 years of experience in PIT installation projects and successfully completed the installation and database management work for the preceding Xayaburi projects.

National University of Laos (NUoL) and Living Aquatic Resources Research Centre (LARReC – a centre within the Ministry of Forestry and Agriculture): Will both assist with in-country project co-ordination, field work and project delivery.

NUoL: Is the primary university in Lao PDR. Has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum.

LARReC: Is the leading institute in aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Ministry of Energy and Mines (MEM): Currently the only agency with an outward facing discussion with all proponents of mainstem hydropower dams. Their role is to review and approve dam projects.

New team members: We will be seeking new skills in the team; policy decision making research and analysis; knowledge brokering expertise, community engagement and GEDSI-appropriate participatory research and capacity building activities.

4.2 Collaboration

The team will collaborate with additional entities who are involved in achieving optimal fish passage outcomes at LMB mainstem hydropower developments. This will require us to work more closely with the Lao Minister of Energy and Mines (than in the past). It will also require us to work in collaboration with individual companies involved in dam funding and development. Both these actors are engaged in dam design decision making for planned hydropower projects.

The team will need to engage the Mekong River Commission more strategically, so their hydropower guidelines and recommendations are updated to include new knowledge generated through this project.

Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

A panel was developed for the previous project (FIS/2017/017) to oversee and guide the project team. This governance structure proved to work very well, so the same structure will be applied to this proposed project for continuity of knowledge and learnings. We will continue to support the existing panel, which has representative stakeholders from all cash/in-kind investors including Charles Sturt University, DFAT, ACIAR, XPCL plus representation of Lao nationals and independent experts. The panel members each have >10 years' experience each in their respective fields. They will conduct their business in confidence and review their current terms of reference at the project initiation phase.

Name	**Gender**	**Agency**	**Position at agency**	**Project Responsibilities**	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	
John Dore	M	Department of Foreign Affairs and Trade	Water Specialist	Reference panel member	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	
TBD	TBD	ACIAR	Fisheries RPM	Reference panel member	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required. Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

FOI Act s. 47f

4.4 Budget Required

[redacted]	TOTAL
[redacted]	[redacted]
[redacted]	$5,700,000

[redacted] project start date.

Draft full budget required, including partner payments, to be administered by the commissioned organisation to deliver the work as scoped:

[redacted]	TOTAL
[redacted]	[redacted]
[redacted]	$5,700,000

Budget assumes a start date of July 2024. In-kind contributions from CSU, partner agencies and XPCL will be significant but will be determined during Phase 1 preparation.

FOI Act s. 47f

4.3 Budget justification

Charles Sturt University

Salaries: [redacted] A key learning from the co-design workshop was that many of the project staff have been active now for almost 20 years. There is a need for succession planning. We therefore seek to recruit a junior social scientist (ideally specialising in Social Network Analysis) to work exclusively on EoPO 2 and 3. Also seeking to recruit a knowledge broker (ideally specialising in hydropower matters to extend knowledge from EoPO1 and EoPO2 to key stakeholders). It is essential that these staff can spend significant amounts of time, in-country, to connect with stakeholders. Finally, seeking support to cover the costs of the advisory reference panel, especially externally funded experts. This will ensure we have a robust and well-resourced project team with capacity to meet the needs of ACIAR/DFAT and the stakeholders we are trying to reach.

Research operating: Research consumables (each year across the four EoPO's); plus office consumables to assist with project running. Seeking support to develop/publish reports, briefs, posters, infographics and other dissemination materials (especially bilingual outputs). Including an allocation for developing educational materials needed for EoPO4 when short-courses and masterclasses are developers for stakeholders).

Travel: Allocated to cover advisory reference panel expenses (annual meetings in the region); with a specific allocation for a mid-term review; fieldwork at Xayaburi/Luang Prabang each year with additional support for social surveys and social network analyses. Allocated a specific amount to cover participation in final project review.

Capital: Seeking computers for project staff along with field tablets to record social survey information, an iPhone for remote fieldwork and printer to support the project team.

Infrastructure: CSU has a compulsory infrastructure levy of 25% but will discount to 13% as per ACIAR guidelines.

National University of Laos FOI Act s. 47f

Salaries: [redacted] This is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together and is also connected to MRC, government and developers.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs of the NUOL team. Boat hire and equipment use for remote fieldwork. There is a need for hatchery consumables for fish husbandry and long-term field trials. Have also included support for masterclasses and education materials as NUOL are the main in-country partner for education outcomes and will co-design and implement on ground knowledge brokering and capacity building.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1 and EoPO 2. Provision made for mid-term review and final project review.

Capital: Included moderate provision for ICT equipment (Year 1).

Infrastructure: National University of Laos sets the infrastructure recovery at 10%.

Living Aquatic Resources Research Centre

Salaries: Mr Douangkham Singhanouvong [redacted] is an emeritus researcher but is a critical liaison point for the Lao government. He will continue his key role, on a part-time basis in his retirement. [redacted] As with NUOL, this is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs. LARReC will be organise the mid-term and end of project review and so provision has been made for these important workshops. Hatchery consumables are included to support fish husbandry and other field expenses.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1 and EoPO 2. Provision made for mid-term review and final project review.

Capital: LARReC purchased a vehicle to cover the ACIAR-suite of work in 2006. It has not been replaced since. The vehicle has been depreciated beyond its effective life and is overdue for replacement. Seeking an allocation. Also included moderate provision for ICT equipment (Year 1).

Infrastructure: LARReC sets the infrastructure recovery at 10% (which is mandated by its head institution, NAFRI).

Ministry of Energy and Mines

Salaries: [redacted]

Research operating: Included a consumables provision to cover expenses whilst assisting with fieldwork.

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: Provision for a laptop from project staff.

Infrastructure: MEM sets the infrastructure recovery at 10%.

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Xayaburi Power Company Limited

Salaries: Xayaburi Power Company Limited will provide four staff members, based on site, who will collaborate with the team and contribute to fieldwork. [redacted]

Research operating: Access to a boat, operating of the fish research facility, maintenance and expansion of the PIT system, including procurement of an acoustic system, will be covered as a cash contribution.

Travel: Any travel-related costs for XPCL staff will be borne by the company. Staff visiting XPCL-controlled sites will be provided with accommodation by XPCL.

Capital: XPCL will purchase any significant equipment and plant needed for the project.

Infrastructure: N/A. XPCL will not be receiving any funds.

4.4 Additional resourcing requirements

The FIS/2017/017 project was based on the premise that the Charles Sturt University team would source their salary and travel, and developers would cover all required equipment. This agreement will extend into the new project and so significant in-kind is provided from hydropower developers. CSU will also make contributions to Masters' courses, student stipends and masterclasses as needed throughout the project.

FIS successfully facilitated, through Clear Horizons Consulting, a co-design process for project logic and a theory of change framework that culminated in a Monitoring-Evaluation-Learning plan for the FishTech project. The project team would see great benefit in extending this approach to the project development phase of FIS/2023/133 should this proposal be accepted.

DFAT and ACIAR also implemented a MSA between the Australian and Lao governments, which acted as a template for the project team to operate in a complex political environment. This included the establishment of a project reference panel to oversee and guide the project. Renegotiating this MSA, and maintaining support for the project reference panel, will be critical.

5. References

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Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

Administrative details

[redacted]

Plant or animal germplasm exchange

[redacted]

If 'yes' to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

[redacted]

Proprietary materials, techniques and information

[redacted]

'Data' means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical expertise and information reduced to material form by that Party. If 'yes' to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If 'yes' to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

Project, background and third-party Intellectual Property

This includes but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Project IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Project IP (IP that is expected to be developed during the project)

The following material is to be developed as part of the Project:

[redacted]

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If 'yes', for each applicable country provide brief details.

[redacted]

FOI Act s. 47

Appendix B: Project variations

Variations to the project after commissioning should be documented in this section

Variation 1.

Variation Date	Purpose	
Example date	Brief explanation of purpose for variation	
Changes (omissions, substitutions, inclusions)	i.	Page 8, line 16-18. - **Omitted line**: '…*example*…' - **Substituted line**: '…example…'
	ii.	Page 9, line 12. - **Included line**: '...example...'
	iii.	
	iv.	
	v.	
	vi.	
	vii.	
	viii.	
	ix.	

Australian Government

Australian Centre for International Agricultural Research

Full Project Proposal

ACIAR Program(s) area	Fisheries
Project Title	Optimising fish passage at hydropower sites in the Mekong
Project Number	FIS/2023/133
prepared by	Lee Baumgartner and Nathan Ning
ACIAR Research Program Manager	Dr Ingrid Van Putten

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the Australian Privacy Principles set out in Schedule 1 of the Privacy Act 1988.

The primary purpose of collecting the personal information provided in this project proposal is to consider the suitability of the project proposal for progression to a project. The names, contact details and CVs of project members may therefore be shared with external project reviewers as part of the project development cycle. Further, if this project proposal progresses to a project, then this project proposal (including personal information provided therein) will form part of project documentation exchanged with project parties such as the commissioned organisation, collaborating institution(s) and partner-country government(s) for use in furtherance of the project.

ACIAR may also use and disclose personal information provided in this project proposal for related secondary purposes, such as:

- in furtherance of the ACIAR Capacity Building Program;
- to develop the ACIAR alumni network; and
- in evaluating and assessing the effectiveness of, and otherwise developing our policies in respect of, our projects.

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

More generally, ACIAR will store, use and disclose personal information in accordance with its privacy policy located on the ACIAR website at www.aciar.gov.au/privacy-policy.

Queries in respect of how ACIAR stores, uses and discloses personal information may be directed to [redacted]

Summary Information

Version # and date of this document	December 2023
Project number	FIS/2023/133
Full project title	Optimising fish passage at hydropower sites in the Mekong
Budget ($)	$5,700,000
Commissioned Organisation	Charles Sturt University
Project Leader	Dr Lee Baumgartner
Country 1 Coordinator	Dr Oudom Phonekhampheng (NUOL)
Country 2 Coordinator	Mr Bounsong Vongvichith (LARReC-NAFRI)
Country 3 Coordinator	Dr Kaviphone Phoutavong (DLF)
Proposed start date	1 July 2024
Proposed end date	30 June 2029

Contents

1. Project justification

1.1 Project aim

This project aims to minimise the potentially harmful impacts of hydropower projects on the productive fisheries, and the people who depend upon them, in the Lower Mekong Basin.

1.2 Development issue and research opportunity

Development issue

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively and severely impacted if all planned large-scale mainstem hydropower projects are completed without appropriate consideration for the impacts on fish migration and people who depend upon migratory fish. There are presently nine large hydropower projects scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The hydropower projects have divided public opinion. The capture fishery in the Lower Mekong Basin has been estimated to be worth US$7-8 billion annually (MRC, 2023b), but the projects are expected to reduce, by more than half, this important source of food and income for many people (ICEM 2010).

Hydropower development (HPD) on the Mekong River is expected to aggravate food insecurity and poverty in the region (MRC, 2018). Thailand is expected to suffer the most economically and ecologically, and full hydropower development will decrease GDP growth for LMB countries by US$29 billion (MRC, 2017, 2018). Native fish stocks will be particularly impacted, with more than 900,000 tonnes of fish biomass, worth US$3.3 billion (Figure 1), predicted to disappear by 2040 (MRC, 2017, 2018). Thailand would have the highest rate of fish loss (55% of fish stocks), then Lao PDR (50%), Cambodia (35%) and Vietnam (30%).

Social impacts are also expected, such as community displacement and livelihood and food security reductions, and will largely affect riparian communities. Indeed, a scenario analysis by the MRC Council on the sustainable management and development of the Mekong River (i.e. the 'Council Study') suggests that planned hydropower development will adversely affect community resilience and sustainability, with hydropower companies benefitting at the expense of fishing households (MRC, 2018). Environmental issues of reduced water quality, decreased fish quantity and unstable water flow will exacerbate these impacts (Soukhaphon et al. 2022). Loss of livelihood is expected to be cumulative and become increasingly significant as more hydropower projects are constructed along the Mekong River. Issues of food and livelihood security are also faced by those relocated and not provided appropriate compensation. Hydropower proponents suggest that the fisheries impacts can be minimised through the application of technical solutions, such as fish passes (Baumgartner et al. 2018; Baumgartner et al. 2012).

The first LMB mainstream site, at Xayaburi, in Lao PDR was completed in late 2018 (Figure 1). The Xayaburi hydropower project blocks the entire width of the river with a wall more than 30 m high, presenting an impassable barrier to all fish species (Orr et al. 2012). Significant investment (US$300M) to provide for fish passage was incorporated into the final designs to minimise impacts on fisheries (Campbell and Barlow, 2020). The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical world. However, at the time of construction, there were no data available globally to inform the likely success, or otherwise, of such an investment in a river system with a highly diverse fish community like the Mekong. The success of this structure was the focus of FIS/2017/017.

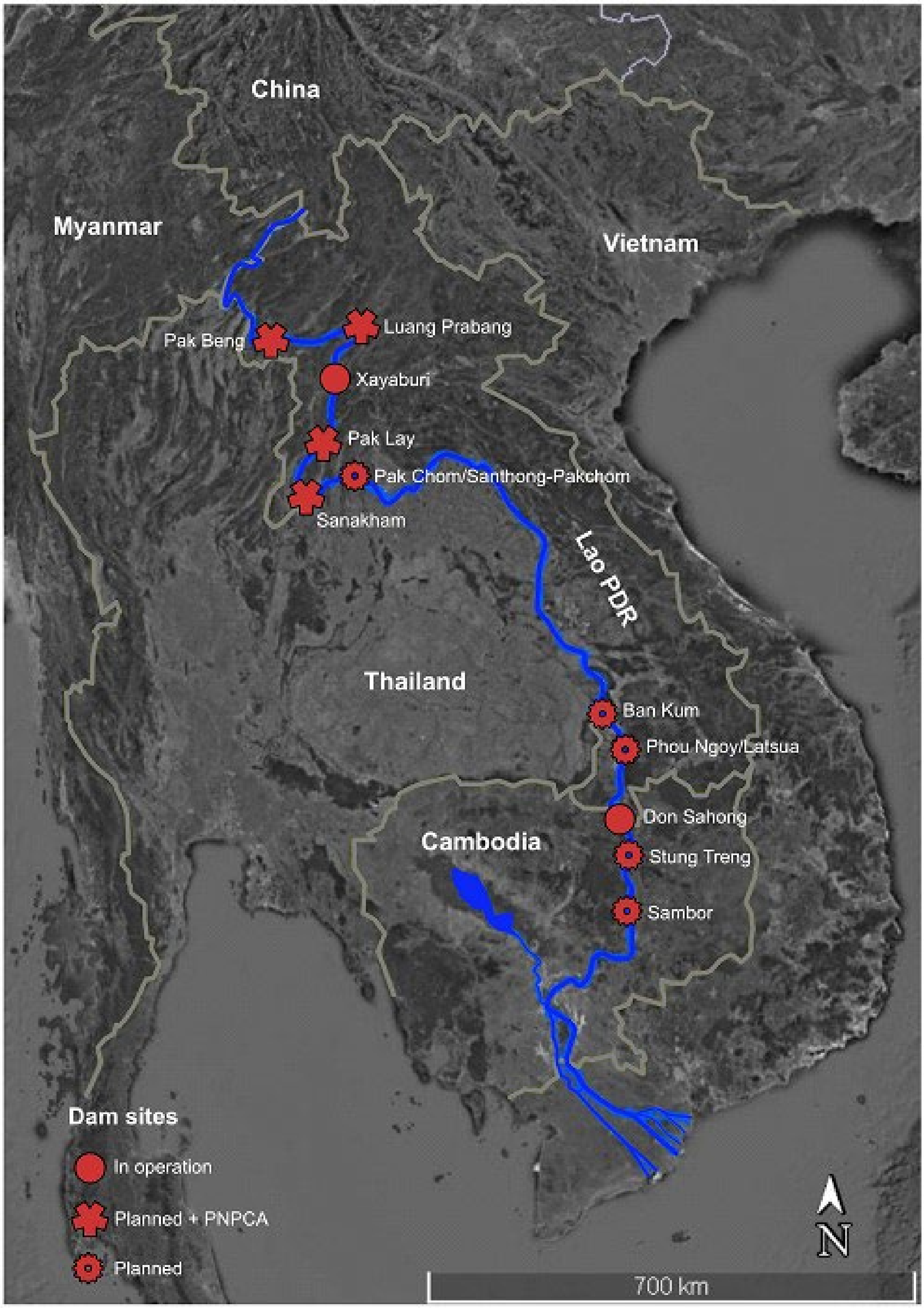

Figure 1. Map of hydropower projects on the mainstem of the lower Mekong River that are either planned, planned and at the PNPCA stage, and already in operation.

What do we already know?

ACIAR/DFAT and Charles Sturt University partnered with Xayaburi Power Company Limited to answer the question of whether the upstream fish passage facilities were effective in passing a large proportion of fish numbers and species. A structured research program was initiated (FIS/2017/017), which focused on the effectiveness of the upstream fish pass within a limited line of inquiry (focused largely on the fish pass effectiveness for fish migrating upstream). Nevertheless, initial results are very promising, demonstrating that large numbers of many species are moving upstream with a >80% ascendency efficiency (i.e. >80% of PIT tagged individuals locating the fish pass entrance have been able to ascend all the way to the fish pass exit) (unpublished data – sourced from PIT tagged fish being detected by PIT antennas at the entrance and exit of the fish pass during FIS/2017/017). Twenty-three migratory species have been detected in the fish pass so far, representing a wide range of fishes that are important for supporting the protein requirements and/or livelihoods of LMB riparian communities (with the most common being *Hypsibarbus* spp., *Puntioplites falcifer* and *Sikukia gudgeri*) (FishNet unpub. data from FIS/2017/017).

This initial work was, deliberately, technically focused. The monitoring technology needed to measure fish pass effectiveness had never been used before in SE Asia, nor at a structure of this size. So, the methods needed to be validated (methods included microchipping and electrofishing). Secondly, efficiency trials had never been completed for such a diverse tropical ecosystem. Methods were therefore needed to be refined for a significant number of Mekong fish. Thirdly, the study represented the first time that fisher-independent data relating to fish passage at hydropower facilities had been generated in the Lower Mekong Basin. Therefore, the mechanisms to analyse and interpret such data needed to be developed. These were all achieved as part of FIS/2017/017, which concludes in June 2024. The project has significantly advanced knowledge generation to inform the development agenda. However, several knowledge gaps remain relating to technical aspects such as downstream fish passage, socio-economic aspects such as local fishers' livelihoods, and knowledge transfer aspects about how best to translate the results of the program work into improved policy outcomes, and whether the learnings can be practically applied at other hydropower sites.

What is the current stage of the development cycle?

The Mekong River Commission (MRC) coordinates a 'prior consultation' process under the Procedures for Notification, Prior Consultation and Agreement (PNPCA). This represents an opportunity for MRC Member Countries and other stakeholders to discuss and review benefits and risks of any water-use project proposed for the mainstream, which may have potential significant cross-border impacts on the Mekong River flow regimes, water quality and other environmental and socio-economic conditions (Table 1). This is a highly public, open and transparent process, by which developers submit their plans for hydropower projects and these then become subject to national and international scrutiny. The MRC has concluded prior consultations for five hydropower projects: Xayaburi, Don Sahong, Pak Beng, Pak Lay and Luang Prabang, and is carrying out the consultations for the Sanakham project (Table 1; Figure 1). The outcomes of these PNPCA processes were that the proposed fisheries mitigation strategies, as submitted, were likely to be insufficient and that the developers needed to work harder to identify sustainable solutions.

Xayaburi, Don Sahong and Luang Prabang altered their plans because of the PNPCA and proposed solutions that were otherwise untested in the region. Other developers (for Pak Lay and Pak Beng) are now actively working to amend their submissions in response to PNPCA feedback. The Mekong River Commission is subsequently seeking evidence and data to support these re-designs. The main point here is that there are few new hydropower plants currently under construction; most are in the design, or redesign phase. Those that are already operating have a significant opportunity to influence those about to be designed, or those that are being re-designed (Table 1).

Therefore, there is an extremely limited, but time bound, opportunity to influence the design of future hydropower projects provided that (a) evidence and learnings from existing sites, in terms of fisheries productivity and livelihood protection, can be disseminated; (b) proponents agree to share and incorporate data into new designs; and (c) the need to protect fisheries and livelihoods is accepted and actioned by developers.

Table 1. Expected completion dates for hydropower projects in the Lower Mekong.

Hydropower project	PNPCA date	Expected commissioning year	Installed capacity (MW)	Mean annual energy (GWh)	Height (m)	Crest length (m)	Max reservoir area (km^2)
Ban Kum	TBD	Beyond 2030	1,872	8,434	53	780	132.5
Latsua (Phou Ngoy)	TBD	Planned. COD Unknown.	800	3,504	22	1,300	13
Luang Prabang	2019	2030	1,200	6,500	57.5	318	72.4
Pak Beng	2018	2033	912	4,846	85	943	87
Pak Lay	2018	2032	1,320	720	35	630	108
Sanakham	2020	Planned. COD Unknown.	700	5,015	25	1,144	81
Santhong-Pakchom	TBD	Planned. COD Unknown.	1,079	5,052	55	1,200	80.3
Stung Treng	TBD	Planned. COD unknown.	980	4,870	22	10,884	211

Knowledge gaps in the 'sustainable hydropower' research for development framework

There is insufficient evidence available, in the public domain, or otherwise, for developers to adequately address PNPCA concerns (Mekong River Commission, 2022). There remains significant debate as to what the 'minimum' requirement would be to define a hydropower project as 'sustainable' and there is virtually no data/evidence publicly available, from existing sites, which demonstrate 'best practice standards'. The Mekong River Commission recently released the 'MRC Hydropower Mitigation Guidelines' (HMG) (MRC 2020), which steps through the key considerations for developers. However, the document lacks local evidence and examples in the guidance are largely from other regions (North and South America). In fact, the only data that currently exists regarding mitigating fish migration outcomes in the LMB has been solely generated by FIS/2017/017 at Xayaburi. Nonetheless, that project was limited in scope and identified several key knowledge gaps that require further investigation, and dissemination, in a 'research for development' sense. Indeed, that work, once disseminated will necessitate an update to the MRC document.

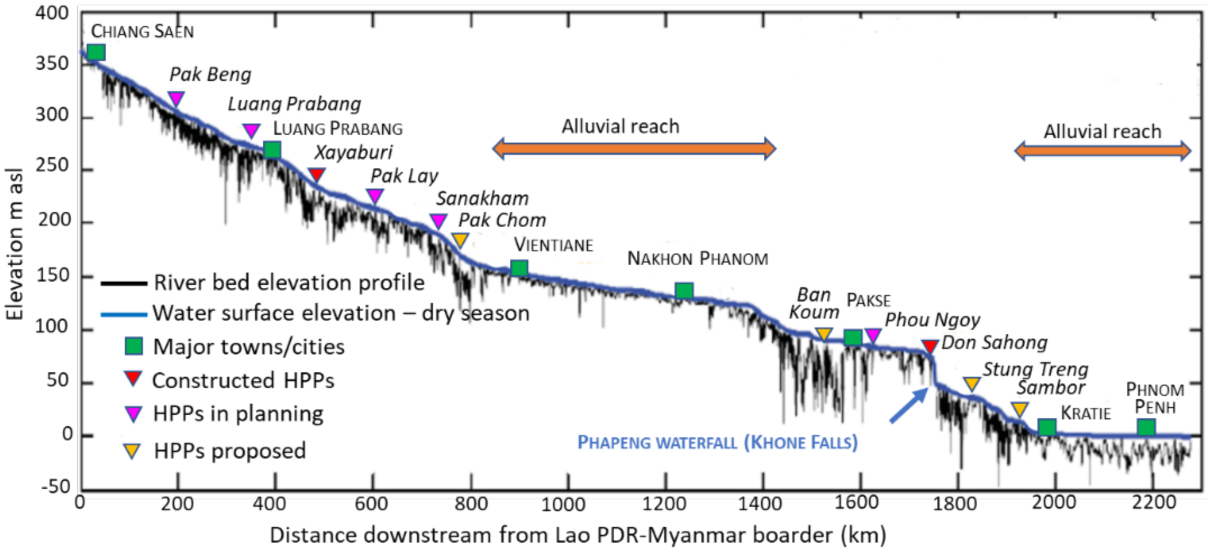

Figure 2. Cross section of hydropower construction along the Mekong River.

Progress so far

Following FIS/2017/017 a knowledge gap workshop was held, comprising of a team with developers, the Lao government, and Charles Sturt University academics. The workshop participants identified scalability of existing results, and any knowledge gaps that remained, to influence the policy and activities of other hydropower planners and developers in the region.

The co-design workshop revealed that:

- The Charles Sturt team is presently the only research group with established relationships, and an active program of fisheries-related work, at all existing mainstem hydropower projects (Don Sahong, Xayaburi and Luang Prabang).
- The team has long-standing (since 2007) and functional links with the Lao government (Ministry of Energy and Mines, Ministry of Agriculture and Forestry and National University of Laos). Additionally, the team actively works with major river development initiatives in association with the Mekong River Commission, the Asian Development Bank and the World Bank.

- The existing project (FIS/2017/017) successfully demonstrated new technology and established trust among partners.
- The existing project only focused on upstream fish pass effectiveness using a single technology at a single site.
- In a 'research for development' sense, there is still a need to understand:
  (a) whether the downstream fish passes are facilitating bi-directional fish movement and if upstream migrating fish are delayed (Knowledge Gap (KG) 1).
  (b) changes in river fisheries structure/yield following construction (KG1).
  (c) factors influencing migratory fish in the region, why fish are migrating, where they are migrating to, and the degree that fish pass facilities are assisting (KG1).
  (d) the long-term benefits of the existing facilities at Xayaburi in mitigating fish-related impacts and supporting livelihoods and food security (KG1).
  (e) what the criteria are for designing hydropower turbines that minimise adverse impacts on the passage of Mekong fish species (KG2).
  (f) how best to disseminate and translate the results of the program of ACIAR/DFAT work into improved policy and decision-making outcomes (KG3).
  (g) whether the learnings from Xayaburi hydropower project can be directly applied to other sites, such as the next hydropower plant (Luang Prabang) and others in Table 1 (KG3).

Consolidating the workshop outcomes into the new activity yielded the following focus areas linked to the requirements of the ACIAR project design brief:

<u>KG 1: Fish pass facility effectiveness.</u> The FIS/2017/017 assessment of the fish passage facilities at Xayaburi hydropower project focused entirely on the fish ladder itself and only on upstream migration. This was urgently needed and filled an important knowledge gap. However, this alone is insufficient to demonstrate that a hydropower project has mitigated its environmental impacts. For instance, there is a need to understand if migratory fish are delayed 'outside' the fish pass and cannot enter the fish pass at all. Fish also need to migrate downstream, but there have been no studies on downstream passage efficiency at any hydropower project site along the Mekong. There is, therefore, an urgent need to document whether fish can pass both upstream and downstream at Xayaburi. There is also a need to determine if fish approaching the hydropower project are delayed, or unable to locate the fish pass entrance at all. These questions are equally relevant to the next project scheduled for construction, Luang Prabang, and there remains significant international demand for this evidence to be generated. The data then needs to be transferred to other sites.

<u>KG 2: Turbine passage.</u> Understanding the principles of effective turbine passage is essential to ensure improved passage of fish in upstream and downstream directions. This pertains largely to issues associated with rapid pressure change, fluid shear and blade strike. There are techniques available to improve turbine design to minimise fish welfare issues whilst also protecting commercial outcomes. However, there is very little data upon which to base any design decisions for Mekong fish. This study will generate the first critical data needed to feed into future turbine design.

<u>KG 3: Designing effective dissemination pathways.</u> The information generated (in KG 1 and 2) on fisheries outcomes needs to be disseminated to the key actors in the most appropriate format (to be determined here in KG 3).

These knowledge gaps form the central concepts needed to close out an adaptive management theory of change. In this instance, an intervention has been designed and data has been gathered on its performance. Future interventions now need to be improved based on this information. So far, only limited information on KG1 has been generated by

FIS/2017/017. Therefore KG 1 and KG2, require urgent resolution to influence the next hydropower projects, which are scheduled for construction over the next seven years. Filling these essential knowledge gaps, and disseminating the data, remain the most significant barriers to the sustainable hydropower movement in the Lower Mekong Basin.

Novelty and timeliness of this research

There are presently no other efforts underway to address these research priorities in the Mekong region. All learnings from this research are novel, and crucial for providing a standard for fish pass construction and monitoring at other hydropower sites in the LMB. Plans to construct eight other mainstem projects on the Lower Mekong are at various stages of development. The next site, Luang Prabang, will be operational in seven years. Additional sites at Pak Beng and Pak Lay will follow and are presently progressing through concept design review. Each hydropower project will add cumulative impacts on migratory fish populations (Halls and Kshatriya 2009), but there is little to no practical understanding or anticipation of these compounded impacts in the region; in fact, the combined CSU and XPCL team is the custodian of the only practical dataset could realistically influence this agenda.

There remain critical knowledge gaps – across ecological management, policy influence and technical interventions – to achieve outcomes at a whole-of-region scale. Continuing the existing research program (from the ACIAR-DFAT co-funded FIS/2017/017 project) is required to assess the quantum and species mix of fish that are passing at fully operational hydropower sites, both up- and downstream. The ongoing fish monitoring will also allow for stock assessment and the detection of changes in community composition or abundance over the longer term associated with any potential far-reaching impacts. Furthermore, there is an increasing and immediate requirement to disseminate the data to a broader audience. This is urgently needed if sustainable practices are to be incorporated into future hydroelectric power development programs.

There is a time-limited opportunity to develop critical knowledge, which can be translated into actions at these new sites. The research outcomes from this proposal could positively influence development at the remaining sites, by building on a solid foundation of industry-relevant research, and an effective policy influence framework for decision makers.

1.3 Partner country and Australian research and development priorities

Country/regional priorities and commitments

Protecting migratory fish from hydropower infrastructure impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to international conservation advocacy groups. The overarching need for this work is largely driven by the 1995 Mekong Agreement, which explicitly requires Lower Mekong Basin countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). It is also driven by the commitment of the XPLC to set the standard for fish pass infrastructure design and fish pass monitoring in the region.

For hydropower projects in Lao PDR, the Lao government (through the Ministry of Natural Resources and Environment - MONRE, and the Ministry of Energy and Mines – MEM, and Ministry of Planning and Investment) enter into 30-year concession agreements with power companies. During this period, the company owns and operates the site, after which ownership transfers to the Government of Lao PDR.

Hydropower proponents are required, via approval processes led by MEM, to take substantial steps to minimise environmental impacts at the hydropower site, including providing successful passage for fish species. MEM is currently the only agency with an outward facing discussion with all proponents of mainstem hydropower projects. Their role in approving hydropower projects includes reviewing the design of the fish pass component. MEM officials recognise their engineers are not equipped to do this work and have sought to engage with FIS/2017/017, requesting that their staff are trained in sustainable fish pass techniques. The new project will bring MEM into the centre of its strategic partnership engagements, given their influence in effecting change in design in Lao PDR. At a recent co-design process with the project team and stakeholders, MEM officials identified that gaining access to critical skills and data is needed to make more informed choices when decision-makers are given consent for future projects.

Australian Development Objectives and/or Foreign Affairs Agenda

In line with DFAT’s international development policy (DFAT 2023a), FIS/2023/013 will support local leadership by employing approaches that increase participation from local actors in all aspects of the project, including planning, design and implementation; and monitoring and evaluation.

DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (DFAT 2017; DFAT 2020a; DFAT 2020b; DFAT 2023a).

FIS/2023/133 is therefore directly related to DFAT's strategies for the four Lower Mekong countries. Hydropower development is the most significant water management issue in the Lower Mekong Basin. The Xayaburi hydropower project, being the first site, remains of particular interest and significance internationally.

Protecting migratory fish from hydropower impacts is a priority for all SE Asian countries with a hydropower development agenda, and is recognised by many foreign aid agencies. Our team members work with ACIAR on fishery-related research in Lao PDR (through active projects FIS/2006/183, FIS/2009/041, FIS/2012/100). Likewise, the recently completed CGIAR Challenge Program on Water and Food commissioned several projects on hydropower sustainability. In addition, the U.S. Agency for International Development (USAID) has an active program, which has identified fisheries sustainability as a priority area for SE Asian countries.

Until the mid-2010s, these programs were largely unilateral, focusing on individual countries, rather than taking a regional collaborative approach as will be the case in this project. USAID recently (in 2019) committed $US600,000 towards an initiative to extend fish passage outcomes (from ACIAR investments FIS/2006/183, FIS/2009/041, FIS/2012/100) to Vietnam, Cambodia and Myanmar. It was agreed that USAID funding would be used to progress initiatives in Cambodia and Vietnam until 2020.

FIS/2023/133 will be designed to ensure the DFAT Design and Monitoring, Evaluation and Learning Standards (DFAT 2023b) are met. A dedicated MEL expert will be engaged from Alinea International at the beginning of the program to assist with refining the program logic and preparing a MEL Plan, within 6 months of program mobilisation, as per the requirements for the DFAT Design and Monitoring, Evaluation and Learning Standards (DFAT 2023b). The MEL System will be fully operational within 12 months of program mobilisation, and baseline data will have been collected (using official data sets) to test the program logic (DFAT 2023b). The MEL expert will also manage all of the ongoing MEL reporting requirements for the remainder of the project. The project team (under the leadership of the MEL expert) will revisit and adapt the program logic continuously, to respond to any contextual changes and new knowledge.

Relevance to ACIAR 10-year strategy

Food security and poverty reduction

SE Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural people are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities.

Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in SE Asia because hard research data does not exist. This project will identify and bridge information gaps, drawing upon data from fishway projects across the region shaping more effective management strategies. Indeed, the knowledge generated from this project will be crucial for sustainably managing SE Asian fisheries in the face of increasing human development and changing climatic conditions.

Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. River development has negatively impacted inland fisheries. This project aims to redress this imbalance and develop win-win scientific solutions so modern river development projects support the sustainable production of fish, rice and energy.

Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. Research has found that women can occupy half of the harvest and post-harvest workforce, and selling fish can provide extra income and offset household needs, and provide extra nutrition with by-catch for the immediate family. This project will document this participation and champion the need to recognise the important role of women and girls in fisheries value chains benefitted by fishway construction (see Section 2.5).

Value chains and private sector engagement

Hydropower modernisation is generally the domain of developers under development bank, or investor, supervision and generally contracting local companies for construction, through local village coordination and then accepting final ownership. The sector is increasingly receptive to considering fish passage during planning and construction activities and is looking to external and private sector experts for assistance. But often solutions that are developed are sub-optimal and based on experiences from outside the LMB. The private sector also plays a key role in shaping government regional decisions and policies. This project will bring both private, developmental and governmental sectors together to recognise the value of fisheries resources and to determine how to maximise those resource returns in sympathy with future growth across the hydropower sector.

Building capacity (individual and institutional)[1]

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner with regional governments, multilateral development banks, regional agencies, and capacity building experts to equip these organisations with capacity to address fish migration challenges beyond the lifespan of the project.

1.4 Relationship to other ACIAR investments and other donor activities

Existing/previous ACIAR work on hydropower sustainability

This research follows on and extends a body of ACIAR research that has developed and tested techniques to assess the performance of the fish pass at Xayaburi – and, to an extent, other future mainstem hydropower projects in the LMB (ACIAR FIS/2017-016 and FIS/2017/017). It also addresses DFAT’s Mekong Australia Partnership – Water Energy Climate (MAP-WEC) goal of strengthening the environmental resilience of countries in the Mekong subregion (Cambodia, Laos, Myanmar, Thailand, and Vietnam). FIS/2017/017 engaged with both technical and policy influence change pathways. The project progressed despite COVID-19, but there remains a significant challenge in providing a rigorous validation of the technical aspects of Mekong hydropower fish passes. There also remains a significant challenge to build local capacity in the design of fish pass infrastructure for environmentally sustainable hydropower and influencing decision making to adopt best practice sustainable fish pass technologies. Furthermore, significant research for development challenges remain, as the team in conjunction with management agencies in the Mekong need to find effective processes for translating research findings into improved decision-making, design and management practices.

We learnt in FIS/2017/017 that there is a need to develop strong evidence that the existing investment in fish passage has been successful for application at other sites to be considered. Second, the (FIS/2017/017) project only focused on upstream fish pass investigations. There remain significant gaps in terms of downstream migration, and, more broadly at the ecosystem scale. Third, the most appropriate dissemination and influencing mechanisms, for each key next user, are yet to be understood.

Further, this project adds to (1) SSS/2020/142, which explores the policy impact in Lao PDR and the transition from research to practice, and (2) the (almost finalised) impact evaluation work conducted by ACIAR on the 'Research-Policy Interface: Lessons from Lao PDR'.

Activities of other actors/donors

Substantial investments have been made by ACIAR, DFAT and XPCL in researching the required infrastructure to build effective fish passage systems and in developing new

[1] relates to components to be funded by ACIAR's Capacity Building section under FIS/2018/153.

technologies to assess fish pass rates when the hydropower facility is operating. Now further research is needed to scale up and scale out the ecological learnings from the Xayaburi hydropower project site; as well as to better understand the cumulative impacts of the Xayaburi and Luang Prabang hydropower project sites on the livelihoods of local communities; and to translate the research outcomes from the Xayaburi and Luang Prabang hydropower project sites into policy. The main additional actors to be brought into this initiative are (a) Lao Ministry of Energy and Mines (as a central partner as opposed to a reference group member like they were in FIS/2017/017), and (b) other hydropower developers who are proposing. The Mekong River Commission is also charged with developing a regional 'Sustainable Hydropower Guidance' document and data generated by the team will be highly relevant to future iterations of that document.

FIS/2023/133 will strengthen the collaboration network established during FIS/2017/017. Critical to this process will be building on our existing collaborations with the Mekong River Commission and making strategic connections to hydropower developers relevant to other projects. The Mekong River Commission has already indicated that they are very motivated to see the outcomes of FIS/2017/017 translated and transferred to other projects. So, there can be an immediate suite of information transfer which can take place whilst other knowledge gaps are advanced.

2. Project Theory of Change (i.e. program logic)

2.1 Overview

Adaptive management is the most appropriate theory of change mechanism applying to 'sustainable hydropower' in the LMB. In this context, adaptive management is described as (Bunnefield, 2015):

"a structured, iterative process for making decisions in 'response to changes in context and new information that promotes intentional learning and minimizes the obstacles to modifying programs."

Relevant to the agenda 'Sustainable Hydropower', adaptive management is fundamentally dependent upon the injection of empirical knowledge and learning at critical phases of the project or programme cycle (Figure's 3 and 4). This would most notably occur during the design and planning phase (to ensure that plans reflect the environment in which they are located, that objectives are relevant and realistic, and that the proposed interventions are feasible and appropriate) and then subsequently during implementation to ensure that experience and lessons are captured and fed back into the next hydropower project, informing adjustments to implementation as required. With respect to fish pass criteria, results determined from FIS/2017/017 could now be, theoretically, directly applied to improve the criteria for fish pass design at the next site, Luang Prabang then the following one at Pak Beng; and so forth. In essence this is occurring, but is also straightforward, because the Luang Prabang hydropower project is owned by the same developer (Xayaburi Power Company Limited). The challenge is establishing dialogue with the other developers and transferring research findings to them in a manner which influences practice change. In this context, we define long term 'practice change' as when a developer proposes a hydropower project which contains a mitigation strategy that is most likely to pass fish, both upstream and downstream, with minimal (or no) impact on fish-dependent livelihoods. We suggest that the ability to do so requires:

(a) technical solutions which are based on robust evidence in the local context.
(b) knowledge of the solutions and how to apply them.
(c) a willingness to adopt, and invest in, the solutions.

(d) a commitment to monitor, evaluate, learn, and apply improved solutions to future situations.

Our Theory of Change (TOC) (Figure 8) approach outlines a specific process and approach to incorporate learning and information into new and ongoing hydropower development activities. In adaptive management frameworks, the TOC needs to be seen as dynamic, allowing stakeholders to review and adapt whenever there is new evidence, or when there are changes in the context that affect assumptions or hypothesized pathways of change. The hydropower agenda in the LMB is dynamic. It is influenced by changes in institutional leadership, investors, developers, ministerial portfolios, government priority setting, and international technology advancements among many factors. Therefore, should a theory of change have been developed in 1995, when the Mekong Agreement was signed, it would have needed revision, over the past 30 years, in response to changing regional and international priorities, technological changes and environmental changes (such as climate change). The TOC presented here reflects our current understanding of the sustainable hydropower development agenda but should be reviewed annually as the project progresses or whenever political, economic, social, technological, legal or environmental factors significantly change.

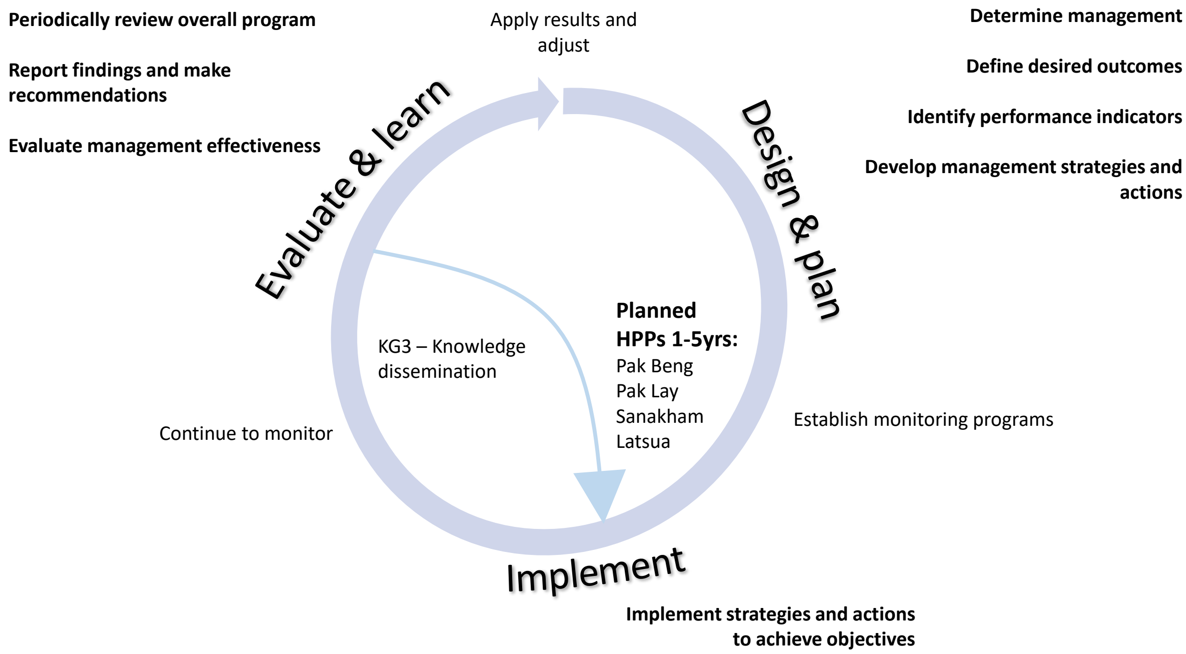

Figure 3. Theoretical adaptive management framework pathways relevant to sustainable hydropower in the LMB.

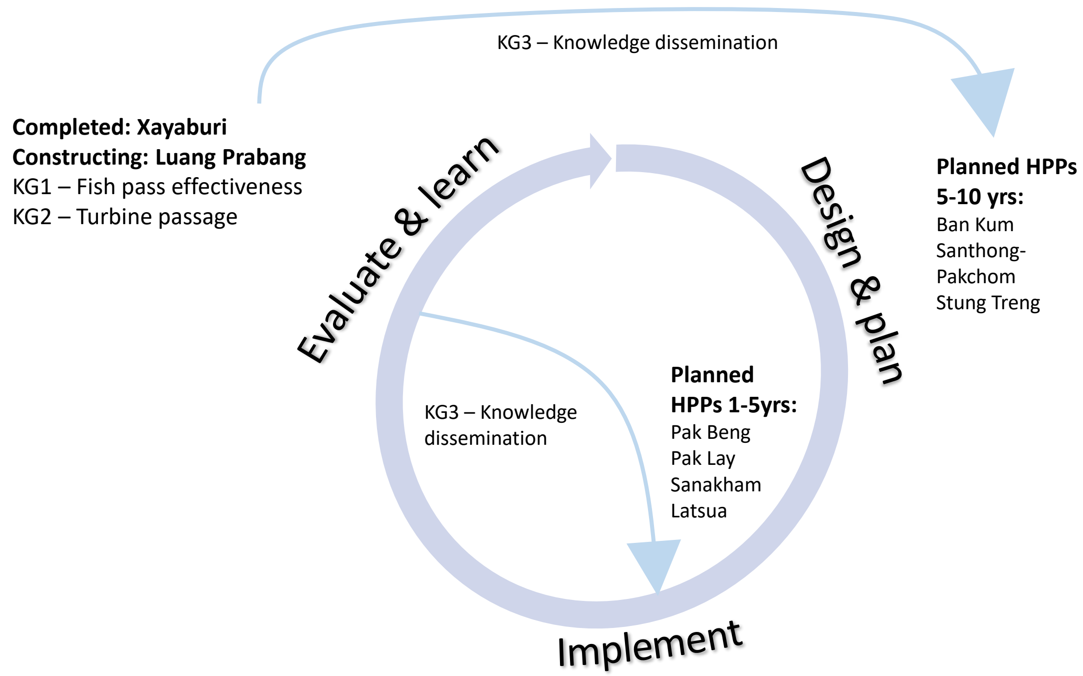

Figure 3. Theoretical adaptive management framework pathways considering the hydropower projects (HPPs) scheduled for design/construction commencement within the next five years (the term of this proposed project activity), with key knowledge gaps (KG's) shown as enablers into a 1-10 year impact pathway. Initially the focus will be on hydropower projects scheduled to commence in the next 1-5yrs; with knowledge dissemination required for hydropower projects on the 5-10 year horizon.

End-of-Project-Outcomes

The overall goal of the ACIAR Fisheries Program is 'to improve fisheries ecosystem health under climate change. It takes a human rights-based approach to development and aims to improve the lives of aquatic resource-dependent rural people. It does this by investing in R4D that aims to improve the health of the aquatic ecosystems and resources that rural people depend upon' (ACIAR Research Design Brief). FIS/2023/133 will contribute to the overall goal of the ACIAR Fisheries Program by achieving End-of-Project-Outcome's (EoPO's) (Figure's 7 and 8), which explicitly link identified knowledge gaps with hydropower project construction schedules in an adaptive management sense. The main focus here is research for development. This is time-bound as the ability to influence hydropower projects, until the sector enters the 'development' stage, is within the next five years.

Consistent with the goals of the ACIAR Fisheries program, our overarching development goal for this activity is: *'To ensure that hydropower does not negatively impact fish and fish-dependent livelihoods'*.

To achieve that objective, there are two primary EOPO's that the activity is targeting. The first one focuses on expanding the evidence base on technical solution effectiveness to inform the sustainable hydropower agenda. The second focuses on transferring, and translating, that evidence base into improved policy, decision making and implementation.

- EoPO 1: Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade
- EoPO 2: Technical staff in relevant government agencies and hydropower companies improve their use of design criteria, which foster fish friendly and inclusive hydropower development.

Links between the EoPO's

The technical fish passage research (EoPO 1) evidence will establish the evidence base that is needed to guide the design and planning for the remaining hydropower projects (but currently missing from the MRC PNPCA process). Absence of evidence is presently being propagated, by some developers, as a reason to proceed with sub-optimal technical solutions. Based on our learnings from FIS/2017/017, we already understand key knowledge gaps, what the next steps are to fill those gaps and who the evidence needs to be disseminated to, to facilitate policy and practice change to influence the adaptive management cycle. Therefore, EoPO 2 seeks to design and evaluate the performance of dissemination/policy framework to ensure that the evidence base (EoPO 1) is disseminated to the identified stakeholders. There are functional and structural links between the EoPO's. The dissemination, policy adoption and capacity building frameworks will subsequently link to meet our overarching development objective of protecting fish-dependent livelihoods.

'Impact pathways' in the theory of change/program logic

The program logic will follow the sequence of undertaking 'Foundational' and subsequent 'Influencing Activities', to achieve 'Immediate' and successive 'Intermediate Outcomes' that eventually result in the 'EoPO's'. These are summarised in Figure 8.

EoPO 1

The Foundational Activities for EoPO 1 will involve continuing the technical research at Xayaburi and Luang Prabang needed to implement solutions which maximise benefits to fisheries. These Foundational Activities will underpin the Influencing Activities of generating empirical evidence to support the inclusion of fish passage in hydropower developments, and disaggregating the fisheries data to allow analyses via a GEDSI twin-track approach. The Immediate Outcome will be that hydropower companies and investment decision makers in central government understand the design criteria needed to build, and the business case for investing in, fish friendly and inclusive hydropower. This should subsequently translate into the corresponding Intermediate Outcome. That is, hydropower companies and government investment decision maker criteria requiring hydropower developments to be fish friendly and inclusive.

EoPO 2

Foundational Activities for EoPO 2 will involve communicating the improved knowledge on the effectiveness of technical solutions to industry and government for incorporation into future development projects. Influencing activities will involve targeted education and dissemination through seminars, workshops, face-to-face meetings, conferences or more formal masterclasses or courses to support fish friendly and inclusive hydropower development. It is important that these activities are targeted towards key stakeholders. This will lead to the Immediate Outcomes of increased individual and institutional capacity to apply technical solutions while also ensuring that outcomes from EoPO 1 are socialised and made publicly available where appropriate. The subsequent Intermediate Outcome will be that individuals are capable of actively applying these outcomes to on-ground projects, and that developers and the MRC provide responsible and appropriate decision-making regarding hydropower sustainability.

The Foundational Activities, Influencing Activities, Immediate Outcomes and Intermediate Outcomes for each EoPO will be used as progress markers for these EoPO's.

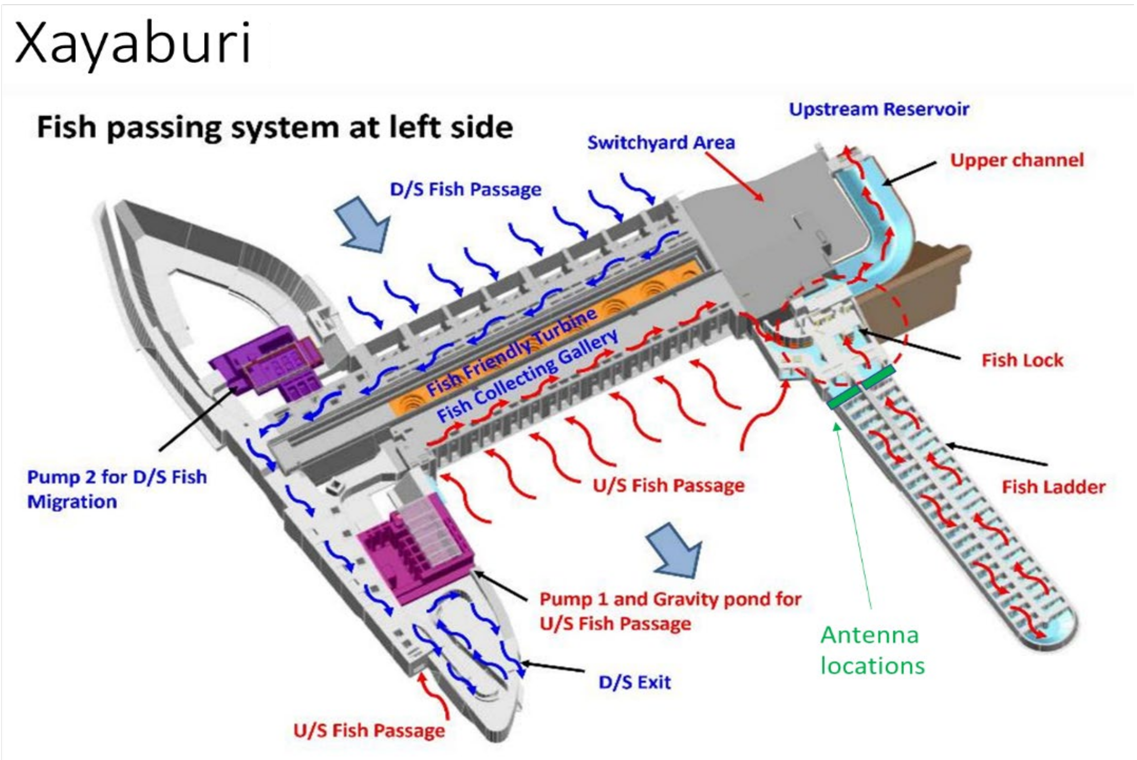

Figure 5. Schematic of the fish pass facilities at Xayaburi hydropower project (top) and an actual aerial photo of the site (bottom) (source: XPCL). In terms of technical data, FIS/2017/017 yielded excellent research data on the upstream fish pass. Matters of downstream migration, delay and turbine passage are still unresolved and are built into FIS/2023/133.

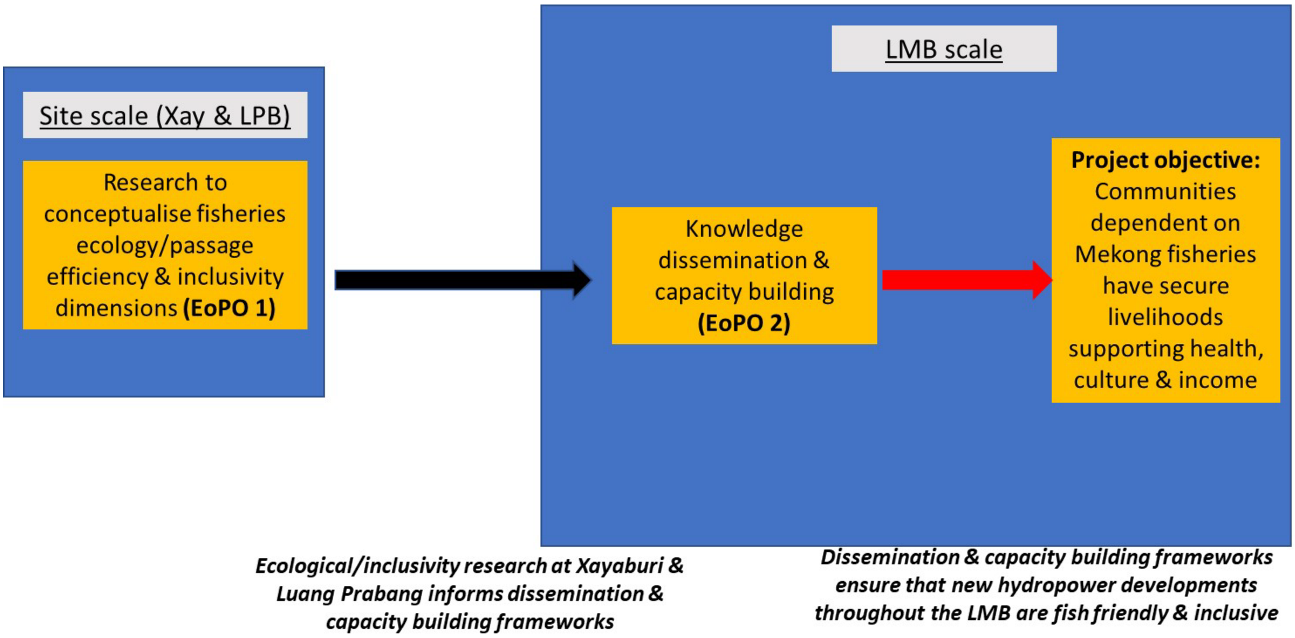

Figure 6. Functional links between EoPO's and the overall development outcome. The activities for EoPO 1 will be conducted at the site scale (at Xayaburi and Luang Prabang), but both project outcomes will transpire at the LMB scale.

Table 2. Impact pathways and functional links to EoPO's.

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 1: Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade (linked to KG 1 and KG 2).	Access to XPCL and other facilities Fisheries researchers	Activity 1.1. Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions; and Activity 1.2. Research on fish friendly turbine design Activity 1.1.1. Collect data/evidence on fisheries mitigation measures from existing sites (KG 1 and 2) -Fish pass monitoring at Xayaburi hydropower project -Acoustic fish tracking at Xayaburi hydropower project -Downstream fish monitoring at Xayaburi hydropower project -Barotrauma and shear stress experiments to investigate the influence of downstream turbine passage on Mekong species -Baseline fisheries surveys and preliminary PIT tagging at Luang Prabang, using the electrofishing boat	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings) Baseline fisheries data for Luang Prabang (i.e. the next proposed hydropower project site) Baseline data on best practice turbine design principles	Evidence base is developed Implemented the fish pass to enhance aquatic biodiversity and ecological sustainability Technical solutions have been internationally and independently assessed Benefits and challenges to inform policy decisions are highlighted	Increased knowledge base to facilitate the construction of effective fish passes at other hydropower sites The conservation of productive and diverse fisheries in the LMB Increased knowledge base to enable evidence-based policy formulation that improves lives and fish-dependent livelihoods in tandem with hydropower development

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
		commissioned for FIS/2017/017 -Angler surveys at Xayaburi and Luang Prabang to determine the harvest rates for developing a sustainable PIT tagging model Activity 1.1.2. Disaggregate the fisheries data & analyse via a GEDSI twin-track approach (KG 1 and 2)			
EoPO 2: Technical staff in relevant government agencies and hydropower companies improve their uptake of design criteria, which foster fish friendly & inclusive hydropower development (links KG 1 and KG 2 to KG 3).	Educators Development of curriculum / masterclasses Travel budgets Operational costs	Activity 2.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 2.2. Deliver capacity building activities Activity 2.2.1. Targeted communication activities and learning opportunities Activity 2.2.2. Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways Curriculum for improved hydropower knowledge within National University of Laos Curriculum Developed for a sustainable	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	Proposed and future hydropower projects have better technical solutions for fisheries sustainability Fisheries and fish-dependent livelihoods are not negatively impacted

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
			hydropower masterclass		

Program objective	Communities dependent on Mekong fisheries have secure livelihoods supporting health, culture & income
Project objective	To ensure that hydropower does not negatively impact fish & fish-dependent livelihoods
Project outcomes	**EoPO 1:** Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade
	IO1.1: Hydropower company & government decision maker criteria require hydropower developments to be fish friendly & inclusive
	EoPO 2: Technical staff in relevant government agencies & hydropower companies improve their uptake of design criteria, which foster fish friendly & inclusive hydropower development
	IO2.1: Technical staff are capable of implementing river hydropower programs that incorporate fish friendly & inclusive designs

Figure 7. Conceptual overview of End-of-Project-Outcome's (EoPO's) and Intermediate Outcomes (IO's).

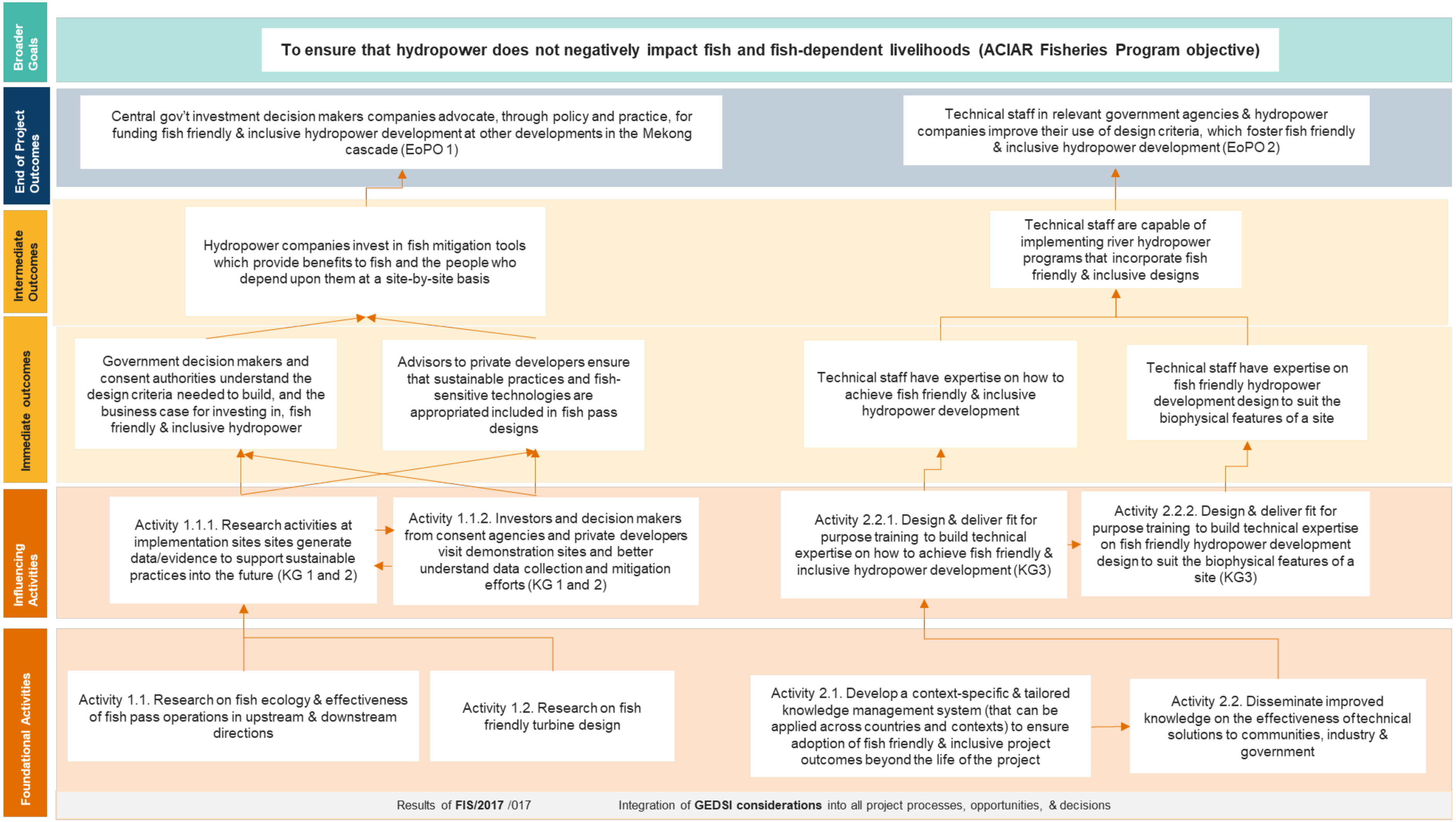

Figure 8. Program logic for FIS/2023/133, showing the impact pathways from the Foundational Acitivities to each End-of-Project-Outcome. Foundational Activities and Influencing Activities are detailed in section 2.6.

Key assumptions

Table 3. Key assumptions underpinning each activity.

EoPO	Activities	Assumptions
EoPO 1: Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade (linked to KG 1 and 2).	Activity 1.1. Research on fish pass operations in upstream & downstream directions; and Activity 1.2. Research on fish friendly turbine design Activity 1.1.1. Collect data/evidence on fisheries mitigation measures from existing sites (KG 1 and 2) -Fish pass monitoring at Xayaburi hydropower project -Acoustic fish tracking at Xayaburi hydropower project -Downstream fish monitoring at Xayaburi hydropower project -Barotrauma and shear experiments to investigate aspects of improved turbine design -Baseline fisheries surveys and preliminary PIT tagging at Luang Prabang, using the electrofishing boat commissioned during FIS/2017/017 -Angler surveys at Xayaburi and Luang Prabang to determine the harvest rates for developing a sustainable PIT tagging model Activity 1.1.2. Disaggregate the fisheries data & analyse via a GEDSI twin-track approach (KG 1 and 2)	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained Barotrauma units able to be constructed Global supply chains sufficient to facilitate delivery to Lao PDR
EoPO 2: Technical staff in relevant government agencies & hydropower companies improve their use of design criteria, which foster fish friendly & inclusive hydropower development (links KG 1 and 2 to KG 3).	Activity 2.1. Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of fish friendly & inclusive project outcomes beyond the life of the project Activity 2.2. Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government -Deliver capacity building through university curriculum and masterclasses Activity 2.2.1. Design & deliver fit for purpose training to build technical expertise on how to	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments

	achieve fish friendly & inclusive hydropower development (KG3) -Targeted communication activities and learning Activity 2.2.2. Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG3) -Policy brief development -Update to MRC guidance document -Research dissemination think tanks / dissemination events	

Time horizon

The team anticipate this being a 10-year program of work; but with the most urgent need to influence developers between 2023 and 2029. We will apply a theory of change framework (Olsen, 2003; UNEP/GPA, 2006) that can guide project governance and management responses based on sound research and improved capacity, and provide a pathway for change, through the uptake of knowledge and technologies. This framework will set out four ‘orders’ of outcomes (over a 10-year period) in the fishway program responses to changing societal, economic and environmental conditions, leading to the ultimate long-term goal of sustainable forms of energy development.

The first order outcomes (1–4 years) will involve the creation of the enabling conditions for a fish passage governance/policy initiative by linking key stakeholders, performing key research, and policy advances. This will be completely evidence-based. The team will complete the technical investigations at Xayaburi, preliminary investigations at Luang Prabang, and develop a resource base for dissemination to other developers involved with Pak Beng, Pay Lay, Sanakham and Latsua.

The second order outcomes (2–6 years) will involve changed behaviour of resource users and key institutions based on uptake of research outcomes. We will be specifically targeting the hydropower projects, which have been through PNPCA but have been required to make changes to their designs to meet sustainability guidelines (like the MRC’s Hydropower Mitigation Guidelines (MRC 2020)).

The third order outcomes (4–10 years) will involve an increasing adoption of fish-friendly practices, aimed at livelihood protection, at other sites in the Mekong. These will focus on the hydropower projects with a longer time horizon for design and construction (Ban Kum, Santhong-Pakchom and Stung Treng).

The fourth order outcomes (1–10 years) will lead to a more sustainable and resilient inland capture fishery, with fisheries and livelihood considerations being integrated into new and existing infrastructure projects; and any future projects that may be considered.

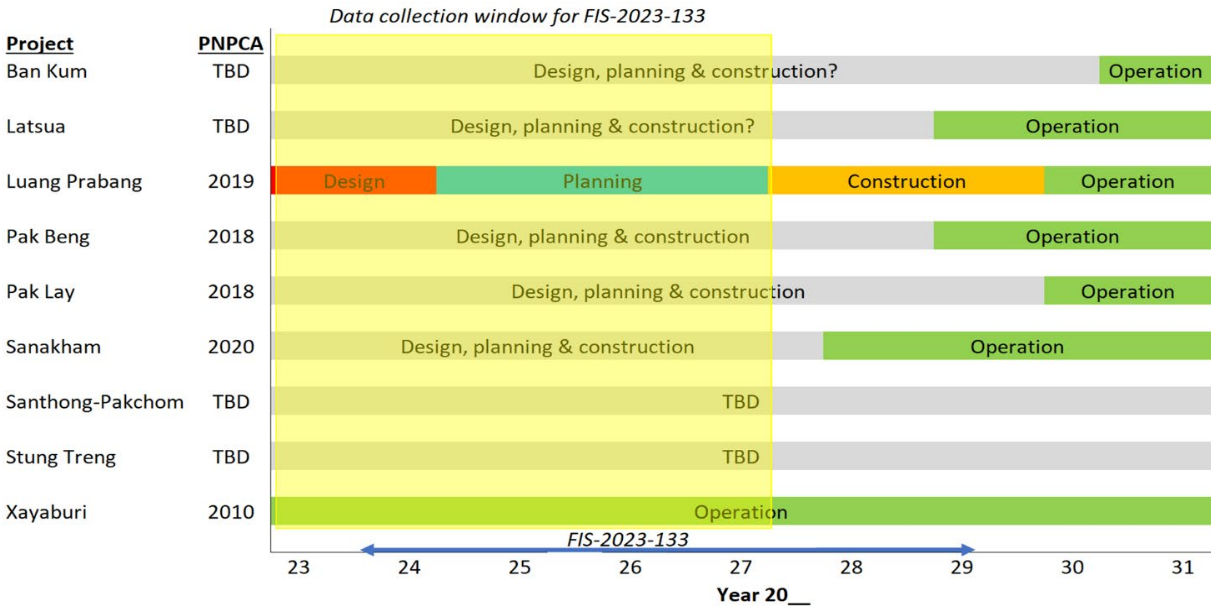

Figure 9. Construction timelines for the nine hydropower sites being built. There is a significant, time-bound opportunity to drive sustainable outcomes if research can be disseminated to the correct stakeholders. NB: Latsua was re-named Phou Ngoy and sometimes the names are used interchangeably.

2.2 Research strategy

2.2.1 Research questions

Question: What are the criteria for fish pass and hydropower turbine facilities to facilitate fish passage at hydropower sites on the Mekong River? (EoPO 1; KG 1 and 2).

Question: How can we apply these criteria to better mitigate the expected cumulative effects of multiple hydropower projects on fisheries migratory ecology? (EoPO 1; KG 1 and 2).

Question: Can we improve the uptake of these criteria into new hydropower projects through targeted in-country individual and institutional capacity building and dissemination programs? (EoPO 2; KG 3).

2.2.2 Addressing research questions

EoPO 1 Research to conceptualise the fish ecology, and passage effectiveness of the fish pass and hydropower turbine designs (technical research)

Specific design parameters were incorporated into the Xayaburi hydropower project design to provide passage for fish through the hydropower site. The fish pass design was engineered to allow the upstream passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter upstream passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) (Table 4) for different seasonal flows and migration patterns.

For upstream migration, the engineering includes a complex fishway system (Figure 10). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Figure 10),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Figure 10),
(c) they then enter a large fish pass facility (left-bank facilities, Figure 10) and
(d) then proceed through a locking system into the weir pool (orange shading, Figure 10); or
(e) alternatively, they can move through the navigation lock.

It is important that fish can successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the hydropower project
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

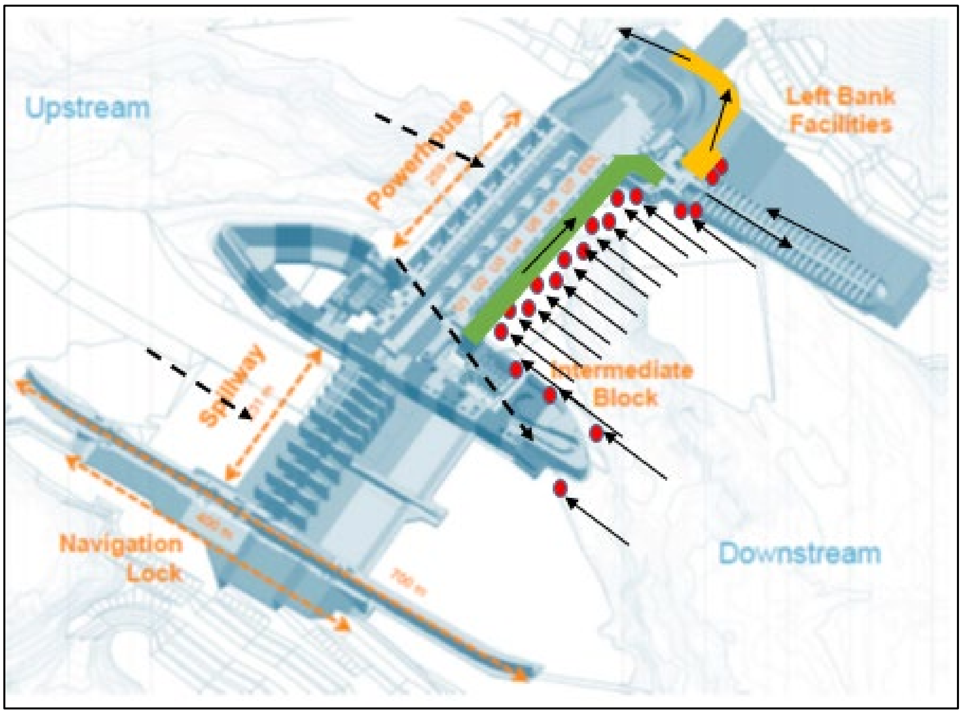

Figure 10. Plan view of facilities at Xayaburi hydropower project. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green, and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

Table 4. List of migratory species found at the Xayaburi site which may be PIT tagged. These are migratory species that were selected for tagging on the basis that they are (1) important for supporting nutrition and/or livelihoods; and/or (2) of conservation significance. Individuals are typically caught using the boat electrofishing method that has been developed and verified during FIS/2017/017. This involves inspecting each individual to ensure that is healthy before re-releasing it to the river. Green-shaded months are based on data from TEAM Consulting and yellow-shaded months are from observations of XPCL fish catch in navigation locks. The list is not definitive.

species	local name	month											
		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Cyclocheilichthys enoplos	Pa Joke												
Cyclocheilichthys repasson	Pa Joke-sai												
Henicorhynchus lobatus	Pa Sroi												
Labeo chrysophekadion	Pa Pia												
Hemibagrus nemurus	Pa Kod												
Mekongina erythospila	Pa Sa-ee												
Sikukia gudgeri	Pa Mang												
Chitala sp.	Pa Tong												
Pangasius macronema	Pa Yorn												
Hemisilurus mekongensis	Pa Dangdaeng												
Phalacronotus apogon	Pa Sa-ngua												
Bagarius suchus	Pa Khae												
Paralaubuca typus	Pa Teab												
Tenulosa thibaudeaui	Pa Mak-pang												
Pangasianodon hypophthalmus	Pa Sway												
Cyprinus carpio carpio	Pa Nai												
Yasuhikotia modesta	Pa Kiaw-Gai												
Macrochirichthys macrochirus	Pa Fak-pa												
Pristolepis fasciata	Pa Chang-yeab												
Pangasius bocourti	Pa Phor												
Pangasius conchophilus	Pa Mong												
Pangasius larnaudii	Pa Thay-po												
Phalacronnotus bleekeri	Pa Sa-ngua												
Wallago attu	Pa Kaow												
Hemibagrus filamentus	Pa Kod-rueng												
Pangasianodon gigas	Pa Buek												

Terms of reference / research questions

A team of Australian, Lao and US fisheries scientists (fish experts) in collaboration with XPCL scoped several key research questions to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags, barotrauma and shear experiments, sensorfish

Turbine design

Research questions	Potential research methods
Question 1 - What are the pressure thresholds for Mekong species?	Targeted barotrauma experiments in specially-designed chambers
Question 2 - What are the shear stress thresholds for Mekong species?	Targeted shear stress experiments in a specially-designed flume
Question 3 - What is the likelihood of blade strike for Mekong species?	Mathematical modelling based on combining Q1 and Q2 with existing models.

Request from XPCL: FIS/2017/017

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was initially requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, was beyond the scope of the available budget so the ACIAR/DFAT team only focused on methods to assess upstream fish passage using PIT systems for FIS/2017/017.

Consequently, the initial research questions posed were:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi hydropower project?

Q2 – Do migratory fish species pass upstream, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for assessments be developed based on the methods we are trialling?

The result of this was that so far there has been no attempt to address the research questions regarding downstream passage, nor about what fish are approaching the dam in either direction. These questions are extremely important, both at Xayaburi and Luang Prabang, and the other hydropower projects under design and planning; and FIS/2023/133 will seek to progress.

PIT tag systems (extension of FIS/2017/017)

The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23 mm or 12 mm long; half or full duplex), which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage, which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date, or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hours a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems were assessed as part of FIS/2017/017 and have proven to be an effective method for assessing upstream fish pass effectiveness. The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It now provides a complete system, which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi hydropower project can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a webpage. Ensuring a standard tagging system is installed at multiple sites will guarantee that fish tagged in other parts of the LMB, can be detected anywhere. The system is online, active and contributing usable data. The team are tracking 4,500 fish so far (but the target was 10,000 to provide statistically meaningful results). The team will continue the existing work and build a longitudinal dataset on fish migration and fish pass efficiency. This data will be directly transferrable to other sites and, if other developers adopt and install this technology, would be the main mechanism for monitoring fish movements once (if) the hydropower cascade is completed. It will provide the largest and most comprehensive transboundary dataset on fish migration in the entire Mekong.

Rationale

FIS/2017/017 provided: (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi hydropower project is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study, the project team were tasked with using PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations, which are all being applied to the work at Xayaburi. So, the team are starting from a strong knowledge and experience base. Our aim is to achieve an increase percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Undertake large-scale tagging to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, we will continue to capture fish downstream of the Xayaburi hydropower project structure as they approach. We will also start a preliminary PIT tagging program at the Luang Prabang site (i.e. the site of the next hydropower project), using the electrofishing boat commissioned for FIS/2017/017. The team is striving to tag approximately 2,000 fish annually at each site. These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate (return rate = percentage of detected fish relative to tagged and released fish). We can make good inferences on passage success rates, with good statistical power for any species where we detect more than 100 fish annually. Because, inevitably, some fish will migrate, shed tags, die or be harvested, there will be a need to tag new fish in every year to maintain a sufficient sized pool of tagged fish. The team will use a model that was developed for FIS/2017/017, to estimate the number of fish that need to be tagged every year to maintain target populations of tagged fish. The model will, however, be enhanced by the addition of a tag harvest program as part of the next project, and tailoring it for specific species.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL operators.

Stage 3. Monitor fish movements through the Xayaburi fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output of mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged) will be plotted per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases to determine if there are flow-related patterns that could be influenced by operations.

Repeat movements: Xayaburi hydropower project includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating efficiently.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to operations, optimization of fish pass operation and XPCL fish passage efficiency reporting requirements back to the government of Laos. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power. This will be achieved by further developing long-term PIT tagging requirement models for key species.

Stage 5: Publication and reporting to other developers and the MRC. Including further development of the MRC hydropower guidance document.

Acoustic systems

Rationale

PIT systems will only be suitable for documenting upstream migration rates through the fish pass. Acoustic systems are more flexible than PIT systems in that their listening stations can detect tagged fish from much further away, and do not require a narrow channel to steer the fish past the detection (antenna) system. Nonetheless, they are more expensive than PIT systems, require more maintenance (e.g. they require a battery unlike PIT systems – which do not), and are constrained by the landscapes in which they can be deployed.

Activities

Acoustic systems will be used either instead of (or in conjunction with) PIT tag systems to determine: (a) what fish species and proportion of tagged individuals are approaching (for both up-and downstream passage), (b) what influences which route is taken (spillway, fish collector or turbines), (c) what is the overall upstream and downstream passage efficiency - the percentage of approaching fish that successfully migrate past (includes whether or not they find the fish pass facility AND whether they then ascend or descend successfully), (d) whether there is migratory delay downstream of the structure, or (e) whether fish survive downstream migration in general.

Sensor Fish and turbine passage

Rationale

Sensor Fish are robotic data logging fish that can assess the hydraulic conditions fish may potentially be exposed to while passing through hydropower turbines. A series of Sensor Fish instructional movies were developed as part of FIS/2017/017 by the team during the COVID-19 pandemic, and shared with the in-country project partners. The in-country staff were then later given face-to-face training on the use of Sensor Fish at Xayaburi hydropower project in October 2022, once XPCL eased their COVID-site access restrictions. The training was provided Dr Daniel Deng (a Pacific Northwest National Laboratory (PNNL) engineer who developed the Sensor Fish) and the CSU team. The in-country staff then assisted in undertaking actual trials with dummy Sensor Fish to apply their learnings.

Activities

Sensor Fish trials will be undertaken to further empirically quantify the hydraulic conditions associated with the hydropower turbines to add a range of approach conditions (fish swimming depth) to the initial trials. Turbine-specific pressure change results will be simulated in laboratory conditions, using a barotrauma chamber, to examine the impact of turbine-related pressure changes on fish survival. These comprehensive experiments will include several target Mekong species and at various life stages. The Sensor Fish data will also be used to model the impacts of turbine-related blade strike on fish survival. The information provided by the Sensor Fish will therefore enable us to validate the 'fish-friendliness' of the hydropower turbines and their associated hydraulic conditions. We will compare the measurements of the hydraulic situation to 'dose rate' information from actual Mekong River fish. Linking these together gives an overall indication of survival rates through turbines.

Furthermore, there are no data yet documented for fish using the other downstream passage routes including: the downstream fish passage channel, the spillway, and the navigation lock. We will use the Sensor Fish technology and actual fish to assess the stresses faced by fish in those routes, including barometric trauma (and rapid decompression in particular), impact trauma and fluid shear stress, which are all important factors that potentially affect downstream migrating fish survival.

A hyperbaric chamber (barotrauma chamber) will be used to simulate and define the critical tolerances of key Mekong species to rapid decompression impacts associated with passing downstream through hydropower turbines. We will refurbish a laboratory-based hyperbaric chamber owned by NUoL (constructed as part of MK15 through the Challenge Program for Food and Water) and also have a new chamber made so that we can perform the required number of replicates. Rapid decompression can cause a fish's swim bladder — a pocket of air inside a fish that is used to control their buoyancy — to rapidly expand and has been known to cause injuries and mortality.

Figure 11. The hyperbaric chamber that may be refurbished and used to undertake barotrauma experiments, for better understanding potential turbine-related impacts on Mekong fish species undertaking downstream fish passage. We will also have a new one made so that we can perform the required number of replicates.

The hyperbaric chamber experiments will focus on the key species and life stages first. Fish will be collected on site from the Mekong River using the electrofishing boat and held at the Xayaburi fish holding facility. Prior to testing, the fish will be acclimated to surface pressure (where ~101 kPa indicates surface pressure and 0 kPa indicates vapour pressure) (Boys et al. 2016). They will then be rapidly decompressed from this pressure to one of ten discrete nadir (lowest) pressures (outside of those expected from the Xayaburi turbines). This will allow us to examine the impacts of rapid decompression over a range of discrete ratios of pressure change (RPC; i.e. exposure pressure ÷ acclimation pressure; as per Boys et al. 2016), so that a full injury/mortality dose rate curve can be developed. It will then be possible to apply the findings to any scenario that becomes of interest. The focal experimental pressures will be based on those measured by the Sensor Fish from being passed through the Xayaburi turbines. For the analyses, the percentage of individuals injured or dead within a test group of fish will be treated as the dependent variable, and regressions will be undertaken to determine whether the total mortality rate is influenced by RPC (as per Boys et al. 2016).

Fish surveys and sustainable PIT tagging models

Rationale

As previously mentioned, with the exception of that collected during FIS/2017/017, there are currently no empirical data on the fish population and community dynamics at the Xayaburi and planned Laung Prabang hydropower project sites to use as a reference point for assessing future potential changes against. Nonetheless, now is the prime opportunity to gain fish population and community dynamics at the Laung Prabang hydropower project site before the facility is constructed.

Furthermore the long-term PIT tagging programs at the Xayaburi and planned Luang Prabang hydropower project sites will need to be informed by robust quantitative knowledge of the long-term PIT tagging requirements to maintain statistically viable PIT tagged populations of the key species. A preliminary sustainable PIT tagging model was developed during FIS/2017/017 to estimate the annual number of fish needing to be PIT tagged to maintain the PIT tagged fish populations in the wild. However, it is currently only a prototype based on a combination of anecdotal information, expert opinion and/or literature for related fish species (where such literature is available). Consequently, the model is still only indicative and not species-specific. It needs to be tailored for each key species by obtaining species-specific empirical data on key factors such as fish harvest by anglers.

Activities

Background fish population and community dynamics will be systematically assessed up- and downstream of both the Xayaburi and planned Luang Prabang hydropower projects using the XPCL electrofishing boat. The sampling will be spatially and temporally replicated using standardised boat electrofishing methods at both sites. The fish sampled during these surveys will also be PIT tagged, and therefore become part of the PIT tagged populations.

An external tag return program will run in conjunction with surveys of fishers living up- and downstream of the Xayaburi and planned Luang Prabang hydropower project sites. The surveys and tag return program will allow estimation of harvest rates of the key fish species at each site. Harvest rates will then be used for populating the species-specific sustainable PIT tagging models. These angler survey data will also complement the boat electrofishing survey data at each site, by providing another perspective for understanding the changes in the background fish population and community dynamics.

EoPO 2: Capacity building

Rationale

Sustainable hydropower is quite a technical field. It is very difficult to explain concepts using theoretical means, and it is far more effective involving staff in on-ground research in a ‘learning by doing’ environment. Consequently, we will formally interrogate our existing knowledge of the key stakeholders associated with hydropower projects (developed during FIS/2017/017) to yield a list of key capacity requirements of these key stakeholders. These key requirements will underpin targeted capacity building activities implemented through a capacity building through research (CBTR) approach. We need to ensure that the technical data (EoPO 1) is transferred to the most appropriate and influential stakeholders through targeted communication and extension activities and capacity building (EoPO 2).

Approach

We envisage this may comprise three levels of training:

1. **Formally recognised international courses.** In preparation for this project, Charles Sturt University has approved, for entry from second semester 2020, a Graduate Certificate in Fisheries Conservation. This has been developed as an in-kind contribution and will be specifically targeted as a training opportunity for international

staff from developing countries. The course comprises two core subjects (BIO 403 – Fisheries Conservation and BIO 405 – Fish Movement and Management). Fish movement and management (BIO 405) has been based on course material which was developed as part of FIS/2014/041 – Crawford Fund Masterclass in Fish Passage Engineering (Baumgartner et al. 2019). The course has been designed to comprise four subjects with intensive residential schools, meaning it can be taken 6 months full time (four subjects per semester), or 12 months part time (two subjects per semester). The curriculum for this course is flexible and bespoke. The content could be adjusted for a hydropower-focused cohort. We will enrol key staff, from each partner country, into this course to facilitate training and development over the course of the next four years. It will be impossible to export significant numbers of students for overseas training in Australia. So, this training will focus on university academics and mid-high-level officials based within fisheries and energy departments, with adequate English skills and Bachelor-level training. The focus will be on training graduates with potential to be future decision and policy makers.

2. **Targeted and specific short courses.** A key outcome from previous ACIAR investments (FIS/2014/041) was to develop a masterclass in 'Fish Passage Engineering'. The course is focused on in-country learning. It is targeted at in-country fisheries and engineering staff (at the federal, district and provincial level). It is taught by a series of international experts in fish passage and has a practical focus. Each student works in a team equally comprised of engineers and fish biologists and over the course of four days, they are required to develop a working concept for a fish pass at a real-world structure. They then develop a research and monitoring program to measure success. The course has been delivered in both Bangkok (to 60 high level professionals from all Mekong countries) and in Myanmar (to federal, district and provincial level staff). The outcomes of these courses have led to on-ground fish passage implementation in a range of Lower Mekong countries, including Myanmar, Lao PDR, Thailand and Cambodia. An outcome of the co-design workshop was to establish a 'Sustainable Hydropower' masterclass, which could focus on optimising fisheries solutions.
3. **National University of Laos Curriculum Improvement.** A key discussion point at the co-design workshop was that the existing course offerings at the National university of Laos (the major education institution in Lao PDR) does not have any subject offerings for hydropower nor sustainable hydropower. The Lao government officials suggested that this would be a useful focus of any extended project to ensure that future generations of managers and technical staff seeking an interest in the hydropower industry would be able to gain a grounding in based concepts relevant to sustainability in the industry.

Analysis

The research aspect of this component is important as we need to ensure the training is relevant and effective. There are existing frameworks in place to track career trajectories of Alumni following training activities. For (1) and (2) we will apply a system analogous to the Australia Award Alumni Tracer Facility. The Australia Award Tracer performs annual research which:

- conducts an Annual Survey, with online and telephone collection of the views and experiences of Alumni from a range of countries;

- identifies a series of case-studies, involving in-depth interviews with Alumni, employers and other stakeholders;
- collects and updates contact information for Alumni.

For the duration of our project, we will maintain contact with training Alumni and investigate benefits that have accrued. We will hold annual structured surveys which focus on understanding elements like (i) retention of technical information, (ii) technical involvement in development bank projects which have incorporated fish passage, (iii) development of new projects incorporating fish passage, and (iv) extension of training outcomes to other staff and a qualitative assessment of benefits. We will also poll graduates on the learning outcomes to ensure that the course remains fit-for-purpose and industry relevant. Key success (and failure) stories will be highlighted as case studies in our annual and final reporting processes.

Additional approaches for communicating knowledge

Knowledge generated from the project will also be communicated using a suite of approaches, beyond the formal training activities described above. This will include:

- Meetings: Face-to-face and online, including Reference Panel meetings, and annual and quarterly project meetings.
- Communication and extension activities targeted towards end users: Training and promotional videos distributed via YouTube.
- Hands-on training of fisheries scientists, managers and students in Asia and Australia: hands-on training provided to students, interns and volunteers.
- Scientific publications
- Conference presentations and other extension activities: Presentations at international and regional scientific conferences, and project display booths at these conferences.
- Other media: Interviews with TV and radio stations, and articles in media like The Conversation and Catch and Culture.

2.3 Gender & Social Inclusion Strategy

Consideration of gender within affected communities

The construction and operation of the Xayaburi Hydroelectric Power Plant have directly affected 15 villages located on both sides of the Mekong Riverbank in Xayaburi and Luang Prabang provinces. Seven of these villages have required relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) by XPCL required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects, and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP must enhance the quality of life for the project-affected people (PAPs) and minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Taking a twin-track approach to GEDSI

Development practice acknowledges that GEDSI strategies are more effective when they adopt a 'twin-track' approach (DFAT 2016). This means progressing opportunities for <u>mainstreaming</u> consideration of GEDSI across all components of a project, alongside <u>targeted</u> GEDSI activities that concentrate resources and seek new knowledge to address the underlying causes of exclusion or disparities. Targeted interventions typically generate analysis and evidence, and new partnerships and networks that can benefit the overall project. ACIAR and DFAT recommend a twin-track approach in their GEDSI policy guidance.

The proposed project will incorporate GEDSI considerations right from the outset of its design phase, and align with the ACIAR 'Gender Equity and Social Inclusion (GESI) Strategy and Action Plan 2022–2027'.

In particular, the proposed project team recognises that although women are highly active in fishing and marketing activities, engineering, and to a lesser extent fisheries management, are traditionally male-dominated fields (noting that this is a global trend and not just within SE Asia). Yet, women who often catch fish are the ones who prepare the fish for domestic consumption and to sell at the market. Training on safe fish handling for these objectives could enhance the nutritional quality and commercial price of the fish, while lowering the likelihood of food poisoning or unnecessary wastage.

The FIS/2023/133 team will enhance opportunities for women by:

- endeavouring to ensure equal participation of men/women in project meetings and discussions (including representative groups)
- engaging women-only training events for existing experts and students, which will be conceived in collaboration with line-agencies
- incorporating gender sensitive analysis and training into the project (especially SNA and village surveys) to ensure that the roles of both men and women are captured, and by allowing the space for both men and women to make appropriate, informed and targeted policies through gender appropriate activities
- seeking to increase the participation of women in strategic decision-making roles shaping governance and policy development.

These actions will be crucial in gathering equitable, diverse and inclusive input from both women and men, and ultimately in achieving sustainable project outcomes. It is pivotal that this knowledge is used to inform policies and strategies moving forward.

The project team has been actively working in Lao PDR for over fifteen years. Therefore, the gender inclusion strategy is largely derived from (a) our lived experience working and living in the region, (b) outcomes of structured interviews convened in association with existing projects, and (c) feedback on our proposal from reviewers. The team has also been investigating broader elements of inclusivity by including disability groups.

There are high incidences of unexploded ordnance injuries in the Lower Mekong Basin, and disability groups have been established to better-cater for the needs of impacted people. Our initial stakeholder mapping activities have identified a number of these groups that we will need to involve in the co-design process.

Nonetheless, our team has recruited a highly qualified GEDSI specialist from Alinea International, who will guide incorporation of these additional initiatives to ensure GEDSI is integrated into all levels of activity implementation. The GEDSI specialist (Mia Urbano) has already been recruited for the FishTech (FIS/2018/153) initiative, and has been helping the project team develop and endorse principles to make explicit a range of GEDSI values and actions. We will apply an analogous mechanism to the current project because the GEDSI considerations (of hydropower and irrigation development) are relatively similar in terms of their impacts on fisheries and fish-dependent livelihoods. During the design phase of FIS/2023/133, the GEDSI specialist will work with the team to adopt and adapt this approach to the context of this project.

Similarly to that for the FishTech project, the GEDSI specialist will guide the team in:
(a) developing a Mekong Women in Science Technology Engineering and Mathematics (STEM) internship (through NUOL); (b) organising ‘female-only’ masterclasses (to overcome male power dynamics); (c) providing targeted scholarships into Australian-based courses; and (d) ensuring equal participation of men/women in project meetings and dialogues. This will involve including women’s and disability groups in the co-design of any activities to make sure that these activities benefit a wide demographic of stakeholders. The project team (under the guidance of the GEDSI specialist) will adopt these additional initiatives as part of the project design process. That way GEDSI will be a common thread across all implementation areas, and ultimately become a thematic endpoint.

2.4 Capacity building strategy

The need for this project primarily arose because Lower Mekong partners were seeking advice and skills from international professionals with demonstrated expertise in fish passage and in fisheries monitoring using novel techniques (FIS/2017/017). Project EoPO 2 was specifically designed to enhance capacity in key hydropower development stakeholders so that they can make more informed decisions around hydropower planning and implementation.

Other partners and agencies in the region have recognised the value of the information generated from FIS/2017/017 and the demand for knowledge has grown. Despite the need, there are no systemic 'sustainable hydropower' capacity building programs being implemented. This project aims to create a platform for such a strategically orientated program of skill development across influencing actors.

The project team will initially conduct Menti surveys to assess the nature of the skills and/or capacity problem and the institutional environment in which the project will operate.

- The team will also assess the 'critical mass' in terms of training needs and key skill requirements to achieve institutional capacity, by employing systematic approaches like institutional motivation-ability (MOTA) analysis.
- These findings will be used to design capacity-building programs with the project partners.
- The design approach will be critical to assist with cultivating project partners' ownership of, and commitment to, the capacity building agenda.
- Upon running these capacity building programs, the team will conduct further Menti surveys to review the appropriateness of the skills and/or capacity building approaches, and make changes where necessary.

The project team's capacity building approach will be tailored to strategically enhance capacity in four key stakeholders:

Xayaburi Power Company

The organisation employs a small team of regional fisheries scientists who are tasked with implementing research and monitoring on site. FIS/2017/017 partnered with this team and built their capacity for fish collecting, tagging, tagged fish monitoring and data analysis of fish passage. This team will broaden its responsibility for generating scientific data to inform operations at the new site at Luang Prabang.

The project will build the technical capacity of the XPCL (and research personnel in the Laos government) through peer-to-peer learning with the Australian research team, and via a range of appropriate skills development approaches, such as on-site training, online training videos (as developed during COVID-19), and workshops.

Educational institutions

A recurring discussion with universities in partner countries is their limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach, resulting in poor learning outcomes for graduates. This issue has largely arisen because academics (lecturers) have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. In response to this capacity gap, we will focus on educating these lecturers and researchers by delivering a master program through CSU (as done in FIS/2017/017 for fish pass design courses targeted at engineers in government and in donor agencies). We anticipate that, over the longer-term, some will potentially take up an international PhD (via CSU scholarships or the Australia Award platform).

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop CSU's newly developed Master's program on fish pass design. Our project team members will then help build capacity (1) through support in designing curriculums in the tertiary sector; (2) by holding targeted faculty masterclasses in Lao PDR and implementing research projects focusing on sustainable hydropower; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host Masters' students as part of the on-site project team. These local students, and their embeddedness within our project team, will be an important capacity-building strategy.

Government departments

A flow-on effect from poor educational institution capacity is that graduates entering the public sector have a poor capacity to effectively engage with fish passage issues in their professional life as public servants. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, there is little historical institutional capacity and no mentoring opportunities for graduates. This results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the contemporary approaches and learnings on fish passage in a hands-on way. Staff will be trained on-site at locations both in Lao PDR and Australia. The second approach will be targeted and opportunistic, by focusing on the most promising graduates within Lao PDR educational settings and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

Other developers

Hydropower developers are funding and implementing a series of new hydropower projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity of, many developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this proactively by building on our trusted relationship with the Ministry of Energy and Mines, whilst engaging with key developers in the region as required. The MEM and hydropower developers both play key roles in influencing the decision making for hydropower project designs. We have a highly effective masterclass approach to training such stakeholders. This has led to direct outcomes for fish passage design in their institutions when they return and apply their learnings to construction projects under consideration.

2.5 Knowledge exchange strategy

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team, which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish in both directions. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream and downstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future hydropower projects will benefit from improved fish passage design and fish monitoring, and associated river communities enjoy maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and developers
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool, which could be applied across the Lower Mekong Basin
- Capacity building of developers into sustainable hydropower practices
- Training of Lao and Thai scientists and managers.

The project outputs will include:

- Publications in high-ranking journals; the team anticipates;
  (a) Modelling numbers of refresh fish for annual PIT tagging required in long-term fish migration monitoring programs
  (b) Behaviour of Mekong River fish when approaching a hydropower plant (swimming depths, movement types, etc).
  c) The effectiveness of downstream fish migration facilities in a tropical river
  d) Limits of tolerance in Mekong fish species to pressure changes and shear stress and subsequently blade strike
  (e) Improved turbine design criteria for Mekong fish species and fish friendly turbines in the LMB
- Annual reports
- A project final report
- Abstracts published in conference proceedings
- A series of online instructional videos
- Submitted manuscripts based on the findings
- Minutes and action plans formulated by the project advisory reference group
- Final report to ACIAR.

Intellectual property and other regulatory compliance

The key stakeholders and end-users of the knowledge generated through this project will consist of the XPCL, educational institutions (e.g. NUOL and CSU), government departments and other hydropower developers. XPCL, educational institutions and government departments were engaged during the project inception stage, while the project was being co-designed. Other developers will be engaged later during the project at targeted knowledge exchange events.

XPCL and CSU have a confidentiality agreement in place (see attachments). This agreement states that neither partner will release information without the approval of the other. This agreement worked well through the FIS/2017/017 phase of the project and will continue into the new activity.

Other cross-cutting program themes

Climate change considerations

FIS/2023/133's activities will be carried out in partnership with private and public agencies to achieve significant climate resilience outcomes, in addition to livelihood and food security outcomes throughout the LMB. The impacts of modelled climate scenarios on streamflow conditions in the LMB have been considered and will be incorporated in the program design phase. As part of the analysis for EoPO 1, we will investigate the relationship between fish movements and changes in river hydrology or different flow conditions. This will enable us to model the impacts of different climate scenarios on fish movements via changes to flow regimes.

The impacts of modelled climate scenarios will also be included in the program risk register and therefore regularly reviewed along with all of the other program risks. Furthermore, the focus on hydropower development is only likely to increase in the coming decade as governments increasingly switch to renewable energy sources in response to escalating climate change impacts and associated political pressure.

Program risks and safeguards

This program has been developed in accordance with DFAT's *Environmental and Social Safeguard Policy.* A risk and safeguard tool has been incorporated into the program design and will be regularly reviewed throughout the program (Appendix C). The tool considers whether the program will have potential adverse environmental and/or social impacts, and assigns risk classifications accordingly. These risks relate to environmental protection; sexual exploitation, abuse and harassment; children, vulnerable and disadvantaged groups; displacement and resettlement; indigenous peoples; and health and safety.

Sustainability

The entire premise of the project is that an evidence-based approach will lead to better knowledge through an adaptive management framework. We will be directly leveraging other sources of finance through XPCL into this project. This is explicitly stated in the project budget construct (that XPCL will provide equipment and access to accommodation) towards the end of this proposal. In the longer term, it will be hydropower proponents that self-fund sustainable aspects of hydropower design. They will need to meet standards, informed by this activity, in order to proceed. That is a fundamental aspect of the theory of change proposed here.

Table 5. Success indicators linked to the long-term outcomes expected to emanate from this project. ACIAR strategic plan outcomes are summarised as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity. MAP-WEC intermediate outcome indicators are:

(1) Regional cooperation: Australian assistance strengthens Mekong institutions that support regional cooperation on clean energy, water security, and climate action
(2) Bilateral partnerships: Australian assistance strengthens our bilateral engagement with Mekong governments to implement policies/practices on clean energy, water security and climate action
(3) Social Inclusion: Australian assistance facilitates participation and leadership of women, marginalised groups in governance related to clean energy, water security and climate action
(4) Evidence and analysis: Australian assistance provides evidence for improved understanding and policy advice on clean energy, water security and climate action
(5) Environmental and social safeguards: Australian assistance enhances application of environmental, social and governance (ESG) standards for energy, water and climate resilient infrastructure
(6) Sustainable electricity: Australian assistance bolsters capacities of Mekong countries in planning and policymaking for clean energy transitions
(7) Agriculture: Australian assistance enhances the adoption of sustainable and climate-sensitive agricultural methods
(8) Urban: Australian assistance enhances the uptake of water-sensitive, nature-based solutions, and climate sensitive approaches, in urban design
(9) Ecosystems: Australian assistance reduces social vulnerability and improves ecosystem health, with respect to the impacts of climate change, and a focus on riverine pollution, plastics, and coastal ecosystems.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi hydropower project	Develop technical guidelines for acoustic or radio tracking at LMB hydropower plants (HPP) (targeted for the hydropower developers, MRC and GoL).	Targeted and relevant research Improved knowledge base Robust science informing decision making	Criteria accepted by MRC and used by other HPP (ACIAR vi) (MAP-WEC 1, 2, 4, 5) Manuscripts produced and citations (ACIAR ii) (MAP-WEC 1, 3, 4)

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
	Revised criteria for fish friendly turbine pressure changes based on Mekong species tolerances Methodology for assessing downstream migration by fish at a large tropical river hydropower project	Ensure best available science is used Improved environmental outcomes	Guidelines obtained and reviewed (ACIAR vi; ii) (MAP-WEC 4, 5, 6, 9) Agencies consulted (ACIAR vi) (MAP-WEC 1, 3
Determining effectiveness of Xayaburi hydropower project facilities	Annual fish tagging Sensor fish trials Barotrauma experiments Data analysis Linking fish movements to real-time operations	Mainstem passage rates quantified in upstream and downstream directions Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC-NAFRI, NUOL, DLF)	% success of fish ascending (ACIAR vi; iv; ii) (MAP-WEC 4, 5) Average time for fish to ascend (ACIAR vi; iv; ii) (MAP-WEC 4, 5) % of tagged fish detected (ACIAR vi; iv; ii) (MAP-WEC 4, 5) Number of fish tagged annually (ACIAR ii; vi; iv) (MAP-WEC 4, 5) Fish pass operation integrated into operation (ACIAR vi; iv) (MAP-WEC 5, 6)
Scale out of methods and fish pass design to other mainstem projects	Contribute to MRC guidelines development Engage with other developers Install PIT systems within fishways at other hydropower sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ACIAR ii; vi; v) (MAP-WEC 4, 5, 9) No. new mainstem projects with functional fish ladders (ACIAR ii) (MAP-WEC 5, 6) No. new tagging studies implemented using the developed methods (ACIAR v) (MAP-WEC 4, 5) No. of Australian-patented PIT systems installed in the Mekong catchment (ACIAR v) (MAP-WEC 1, 4, 5)

2.6 Research activities, approaches, and outputs

EoPO 1

No.	Activity	Output(s)	Milestone date of output(s)
1.1 **and 1.2**	Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions (1.1); & research on fish friendly turbine design (1.2)	Data and knowledge to inform fish-friendly hydropower development	2024 - 2027
	Approach	Fish pass monitoring at Xayaburi hydropower project in upstream and downstream directions Acoustic fish tracking above and below Xayaburi hydropower project Monitoring fish that pass through turbines, the spillway, the downstream fish pass channel or the navigation lock at Xayaburi hydropower project Modelling limits of tolerance of Mekong fish species to changes in pressure, blade strike and fluid shear stress associated with HPP	
	Risks/Assumptions	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained	
	Application of outputs	Knowledge sharing and influencing the design and planning of other developments	
1.1.1	Collect data/evidence on fisheries mitigation measures from existing sies (KG 1 and 2)	Manuscripts on (1) Mekong fish species behaviour at HPP, (2) PIT tag refresh rates required for Mekong species to maintaining statistically robust tagged populations (3) limits of tolerance in Mekong fish species to pressure changes and shear stress (4) Improved criteria for fish friendly turbines and spillways at LMB HPP (5) Attractiveness (% of migrating fish that find) of the upstream fish ladder and downstream fish pass at a large tropical HPP.	2024-2027
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs	
	Risks/Assumptions	Manuscripts not completed	
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments	
1.1.2	Data is disaggregated & analysed via a GEDSI twin-track approach (KG 1 and 2)	Manuscripts on GEDSI implications of hydropower developments	2024-2029

	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs
	Risks/Assumptions	Manuscripts not completed
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments

EoPO 2

No.	Activity		Output(s)	Milestone date of output(s)
2.1	Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of project outcomes beyond the life of the project		Knowledge management system	2025-2029
	Approach	Develop a knowledge management system for stakeholders identified.		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange		
2.2	Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Deliver capacity building activities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		

2.2.1	Design & deliver fit for purpose training to build technical expertise on how to achieve fish friendly & inclusive hydropower development (KG3)		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Targeted communication activities and learning opportunities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		
2.2.2	Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG3)		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2027-2029
	Approach	Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		

Cross-cutting activities

No.	Activity	Output(s)	Milestone date of output(s)
3.1	Approvals to commence	Exa MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement

	Approach	Obtain approvals to commence from relevant stakeholders		
	Risks/Assumptions	Salaries and travel secured for Australian partners		
	Application of outputs	Establish the project team		
3.2	Continue PIT tagging more fish in the wild		Increased numbers of PIT tagged fish in the Mekong	Ongoing
	Approach	Continue PIT tagging more fish in the wild using the e-fishing boat		
	Risks/Assumptions	E-fishing boat is operating without issue		
	Application of outputs	Build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements models).		
3.3	Update and exchange knowledge with other groups		Sharing of key learnings Minutes from meetings	Opportunistically
	Approach	Liaise with MRC and other interested groups where work overlaps		
	Risks/Assumptions	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers		
	Application of outputs	Knowledge sharing and influencing the design and planning of other hydropower developments		
3.4	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2025
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.5	Hold annual team meeting		Annual team meeting minutes	April 2025
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		

	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.6	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2025
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.7	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2026
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.8	Hold annual team meeting		Annual team meeting minutes	April 2026
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.9	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2026
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.10	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2027

	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.11	Hold annual team meeting		Annual team meeting minutes	April 2027
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.12	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2027
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.13	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2028
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.14	Hold annual team meeting		Annual team meeting minutes	April 2028
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		

	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.15	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2028
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.16	Final reporting		Final project report to ACIAR and DFAT	June 2029
	Approach	Final project report delivered in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Overview of final project results/outcomes and final report is accepted		
3.17	Hold project final review meeting		Meeting minutes	June 2029
	Approach	Key team members and project stakeholders meet to review final project outcomes and report		
	Risks/Assumptions	Key members can attend, and all milestones are completed		
	Application of outputs	Confirm that project has been satisfactorily completed and recommended changes made to final report		
3.18	Final manuscripts		Published papers	June 2029
	Approach	Complete and submit final manuscripts to target journals		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination of key findings to the scientific community		

3. Project management

3.1 Project performance and monitoring plan

Strategic monitoring and evaluation plan

The framework for the project's strategic monitoring and evaluation (M&E) approach will be developed within the first 6 months of project implementation, and will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes foundational and intermediate activities, which take the activities and break them down into manageable sub-activities. Each activity has been included includes into the logframe (Figure 8) with defined impact pathways.

Medium-term cycles

The yearly reports and a forum will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place, which will include a facilitated lessons learned workshop, and a written final report.

Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large-scale impacts will accrue with time and may extend beyond the project funding envelope.

3.2 Management aspects

Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Under the contract terms of the first phase of research (FIS/2017/017), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated that the panel meet on an annual basis, at the hydropower site. The Project Reference Panel has advisory status and consists of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited, Ministry of Energy and Mining, plus representation of Lao nationals (Figure 2).

They conduct their business in confidence, which will be defined by a term of reference established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly funded data must be openly available according to ACIAR’s contractual requirements, and that that some IP will be required to remain commercial-in-confidence.

Mid- and final-project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR ‘mid-project review’ (after 24 months) and ‘end-of-project review’ processes.

Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Lao PDR dating back over ten years). The team will communicate regularly:

- Through face-to-face meetings, on ground and in country visits and networking
- Using Internal information-sharing and communication strategies
- Through bi-annual face-to-face planning workshops
- By developing workplans for achieving each of the EoPO's
- Holding regular work in progress meetings leveraging a full range of technology
- By documenting and distributing meeting minutes and action items
- Through routine monitoring and status reporting of deliverables
- Through the development of instructional videos and manuals as reference items.

Project coordination mechanisms and responsibilities

Project coordination will be undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Gulbali Institute, but he will work closely with Dr Michael Raeder and Thanasak Poomchaivej from XPCL to ensure project activities are realistic and fit within XPCL expectations. Finally, each agency will have a nominated ‘leader’ who will coordinate activities and partnerships with the agency. Dr Oudom Phonekhampheng will represent the National University of Lao PDR, and Bounsong Vongvichthit will represent Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute. These officers will take on local leadership roles (including managing resourcing and project management) to ensure the project team can effectively operate within local frameworks.

3.2 Avoiding harm

The project will seek to extrapolate and adopt the principles and guidelines of International Organisation for Standardization (ISO) 31000:2018 Risk Management. Detailed risk mapping will be undertaken at the inception meeting. The main aspects of the project will be identified and related to:

- Risk mapping based on previous projects and outcomes in Lao PDR (since institutional frameworks and expectations are well-known to the project team from prior projects)
- A risk management strategy, with defined risks, treatments and mitigation measures, for each key project milestone/activity
- A routine audit of and assurance on activities, which will form a key part of project measurement and evaluation by ensuring that anticipated activities are tracking as expected
- Regular communication and sound project management.

Animal research undertaken in Lao PDR is governed by the provisions of Animal Care and Ethics under Australian Law.

Therefore, the project team will apply for, and maintain, appropriate Animal Care Authorities for the duration of the project to cover all planned animal research.

Any fish research will also be in accordance with the requirements of relevant legislation (i.e. the Environment Protection and Biodiversity Conservation Act 1999, The Australian Code for the Responsible Conduct of Research (2018), and The Australian Code for The Care and Use of Animals for Scientific Purposes 8th edition (2013)).

Likewise, all human research will be conducted in accordance with The National Statement on Ethical Conduct in Human Research (2007)—Updated 2018.

3.3 Data management plan

Research Data Management (RDM) is a recommendation of the Australian Code for Responsible Conduct of Research. To ensure Charles Sturt University researchers follow good RDM practice, Charles Sturt has established an RDM policy. This policy requires all active research projects (whether funded externally or not) to have a RDM Plan which follows a standard template, and that all researchers generating research data must perform compulsory training. The RDM Plan will be provided to ACIAR upon completion.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how operation is portrayed in the public sphere. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support. The data sharing and publication arrangements therefore need to be carefully considered, discussed, and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

In terms of ACIAR good management principles:

Findable: CSU will have cloud-based systems established for most data management. Both PIT tag, and acoustic tag, data will be stored in the Cloud-based database *FishNet,* which is backed up, reliable and robust.

Accessible: Access to NVivo and FishNet is managed at a user-level. Users can be added and deleted by KarlTek Pty Ltd as required.

Interoperable: The cloud-based databases can be accessed via and operating system platform from any location globally provided there is an internet connection.

Re-Usable: The databases have a set of pre-defined '*Queries'* which allow 'clickable' reports to be generated by the user at any time. The reports update whenever new data is added to the database making the data re-usable indefinitely.

3.4 Intellectual property and other regulatory compliance

CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties.

An intellectual property register will be established at the beginning of the project in accordance with ACIAR's requirements. The register will encompass foreground, background and third-party intellectual property, and will include details on proprietary materials, techniques; and other contracts, licenses or legal arrangements.

In addition, the Mid-Term Review will include a review of the use of Background IP in the project to date and any Project IP that is in development and likely to lead to IP that is protectable. The Mid-Term Review team will be tasked with recommending to ACIAR whether additional actions, beyond that defined in the Standard Conditions, are required to clearly define ownership and/or public access to Project IP, that has been funded by Australian taxpayers.

3. Resourcing

3.1 Project team and partnerships

Name	Gender	Organisation	Discipline	[redacted]
Prof. Lee Baumgartner	M	CSU	Professor in fisheries/ river management	[redacted]
Dr Wayne Robinson	M	CSU	Biometrician and hydropower/ fisheries/ river management	[redacted]
Dr Nathan Ning	M	CSU	Aquatic ecology and hydropower/ fisheries/ river management	[redacted]
Mr Tisi Tukuniu	M	CSU	Project co-ordination and management	[redacted]
Dr Katie Doyle	F	CSU	Fisheries Scientist (hydropower)	[redacted]
Mr Zac Rolfe	M	CSU	Fisheries Technician	[redacted]
Casual staff - TBD	M/F	CSU	Fisheries Technician	[redacted]
Ms Mia Urbano	F	Alinea International	GEDSI-appropriate participatory research	[redacted]

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Name	Gende r	Organisatio n	Discipline	[redacted]
				[redacted]
Ms Ana Ilic/Dr Primatia Romana Wulandari	Both F	Alinea International	MEL experts	[redacted]
Martin Mallen-Cooper	M	Fishway Consulting Services	Fish passage expert	[redacted]
Jody Swirepik	F	Consultant	Governance/Wate r expert	[redacted]
Daniel Deng	M	Consultant	Hydropower and fisheries expert	[redacted]
Lizzie Pope	F	Snowy Hydro	Hydropower and fisheries expert	[redacted]
Secretariat – TBD	M/F	TBD	Manage the advisory reference group	[redacted]
Mr Karl Pomorin	M	KarlTek Pty Ltd	PIT tag system installation and management	[redacted]
Mr Garry Thorncraft	M	National University of Laos	Hydropower/ fisheries/ river management and fish passage expert	[redacted]
Dr Oudom Phonekhamphen g	M	National University of Laos	Fisheries/ river management	[redacted]

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Name	Gender	Organisation	Discipline	[redacted]
Mr Thonglom Phommavong	M	National University of Laos	Fisheries/ river management	
Mr Phousone Vorasane	M	National University of Laos	Fisheries technical	
Mr Saluemphone Chantavong	M	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries/ river management	
Mrs Khampheng Homsombath	F	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries/ river management and social dimensions	
Mr Bounsong Vongvichith	M	Living Aquatic Resources Research Centre -	Centre Director	

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Name	**Gender**	**Organisation**	**Discipline**	[redacted]
		National Agriculture and Forestry Research Institute		[redacted]
Mr Khamla	M	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries technician	[redacted]
Mr Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental engineering and hydropower	[redacted]
Dr Michael Raeder	M	Xayaburi Power Company	Engineering and hydropower development	[redacted]
Lamphone Dimmanivong	M	Ministry of Energy and Mines	Department of Planning Division	[redacted]

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Name	Gender	Organisation	Discipline	[redacted]
Vithounlabandid Thommabout	M	Ministry of Energy and Mines	DDG, Energy Policy, Department of Planning Division	
Dr Kaviphone Phoutavong	M	Ministry of Agriculture and Forestry	Department of Livestock and Fisheries	
Ms Somphou Phatsulath	F	Ministry of Agriculture and Forestry	Department of Livestock and FIsheries	

The hydropower development space is a politically challenging environment. It takes time (years) to establish relationships, trust, and demonstrate an ability to deliver on research outcomes. The FIS/2017/017 project developed trust and a highly productive working relationship among partners. The project team currently includes a private-public partnership team that now has an established track record and positive reputation in the region.

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies involved have the scientific and financial capabilities to successfully complete an international collaboration. Specifically:

Charles Sturt University: Has a long history with ACIAR and in working in the SE Asian region and will lead the project. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. CSU has extensive experience with PIT system data analysis and installations. There are no other universities in Australia with such extensive experience and networks for fishway design and monitoring.

Xayaburi Power Company: Owns and operates the Xayaburi hydropower project. They will own the facilities for the next 30 years under a concession agreement. Their fish monitoring researchers will partner with the CSU team to conduct on-site project activities.

KarlTek Pty Ltd: Is a Melbourne-based, 100% Australian owned and operated company that provides PIT tag-based solutions to a wide range of wildlife monitoring applications. Set up the PIT database for Xayaburi and will continue to manage this PIT database and advise on any new PIT installation works at the new site. Has >20 years of experience in PIT installation projects and successfully completed the installation and database management work for the preceding Xayaburi projects.

National University of Laos (NUoL) and Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute (LARReC-NAFRI – a centre within the Ministry of Agriculture and Forestry): Will both assist with in-country project co-ordination, field work and project delivery.

NUoL: Is the primary university in Lao PDR. Has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum.

Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute (LARReC-NAFRI): Is the leading institute in aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC-NAFRI has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Ministry of Energy and Mines (MEM): Currently the only agency with an outward facing discussion with all proponents of mainstem hydropower projects. Their role is to review and approve hydropower projects.

Department of Livestock and Fisheries (DLF): Is the national regulatory authority for fisheries-related matters in Lao PDR. Their role is to ensure that fisheries sustainability is adequately captured in project delivery and in discussions among government agencies as the project develops.

3.2 Collaboration

The team will collaborate with additional entities who are involved in achieving optimal fish passage outcomes at LMB mainstem hydropower developments. This will require us to work more closely with the Lao Ministry of Energy and Mines (than in the past) and Department of Livestock and Fisheries. It will also require us to work in collaboration with individual companies involved in hydropower project funding and development. Both these actors are engaged in design decision making for planned hydropower projects.

The team will need to engage the Mekong River Commission more strategically, so their hydropower guidelines and recommendations are updated to include new knowledge generated through this project.

Key knowledge gaps will be aided by the team’s use and referencing where appropriate approved fisheries guidance already in the public domain, negotiated and agreed by MRC Member Countries.

The team is aware of the new Preliminary Design Guidance (PDG), approved by MRC Member Countries, published by the MRC in February 2023, that is an updated version of the original PDG introduced in 2009. It incorporates not only what the MRC Member Countries have learnt from their own experience with hydropower, but also from examples and best practices around the world. It also includes the most current knowledge regarding design criteria, science and technology. While the older PDG spanned this range of construction and operation elements (hydraulics; sediment transport; geomorphology; water quality; aquatic ecology; fish and fisheries; safety; and navigation), the new PDG now includes hydrology and socio-economic impact to reflect the greater attention paid today to riparian communities and riverine livelihoods.

MRC’s Hydropower Mitigation Guidelines, approved and published in 2020, includes three technical volumes of 738 pages (vol 1 & 2), addressing a range of known risks during hydropower development through an assessment of five major themes. They include river hydrology and downstream flows, geomorphology and sediments, water quality, fisheries and aquatic ecology and biodiversity, natural resources, and ecosystem services.

According to the MRC’s HMG, during the planning, feasibility study and design process hydropower developers can take various steps to optimise benefits and avoid adverse impacts. They include, for instance, selecting the most appropriate project locations, adopting alternative project scales such as lower hydropower projects, and using alternative energy sources.

The 2020 HMG were an important complement to the 2009 PDG and remain valid. However, the team are aware that the 2023 PDG has further updated and approved guidance, including of most relevance to this project proposal, elaborated guidance on fisheries that ‘raises the bar’ for intending developers.

Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

A panel was developed for the previous project (FIS/2017/017) to oversee and guide the project team. This governance structure proved to work very well, so the same structure will be applied to this proposed project for continuity of knowledge and learnings. We will continue to support the existing panel, which has representative stakeholders from all cash/in-kind investors including Charles Sturt University, DFAT, ACIAR, XPCL plus representation of Lao nationals and independent experts. The panel members each have >10 years' experience each in their respective fields. They will conduct their business in confidence and review their current terms of reference at the project initiation phase.

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Expert advisor	Consultant	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power Company Limited	Owner Representative	Reference panel member	
John Dore	M	Department of Foreign Affairs and Trade	Lead Specialist – Climate Resilience & Water Security	Reference panel member	
MEM representative	F	Lao government	Local	Reference panel member	
TBD	TBD	ACIAR	Fisheries RPM	Reference panel member	
Lee Baumgartner	M	Charles Sturt University	Research Professor (Fisheries and River Management)	Project leader and reference panel member	

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC-NAFRI, MEM, DLF and NUOL budgets to facilitate this participation.

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3.3 Budget justification

Charles Sturt University

Salaries: [redacted] A key learning from the co-design workshop was that many of the project staff have been active now for almost 20 years. There is a need for succession planning. Also seeking to recruit a MEL expert (ideally specialising in hydropower matters to extend knowledge from EoPO1 to key stakeholders). It is essential that these staff can spend significant amounts of time, in-country, to connect with stakeholders. Finally, seeking support to cover the costs of the advisory reference panel, especially externally funded experts. This will ensure we have a robust and well-resourced project team with capacity to meet the needs of ACIAR/DFAT and the stakeholders we are trying to reach.

Research operating: Research consumables (each year across the two EoPO's); plus office consumables to assist with project running. Seeking support to develop/publish reports, briefs, posters, infographics and other dissemination materials (especially bilingual outputs). Including an allocation for developing educational materials needed for EoPO 2 when short-courses and masterclasses are developers for stakeholders).

Travel: Allocated to cover advisory reference panel expenses (annual meetings in the region); with a specific allocation for a mid-term review; fieldwork at Xayaburi/Luang Prabang each year with additional support for fisher surveys. Allocated a specific amount to cover participation in final project review.

Capital: Seeking computers for project staff along with field tablets to record fisher survey information, an iPhone for remote fieldwork and printer to support the project team.

Infrastructure: CSU has a compulsory infrastructure levy of 25% but will discount to 13% as per ACIAR guidelines.

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National University of Laos

Salaries: [redacted] This is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together and is also connected to MRC, government and developers.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs of the NUOL team. Boat hire and equipment use for remote fieldwork. There is a need for hatchery consumables for fish husbandry and long-term field trials. Have also included support for masterclasses and education materials as NUOL are the main in-country partner for education outcomes and will co-design and implement on ground communication, extension and capacity building activities.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1. Provision made for mid-term review and final project review.

Capital: Included moderate provision for ICT equipment (Year 1).

Infrastructure: National University of Laos sets the infrastructure recovery at 5%.

Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute

Salaries: Mr Douangkham Singhanouvong [redacted] is an emeritus researcher but is a critical liaison point for the Lao government. He will continue his key role, on a part-time basis in his retirement. [redacted] As with NUOL, this is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs. LARReC-NAFRI will be organise the mid-term and end of project review and so provision has been made for these important workshops. Hatchery consumables are included to support fish husbandry and other field expenses.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1. Provision made for mid-term review and final project review. $10k per year allocated to travel to support inclusion of MEM staff.

Capital: LARReC-NAFRI purchased a vehicle to cover the ACIAR-suite of work in 2006. It has not been replaced since. The vehicle has been depreciated beyond its effective life and is overdue for replacement. Seeking an allocation. Also included moderate provision for ICT equipment (Year 1).

Infrastructure: LARReC-NAFRI sets the infrastructure recovery at 5% (which is mandated by its head institution, NAFRI).

Ministry of Energy and Mines (to be included within the LARReC-NAFRI budget)

Salaries: [redacted].

Research operating: No operating expenses required

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: No capital required.

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Infrastructure: Infrastructure recovery at 5% through LARReC-NAFRI.

Department of Livestock and Fisheries

Salaries: [redacted] For the first two years, Ms Somphou will undertake a Masters in Sustainable Hydropower through an Australia Award scholarship.

Research operating: Included a consumables provision to cover expenses whilst assisting with fieldwork.

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: Provision for a laptop from project staff.

Infrastructure: DLF sets the infrastructure recovery at 5%.

Xayaburi Power Company Limited

Salaries: Xayaburi Power Company Limited will provide four staff members, based on site, who will collaborate with the team and contribute to fieldwork. [redacted]

Research operating: Access to a boat, operating of the fish research facility, maintenance and expansion of the PIT system, including procurement of an acoustic system, will be covered as a cash contribution.

Travel: Any travel-related costs for XPCL staff will be borne by the company. Staff visiting XPCL-controlled sites will be provided with accommodation by XPCL.

Capital: XPCL will purchase any significant equipment and plant needed for the project.

Infrastructure: N/A. XPCL will not be receiving any funds.

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3.4 Additional resourcing requirements

The FIS/2017/017 project was based on the premise that the Charles Sturt University team would source their salary and travel, and developers would cover all required equipment. This agreement will extend into the new project and so significant in-kind is provided from hydropower developers. CSU will also make contributions to Masters' courses, student stipends and masterclasses as needed throughout the project.

FIS successfully facilitated, through Clear Horizons Consulting, a co-design process for project logic and a theory of change framework that culminated in a Monitoring-Evaluation-Learning plan for the FishTech project. The project team would see great benefit in extending this approach to the project development phase of FIS/2023/133 should this proposal be accepted. We will also engage an MEL expert to guide the MEL reporting.

DFAT and ACIAR also implemented a MSA between the Australian and Lao governments, which acted as a template for the project team to operate in a complex political environment. This included the establishment of a project reference panel to oversee and guide the project. Renegotiating this MSA, and maintaining support for the project reference panel, will be critical.

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Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to

[redacted] FOI Act s. 47f

Administrative details

[redacted]

Plant or animal germplasm exchange

[redacted]

If 'yes' to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

[redacted]

Proprietary materials, techniques and information

[redacted]

'Data' means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical expertise and information reduced to material form by that Party. If 'yes' to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

Country	Details of proprietary materials, techniques and information

[redacted]

Other agreements

[redacted]

If 'yes' to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

Project, background and third-party Intellectual Property

This includes but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Project IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Project IP (IP that is expected to be developed during the project)

The following material is to be developed as part of the Project:

[redacted]

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

[redacted]

If 'yes', for each applicable country provide brief details.

[redacted]

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Appendix B: Project variations

Variations to the project after commissioning should be documented in this section

Variation 1.

<table>
<tr><th>Variation Date</th><th colspan="2">Purpose</th></tr>
<tr><td>Example date</td><td colspan="2">Brief explanation of purpose for variation</td></tr>
<tr><td rowspan="9">Changes
(omissions, substitutions, inclusions)</td><td>i.</td><td>Page 8, line 16-18.
- Omitted line: '…example…'
- Substituted line: '…example…'</td></tr>
<tr><td>ii.</td><td>Page 9, line 12.
- Included line: '...example...'</td></tr>
<tr><td>iii.</td><td></td></tr>
<tr><td>iv.</td><td></td></tr>
<tr><td>v.</td><td></td></tr>
<tr><td>vi.</td><td></td></tr>
<tr><td>vii.</td><td></td></tr>
<tr><td>viii.</td><td></td></tr>
<tr><td>ix.</td><td></td></tr>
</table>

Appendix C: The risk and safeguard tool

Safeguard Screening and Rating Instructions

All aid investments must be screened against DFAT's five environmental and social safeguards using the Safeguard Screening Checklist (the table on the left hand side of this tab). Risks identified during this screening are recorded in the risk register (the next tab).

Safeguard Screening

Familiarise yourself with the Environmental-and-Social-Safeguard-Policy. Consider whether the investment will have potential negative environmental and/or social impacts, taking into account:

- both direct and indirect impacts

- impacts of activities associated with the investment

- impacts that are reasonably foreseeable, given the nature of the proposed investment, and any activities.

In the table to the left record answers to all of the safeguard screening questions with either, 'yes', 'no' or 'unsure'. Where the answer to any screening question is:

- 'no', the investment is not likely to cause adverse environmental and/or social impact, and the safeguard risk rating is likely to be 'low'.
- 'yes', the investment is likely to cause adverse environmental and or social impacts.
- 'unsure', the investment will require further consideration of potential environmental and social impacts.

Rate the Safeguard Risk

Estimate the level of risk: If you answer 'yes' or 'unsure' for one or more of the questions, estimate the level of risk for the corresponding safeguard using the Aid Risk and Safeguard Matrix (see relevant tab) and include the risk in investment risk register (the next tab).

Note: Investments must be screened for their inherent environmental and social risks and impacts (i.e. before controls, treatments or management measures are put in place).

Consider the need for review by safeguard teams. Where investments have a 'high' or 'very high' safeguard risk please contact the safeguard team [redacted] FOI Act s. 47f

Note: The *Environmental and Social Safeguard Policy* mandates that a proportional impact assessment of safeguard risks, must occur during investment design, where the safeguard risk rating is 'high' or 'very high'.

For further information, refer to the Environmental and Social Safeguards Intranet page, and safeguard operational procedures and guidance.

Safeguard screening

	Safeguards Screening Checklist				
	Environmental and Social Safeguards	No Yes Unsure	If 'Yes' or 'Unsure'		Inherent risk rating (before controls)
			Likelihood	Consequence	
1	Environmental protection				
1.1	Could the investment have an adverse impact on the environment? For example, by supporting or providing advice on any of the following: • infrastructure development, such as roads, bridges, airports, railways, ports, dams, water, sanitation and hygiene (WASH), waste management, telecommunications, energy production and distribution facilities, urban development. •construction/renovation/refurbishment/demolition of buildings such as schools, hospitals, health facilities or any of the infrastructure above • diversion of water, including for water supply, irrigation, flood-mitigation, or aquaculture • rural development, agriculture, food production, or forestry activities • activities in the extractives (oil, gas, mining), manufacturing, transportation and tourism sectors • activities on top of or close to sites of cultural significance and require special measures.	No	Rare	Limited	Low

			Likelihood	Consequence	
1.2	Could the investment increase environmental, climatic and/or social vulnerability, including by (but not limited to): • increasing emissions of greenhouse gases (e.g. energy intensive process will lead to an increase in Green House Gas production) • reducing incentives to adapt (e.g. change in social norm away from responsible water conservation to increased consumption) • increasing the vulnerability of people (particularly the most vulnerable) or the environment to climate change (e.g. pesticides, used to eradicate mosquitoes that carry dengue fever, damage native insect populations which reduces agricultural productivity, leading to food insecurity) • increasing the impact of disasters, e.g. will infrastructure building codes and specifications be adequate for the intensity of disasters/hazards experienced in the investment area (e.g. floods, earthquakes, cyclones), will the investment impact the food security of a vulnerable population • setting paths that limit future choices (e.g. large capital and institutional commitment reduces portfolio of future adaptation options).	No	Rare	Limited	Low

			Likelihood	Consequence	
2	**Sexual exploitation, abuse and harassment**				
	Is there a risk of sexual exploitation abuse or harassment occurring in any aspect of the delivery of this DFAT activity (including DFAT activities implemented by downstream partners)?	No	Rare	Limited	Low
	Does this activity include risk factors that exacerbate the SEAH risks	No	Rare	Limited	Low
	Children, vulnerable and disadvantaged groups				
	Could the investment have an adverse impact on vulnerable and/or disadvantaged groups including children, women, people with disabilities, minority groups, or the elderly?	No	Rare	Limited	Low
	Could the investment involve contact with children or working with children?	No	N/A	N/A	
	Displacement and resettlement				
	Could the investment involve activities or provide advice about an activity that will: • displace people, either physically or economically • exclude or reduce people's access to land they live on or used to generate livelihoods • exclude or reduce people's access to land that is of cultural or traditional importance to them?	No	Rare	Limited	Low

If you answer 'yes' or 'unsure', a risk assessment must be undertaken and appropriate minimum standards applied consummate with the level of risk. Please refer to the PSEAH risk guidance note for instructions. Please contact [redacted] for further advice.

Complete Steps 1-3 of the Guidance Note: Establishing Child Protection Risk Context to assess the overall child protection risk. This will help determine the risk level for this question.

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	Safeguards Screening Checklist				
	Environmental and Social Safeguards	No Yes Unsure	If 'Yes' or 'Unsure'		Inherent risk rating (before controls)
			Likelihood	Consequence	
5	Indigenous peoples				
5.1	Could the investment involve activities that adversely impact the: • dignity, human rights, livelihood systems or culture of indigenous peoples • land or natural and cultural resources that indigenous peoples own, use, occupy or claim?	No	Rare	Limited	Low
6	Health and safety				
6.1	Could the investment involve activities that adversely impact the health and safety of workers and/or others?	No	Rare	Limited	Low
6.2	Could the investment involve DFAT workers?	No	If yes, follow relevant departmental WHS policies and contact [redacted] for advice.		
6.3	Could the investment involve risk of exposing workers and/or communities to asbestos?	No	If yes, ensure that this investment complies with the Department's policy on managing asbestos risk in the aid program.		
Overall Safeguard Risk Rating			Low		

If you answer ‘yes’ or ‘unsure’, DFAT’s health and safety obligations may be shared with others depending on the nature of the investment. DFAT must satisfy itself that the relevant delivery partner's health and safety management processes are adequate to ensure the health and safety of workers and others, so far as is practicable in the circumstances. Please contact [redacted] for further advice.

Refer DFAT’s Managing asbestos risks policy and guidance note. Please note you do not need to rate the risk. If your answer is 'yes' or 'unsure' you must assess the risk associated with asbestos containing material at investment design

This field is automatically calculated.

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Risk register

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	**23/11/2023**	**Date of Next Review:**	**1/07/2024**	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Operating environment	Timeline and budgets are not achieved	Covid delays, contracting issues, financial transfer delays, recruitment	May be unable to complete project on time	Project Team	Possible	Moderate	Medium	Workplans, payment schedules, regular meetings, project planning and shared expectations	Unlikely	Moderate	Medium	N/A. Project planning will be OK to manage this.			Unlikely	Minor	Low	No
Partner capacity and relations	Program activities not aligned with community and industry expectations	Poor engagement, Covid delays, language barriers	Unable to source approval for research to commence	Project Team	Possible	Moderate	Medium	Stakeholder analysis, regular consulations and co-design with stakeholders, follow partner frameworks	Rare	Moderate	Low	N/A. The team has a good process for consultation already proposed			Unlikely	Minor	Low	No
Other	Hydropower developer will not allow for the sharing or publishing of results	Sensitive or unfavourable findings from the research	Unable to share results with MRC and other stakeholders; or unable to publish results	Project Team	Possible	Major	High	Legal agreements in place to allow for key findings to be shared	Unlikely	Major	Medium	Existing treatments plus exploring the reasons behind the lack of willingness to share data and negotiating to find a compromise.						

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods		AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review: 1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate: MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:				

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating L Refer to matrix	Inherent Risk Rating C Refer to matrix	Inherent Risk Rating RR Refer to matrix	Existing Controls What's currently in place?	Current (Residual) Risk Rating L Refer to matrix	Current (Residual) Risk Rating C Refer to matrix	Current (Residual) Risk Rating RR Refer to matrix	Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating L Refer to matrix	Target Risk Rating C Refer to matrix	Target Risk Rating RR Refer to matrix	Does this risk need to be escalated?
Other	Non-use of research learnings/existing guidance by hydropower companies, and/or failure to insist on compliance by Mekong governments and some financiers	Sensitive or unfavourable findings from the research	Hydropower developers fail to adopt fish friendly, socio-economic and inclusive practices	Project Team	Possible	Major	High	Empirically demonstrating the ecological benefits of making hydropower developments fish friendly	Unlikely	Major	Medium	Existing treatments plus empirically demonstrating the socio-economic benefits of using the research findings to guide fish-friendly, socio-economic and inclusive hydropower development in the LMB. Also normalisation of support for and compliance with the MRC's hydropower mitigation guidelines and recommendations already negotiated, packaged and approved.						
Resources, management and planning	PL or key staff resign	A range of sources but usually individual preference	Could delay works depending on the skillset which has departed	Project Leader	Possible	Minor	Medium	We have a large team with some degree of redundancy to counter and staff departures.	Possible	Minor	Medium	N/A. Planning for team structure has assumed that some staff may depart.			Possible	Limited	Low	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	**23/11/2023**	**Date of Next Review:**	**1/07/2024**	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Partner capacity and relations	A partner(s) becomes misaligned with the aims and objectives of the activity	Changing agency priorities, political pressure, lack of understanding	Could delay works or mean the project moves in a different direction	Project leader	Possible	Major	High	Several levels of project agreement. Milestones and timelines in place. In-country leaders to keep items on track.	Unlikely	Minor	Low	N/A			Unlikely	Minor	Low	No
Operating environment	Legislative workplace requirements - WHS, Human resources, etc	Fieldwork, construction or operation accidents	Staff injury, slowed project progress	All staff	Possible	Minor	Medium	Risk assessment framework, staff training, masterclasses and ongoing information sharing. Contractors responsible for their own WHS	Unlikely	Minor	Low	N/A. Existing treatments should be sufficient.			Unlikely	Minor	Low	No
Resources, management and planning	Access to data / cyber security issues; Privacy; contact lists, data information of members etc	Data loss or loss of control over data	Inability to report, data used by third parties, potential for financial loss	CSU and partners	Rare	Minor	Low	Data management plan required by CSU and will be signed by all partners	Rare	Limited	Low	Existing controls should be sufficient			Rare	Limited	Low	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating** **L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating** **L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating** **L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	**Does this risk need to be escalated?**
Partner capacity and relations	Partner(s) leave the activity	Changing agency priorities, political pressure, lack of understanding	Inability to deliver particular in-country components	CSU and partners	Rare	Moderate	Low	Partners required to enter into MOU, ACIAR ensure that MOU agreed and signed at high level	Rare	Moderate	Low	Existing controls should be sufficient			Rare	Moderate	Low	No
Political	Low traditional owner buy-in / acceptance / participation	Covid delays, lack of interest/influence, village chief not inclusive	Reduced benefits of activity as not all stakeholders included	Project Team	Unlikely	Minor	Low	Strong approach to GEDSI will mitigate this risk and seek to mitigate risks.	Unlikely	Minor	Low	GEDSI advisor will help advise and ensure project design is sound			Unlikely	Minor	Low	No
Environment and social safeguards	Covid and travel interruptions	Global pandemic and government response	Unable to hold meetings, forums, access sites	Project Team	Possible	Major	High	Government agencies becoming exempt from travel restrictions, international experts able to resume travel, need to have this activity listed as a nationally significant activity	Unlikely	Minor	Low	High level engagement to ensure project is listed as a high priority activity and exempt from restrictions where possible	DFAT/ACIAR/CSU	On commencement	Unlikely	Minor	Low	No, but a watching brief on covid situation

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Fiduciary and fraud	Misuse of project funds	In-country touch points, contractors, departmental staff	Main risk is fraud, misappropriation of activity funds	Project team	Rare	Major	Medium	Financial auditing will take place every six months, activities linked to payments, formal procurement processes need to be followed	Rare	Major	Medium	N/A. ACIAR has strong financial reporting and acquittal processes in place.	ACIAR/CSU	On commencement	Rare	Major	Medium	No, would only escalate if circumstances required
Resources, management and planning	GEDSI targets in terms of involvement, attendance and equal participation are not met	Institutional barriers, lack of engagement, poor consultation	Project advances but without GEDSI considerations captured	Project team	Possible	Moderate	Medium	Specific GEDSI budget included, training of project team, undertake GEDSI analysis, employ GEDSI advisor	Unlikely	Moderate	Medium	N/A			Unlikely	Moderate	Medium	No
Environment and social safeguards	Project budget insufficient	AUD significantly de-values against USD	Reduced ability to deliver	Project team	Possible	Major	High	Flexible workplan budget advanced at known rate	Possible	Moderate	Medium				Possible	Moderate	Medium	No, would only escalate if circumstances required

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Operating environment	Large scale weather (e.g. flood) events damaging data-capturing equipment (especially the PIT antennas)	Weather	Loss of fishway efficiency data	In-country leads	Possible	Major	High	Agile and responsive team members in place. Protocols for removing equipment when water levels reach trigger values.	Possible	Moderate	Medium	Manage to have contingencies for unforseen disruptions.			Possible	Moderate	Medium	No
Operating environment	Faults/power loss in PIT antenna systems	Weather, faulty equipment, flat batteries	Loss of fishway efficiency data	In-country leads	Possible	Major	High	Agile and responsive team members in place. Protocols for replacing batteries etc at set intervals. Having backup/spare batteries and other key equipment on standby.	Possible	Moderate	Medium	Manage to have contingencies for unforseen disruptions.			Possible	Moderate	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods		AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review: 1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate: MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:				

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Operating environment	Lack of continued agency and/or financial support	Changing government and/or government commitment, policies and priorities in the recipient countries; or changes in diplomatic relations between countries.	May be unable to complete project on time	Project Team	Possible	Moderate	Medium	Agile and responsive team members in place.	Possible	Moderate	Medium	Manage to have contingencies for unforseen delays and other disruptions/changes in political context.			Possible	Moderate	Medium	No
Operating Environment	Structures are not maintained or operated effectively	Operating budget for weir-dam does not include adequate budget for maintenance of PIT antenna equipment or training of staff	PIT tagging antennas would be less effective at assessing fish pass efficiency	Project team, in-country partners	Possible	Major	High	Ownership, long-term maintenance, training is part of hydropower dam owners mandate	Possible	Moderate	Medium	Include in project planning and execution of project contract			Possible	Moderate	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods	AidWorks Number:	
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Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker · Delegate: MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:			

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Environment and social safeguards	Women don't participate in the project	Challenging gender norms creates risks for women to participate	GEDSI targets are not met; the project's inclusion of gender equality is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI ewxpert has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis to ensure approaches are gender and culturally sensitive & address risk to women caused by challenging existing norms	Unlikely	Limited	Low	Complementary to women only internships and trainings will be training for staff (men and women) to understand why women are being targeted and their role in ending gender inequality; to ensure equal participation of women in meetings, the project team will address participation in a culturally and gender sensitive way so women's attendance and use of her time is not tokenistic but productive			Unlikely	Limited	Low	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate:	MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
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Environment and social safeguards	Women's risk of violence increase	Challenging gender norms creates risks for women to participate	GEDSI targets are not met; the project's inclusion of gender equality is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI advisor has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis to ensure approaches are gender and culturally sensitive and address risk to women caused by challenging existing norms	Unlikely	Limited	Low	Complementary to women only internships and trainings will be training for staff (men and women) to understand why women are being targeted and their role in ending gender inequality; to ensure equal participation of women in meetings, the project team will address participation in a culturally and gender sensitive way so women's attendance and use of her time is not tokenistic but productive			Unlikely	Limited	Low	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	**23/11/2023**	**Date of Next Review:**	**1/07/2024**	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
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Environment and social safeguards	Disability approaches lack sensitivity or cultural application.	Lack of awareness of disability inclusive development	GEDSI targets are not met; the project's inclusion of disability is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI advisor has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis that includes entry points for the project to conduct meaningful disability work with organisations for people with disabilities.	Unlikely	Limited	Low	GEDSI analysis will take into account the intersectional gender equality approach rather than interpreting Gender Equality, Disability and Social inclusion as siloed identities.			Unlikely	Limited	Low	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate:	MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:					

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Environment and social safeguards	Sexual harassment or exploitation occur within the project.	Societal gender inequality in the project team and targeted communities	Reduced ability to deliver	Project leaders	Possible	Moderate	Medium	Prevention of Sexual Exploitation, Abuse and Harassment training is required for all staff and partners through the CSU ELMO system. Training should include discussion around consent and other concepts which may be new in the Asia context	Possible	Moderate	Medium	Confidential complaints mechanisms are established and are gender and culturally sensitive; a series of mandatory gender and inclusion related trainings (one-off trainings are not enough to change behavioural norms)			Possible	Moderate	Medium	No
Environment and social safeguards	Fishway incorectly operated	Inadequate training in operations and maintenance	Fish pass operates inefficiently, fisheries resources impacted	Project team	Possible	Major	High	Sufficient operations and maintenance training	Possible	Moderate	Medium	Existing controls should be sufficient			Possible	Moderate	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:		
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region	
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Environment and social safeguards	Uncertain fishway ascent performance	Inadequate monitoring end evaluation	Fish pass operates inefficiently, fisheries resources impacted	Project team	Possible	Major	High	Sufficient fish pass evaluation design for the project	Possible	Moderate	Medium	Existing controls should be sufficient			Possible	Moderate	Medium	No
Environment and social safeguards	Construction of the fishway (for new hydropower dams) caused environmental damage	Fuel spill, vegetation removal, erosion	Habitat destruction, loss of terrestrial or aquatic biota, reduced water quality	Project team	Unlikely	Minor	Low	Pre-construction site specific Risk Mitigation Plan	Rare	Minor	Low	Existing controls should be sufficient			Rare	Minor	Low	No
Environment and social safeguards	Operation of fishway increases risk of disaster	Unsafe fishway design for new hydropower dams	Drownings, injuries	Project team	Rare	Severe	Medium	Fishway Safety Management Plan	Rare	Major	Medium	Existing controls should be sufficient			Rare	Major	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
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Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
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Environment and social safeguards	Construction of fishway (for new hydro dams) involves children or fishway operation poses risks to disadvantaged	Poor management of fishway construction	Exploitation of children or disadvantaged groups	Project team	Rare	Moderate	Low	Before construction site specific Risk Mitigation Plan and Fishway Management Plan	Rare	Moderate	Low	Existing controls should be sufficient			Rare	Moderate	Low	No
Environment and social safeguards	Construction of fishway (for new hydro dams) displaces people	Poor management of fishway construction	People's homes and/or water or fisheries resources impacted	Project team	Rare	Moderate	Low	Pre-construction site specific Risk Mitigation Plan	Rare	Major	Medium	Existing controls should be sufficient			Rare	Major	Medium	No
Resources, management and planning	Team staff are over-allocated and are no longer able to assess fishway effectivness effectively and/or efficiently	Staff member's workloads increase as demand for their expertise increases (i.e. more agencies request assistance with fishway assessments).	Poor quality fishway outputs, staff burnout, inefficient work practices, missed opportunities to scale out further to new hydropower dams	Project team	Likely	Moderate	High	Minimising overallocations in workload by capping the work taken on by the team	Possible	Moderate	Medium	Re-allocating budget to increase staffing resources to be able to take on more work in a sustainable manner	Team and DFAT/ACIAR		Unlikely	Moderate	Medium	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**											**AidWorks Number:**						
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Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**				**Delegate:**		MAP WEC Team - Vientiane office					**Sector/s:**	Water					
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Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
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Resources, management and planning	The available budget becomes insufficient to deliver on the original project plan	Currency fluctuations and/or inflation; having to pay more for contractors if activities not completed on schedule	Reductions to the project's abilty to scale out and scale up fishway developments at new hydropower developments	Project team	Likely	Major	High	Having 'Plan B' options to undertake fewer project activities	Likely	Minor	Medium	Re-allocating budget to have a buffer for currency fluctuations and/or inflation	Team and DFAT/ACIAR		Unlikely	Moderate	Medium	No

Risk summary

Investment Risk Summary	Highest individual inherent risk rating in each category (before controls)	Highest individual residual risk rating in each category (after controls but before treatments)
1. Operating environment: What factors in the operational or physical environment (security, lack of essential infrastructure, gender inequality, land tenure etc.) might impact directly on achieving the outcomes? Is the investment or intended outcomes exposed to disasters that typically occur in the investment area and/or country? Will the investment be exposed to climate change risk?	-	-
2. Partner capacity and relations: Could a relationship breakdown occur with key partners or stakeholders and would this prevent the outcomes from being achieved? Does the intended partner/s (if known) have the capacity and capability to manage their role/work involved in this investment, including risks? Are there governance mechanisms (in the design and agreement) in place to ensure adequate ongoing communication and reporting between DFAT and the investment partner?	-	-
3. Fiduciary and fraud: Are there any significant weaknesses that mean funds may not be used for intended purposes, not properly accounted for or do not achieve value for money? Is there a risk that DFAT aid program funding could be diverted for use by terrorists?	-	-
4. Political: Is there a likelihood that political instability, changes to a partner government's strategy or policy may jeopardise the investment outcomes? Change in government? Might this negatively affect DFAT's relationship with the partner government?	-	-
5. Resources, Management and Planning: How realistic are the outcomes and can they be achieved within the timeframe? Are the outcomes sustainable? What factors may prevent the outcomes being met? Are there adequate resources, including budget and people allocated to implementation (within DFAT and/or the partner government)?	-	-
6. Environment and Social Safeguards: Do any of the activities involved in this investment have the potential to cause harm to the environment and people - (environmental protection; children, vulnerable and disadvantaged groups; displacement and resettlement, indigenous peoples; health and safety)?	-	-
7. Other: Are there any other factors specific to this investment that would present a risk (e.g. this is a new area of activity or it is an innovative approach?	-	-
	Use this overall inherent risk rating during planning and concept.	Use this overall residual risk rating during design and implementation.
Overall Risk Rating	-	-

Risk matrix classifications

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Operating environment	Limited impact on investment objectives and beneficiaries, including from operating environment, disaster, reputational, fraud/ fiduciary, partner, resourcing and/or other risks factors.	Political, governance, social and/or security (conflict or violence) factors threaten investment effectiveness but can be dealt with internally.	Political, governance, social and/or security (conflict or violence) factors creates moderate disruption to one or more investment activities.	Political, governance, social and/or security (conflict or violence) factors creates major disruption to the investment.	Political, governance, social and/or security (conflict or violence) instability severely undermines the investment.
Disaster risk		Minor disaster impacts to investment objectives and outcomes.	Moderate disaster impacts to investment objectives and outcomes. Moderate damage to property.	Significant disaster impacts to key investment objectives or outcomes. Major damage to critical property or multiple properties.	Severe disaster impacts to overall investment objectives or outcomes. Extensive damage or loss of property/or multiple properties.
Development results	Results in consequences that can be dealt with by routine operations.	Delay in achieving investment objectives, resulting in minor impact on service delivery beneficiaries and/or country program.	Delay in achieving investment objectives, resulting in moderate impacts on service delivery, beneficiaries and/or country program.	Delay or failure to achieve investment objectives, resulting in major impact on service delivery and/or beneficiaries. Threaten the continued effectiveness of the country program.	Critical failure to achieve investment objectives, resulting in severe impact on service delivery, beneficiaries and/or country program. Country program stopped as a result of investment.
Partner capacity and relations		Institutional and/ or partner capacities is generally adequate. Some weakness may reduce effectiveness of aspects of the investment.	Institutional and/ or partner capacity is constrained, resulting in moderate impact on investment effectiveness.	Institutional and/ or partner capacity is very weak, resulting in major impact on investment effectiveness.	Critical institutional and/ or partner capacity failure undermines the effectiveness of entire investment.
Fiduciary and fraud		DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money. Fraud threatens the effectiveness of key investment objectives and/or services.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money, affecting achievement of key investment objectives. Systemic fraud perpetrated over a period of time.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money, undermining overall investment viability. Systemic institutional fraud involving multiple organisations over an extended period of time.

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Compliance		Minor breach of investment accountability, legislative/ contractual or security obligations.	Moderate breach of investment accountability, legislative/ contractual or security obligations.	Multiple breaches of investment accountability, legislative/ contractual or security obligations.	Systemic breach of investment accountability, legislative/ contractual or security obligations. Funds are diverted to known terrorists/ terrorist organisations.
Security		Minor damage to national interests.	Significant damage to national interests. Funds are unintentionally diverted to a Terrorist Organisation or individual i.e. goods/funds are ceased.	Serious damage to national interests. Funds are negligently / recklessly diverted to a Terrorist Organisation or Individual i.e. local service providers are not appropriately screened / due diligence completed.	Exceptionally grave damage to national interests. Funds are knowingly and deliberately diverted to a Terrorist Organisation or Individual i.e. Engagement of a Terrorist Organisation to provide security services / access in country. DFAT funds are used to fund a terrorist attack domestically or overseas.
Reputation		Minor impact to relations with stakeholders.	Moderate damage to relations with partners, beneficiaries, or other key stakeholders and media criticism.	Major damage to relations with partners, beneficiaries, or other key stakeholders. Strong media criticism.	Total loss of confidence in DFAT and breakdown of partner relations. Severe public criticism of DFAT.
Other		DFAT resources (budget, people, or timeframes) occasionally constrained.	DFAT resources (budget, people, or timeframes) moderately constrained.	DFAT resources (budget, people, or timeframes) significantly constrained.	DFAT resources (budget, people, or timeframes) critically constrained.
Environmental Protection	Minimal impact on the environment. Impacts are largely undetectable. No or negligible increase to people's vulnerability to climate change impacts, and negligible GHG emissions	Minor impact on the environment. Impacts are temporary and confined to a small area of low environmental sensitivity. Minimal and short term increase to people's vulnerability to climate change impacts, and/or minimal GHG emissions.	Moderate impact on the environment. Impacts may be long lasting, extend beyond the local area and include sensitive environmental communities. Moderate and short term increase to people's vulnerability to climate change impacts, and/or moderate GHG emissions.	Significant impact on the environment. Impacts are irreversible, diverse, over a sensitive geographic area. Significant and long term increase to people's vulnerability to climate change impacts, and/or significant GHG emissions.	Significant impact on the environment. Impacts are irreversible, diverse, with strong cumulative impacts over a large and/or sensitive geographic area. Severe and permanent increase to people's vulnerability to climate change impacts, and very high GHG emissions.

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Children, vulnerable & disadvantaged groups	No harm/injury to a child. Minimal social impact, vulnerable and/ or disadvantaged groups. No concern from local community, NGOs, medium or other stakeholders.	Minor injury to a child, requiring first aid. Short-term nuisance or minor social impact on local population, including vulnerable and/or disadvantaged groups. No attention from affected community, NGOs, media or stakeholders beyond the affected population.	Serious harm/ injury to a child. Moderate social impact which effects the majority of the local population including vulnerable and/or disadvantaged groups. Concern from affected community, NGOs, media or stakeholders may cause delay to the investment.	Life-threatening harm/ injury to a child. Significant social impact which extends beyond local population, including vulnerable and/or disadvantaged groups. Concern from affected community, NGOs, media or stakeholders may prevent the investment from continuing.	Fatality of a child. Life-threating injury/ harm of more than one child. Significant social impact which extends beyond local population, including vulnerable and/or disadvantaged groups. Increases conflict and/or social fragility. Concern from affected community, NGOs, media or stakeholders prevents the investment from continuing.
Displacement & resettlement	No displacement and/ or resettlement. Limited impact on potentially affected households.	>5 households/ businesses displaced.	>5<20 households/ businesses displaced.	>20<100 households/ businesses displaced.	>100 households/ businesses displaced.
Indigenous Peoples	Indigenous group living in project area of influence. No adverse impact.	Short-term nuisance to indigenous population. No damage to/ or loss of access to indigenous land, assets, resources, and/or cultural heritage.	Moderate impact on indigenous population. Damage to/ or temporary loss of access to indigenous land, assets, resources, and/or cultural heritage.	Significant impact on indigenous population. Damage to/ or protracted loss of access to indigenous land, assets, resources, and/or cultural heritage.	Significant, long-lasting impact that effects the indigenous population. Permanent loss of/ or access to indigenous land, assets, resources, and/ or cultural heritage.
Health and Safety	Limited worker and/ or community health and safety impacts. Injury requiring first aid.	Short-term worker and/ or community health and safety impacts. Minor injury requiring medical care.	Moderate worker and/ or community health and safety impacts. Serious injury or multiple minor injuries.	Significant worker and/ or community health and safety impacts. Life threatening injury/ multiple serious injuries.	Significant worker and/ or community health and safety impacts. Death or multiple life threatening injuries.

Likelihood	Probability					
Almost Certain	Very likely. The event is expected to occur in most circumstances as there is a history of regular occurrence at DFAT, similar organisations or investments.	**Medium**	**Medium**	**High**	**Very High**	**Very High**
Likely	There is a strong possibility the event will occur as there is a history of frequent occurrence at DFAT, similar organisations or investments.	**Medium**	**Medium**	**High**	**High**	**Very High**
Possible	The event might occur at some time as there is a history of casual occurrence at DFAT, similar organisations or investments.	**Low**	**Medium**	**Medium**	**High**	**High**
Unlikely	Not expected, but there's a slight possibility it may occur at some time.	**Low**	**Low**	**Medium**	**Medium**	**High**
Rare	May occur only in exceptional circumstances. Is possible but has never occurred to date.	**Low**	**Low**	**Low**	**Medium**	**Medium**

Issues register

Issue Register								
Issue No.	Description	Priority (H,M,L)	Proposed Strategies	Reported by	Assigned to	Status	Date resolved	Comments
1								
2								
3								
4								
5								
6								
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Australian Government

Australian Centre for
International Agricultural Research

Full Project Proposal

ACIAR Program(s) area	Fisheries
Project Title	Optimising fish passage at hydropower sites in the Mekong
Project Number	FIS/2023/133
prepared by	Lee Baumgartner and Nathan Ning
ACIAR Research Program Manager	Dr Ingrid Van Putten

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the Australian Privacy Principles set out in Schedule 1 of the Privacy Act 1988.

The primary purpose of collecting the personal information provided in this project proposal is to consider the suitability of the project proposal for progression to a project. The names, contact details and CVs of project members may therefore be shared with external project reviewers as part of the project development cycle. Further, if this project proposal progresses to a project, then this project proposal (including personal information provided therein) will form part of project documentation exchanged with project parties such as the commissioned organisation, collaborating institution(s) and partner-country government(s) for use in furtherance of the project.

ACIAR may also use and disclose personal information provided in this project proposal for related secondary purposes, such as:

- in furtherance of the ACIAR Capacity Building Program;
- to develop the ACIAR alumni network; and
- in evaluating and assessing the effectiveness of, and otherwise developing our policies in respect of, our projects.

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

More generally, ACIAR will store, use and disclose personal information in accordance with its privacy policy located on the ACIAR website at www.aciar.gov.au/privacy-policy.

Queries in respect of how ACIAR stores, uses and discloses personal information may be directed to [redacted]

FOI Act s. 47f

Summary Information

Version # and date of this document	December 2023
Project number	FIS/2023/133
Full project title	Optimising fish passage at hydropower sites in the Mekong
Budget ($)	$5,700,000
Commissioned Organisation	Charles Sturt University
Project Leader	Dr Lee Baumgartner
Country 1 Coordinator	Dr Oudom Phonekhampheng (NUOL)
Country 2 Coordinator	Mr Bounsong Vongvichith (LARReC-NAFRI)
Country 3 Coordinator	Dr Kaviphone Phoutavong (DLF)
Proposed start date	1 July 2024
Proposed end date	30 June 2029

Contents

1. Project justification

1.1 Project aim

This project aims to minimise the potentially harmful impacts of hydropower projects on the productive fisheries, and the people who depend upon them, in the Lower Mekong Basin.

1.2 Development issue and research opportunity

Development issue

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively and severely impacted if all planned large-scale mainstem hydropower projects are completed without appropriate consideration for the impacts on fish migration and people who depend upon migratory fish. There are presently nine large hydropower projects scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The hydropower projects have divided public opinion. The capture fishery in the Lower Mekong Basin has been estimated to be worth US$7-8 billion annually (MRC, 2023b), but the projects are expected to reduce, by more than half, this important source of food and income for many people (ICEM 2010).

Hydropower development (HPD) on the Mekong River is expected to aggravate food insecurity and poverty in the region (MRC, 2018). Thailand is expected to suffer the most economically and ecologically, and full hydropower development will decrease GDP growth for LMB countries by US$29 billion (MRC, 2017, 2018). Native fish stocks will be particularly impacted, with more than 900,000 tonnes of fish biomass, worth US$3.3 billion (Figure 1), predicted to disappear by 2040 (MRC, 2017, 2018). Thailand would have the highest rate of fish loss (55% of fish stocks), then Lao PDR (50%), Cambodia (35%) and Vietnam (30%).

Social impacts are also expected, such as community displacement and livelihood and food security reductions, and will largely affect riparian communities. Indeed, a scenario analysis by the MRC Council on the sustainable management and development of the Mekong River (i.e. the 'Council Study') suggests that planned hydropower development will adversely affect community resilience and sustainability, with hydropower companies benefitting at the expense of fishing households (MRC, 2018). Environmental issues of reduced water quality, decreased fish quantity and unstable water flow will exacerbate these impacts (Soukhaphon et al. 2022). Loss of livelihood is expected to be cumulative and become increasingly significant as more hydropower projects are constructed along the Mekong River. Issues of food and livelihood security are also faced by those relocated and not provided appropriate compensation. Hydropower proponents suggest that the fisheries impacts can be minimised through the application of technical solutions, such as fish passes (Baumgartner et al. 2018; Baumgartner et al. 2012).

The first LMB mainstream site, at Xayaburi, in Lao PDR was completed in late 2018 (Figure 1). The Xayaburi hydropower project blocks the entire width of the river with a wall more than 30 m high, presenting an impassable barrier to all fish species (Orr et al. 2012). Significant investment (US$300M) to provide for fish passage was incorporated into the final designs to minimise impacts on fisheries (Campbell and Barlow, 2020). The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical world. However, at the time of construction, there were no data available globally to inform the likely success, or otherwise, of such an investment in a river system with a highly diverse fish community like the Mekong. The success of this structure was the focus of FIS/2017/017.

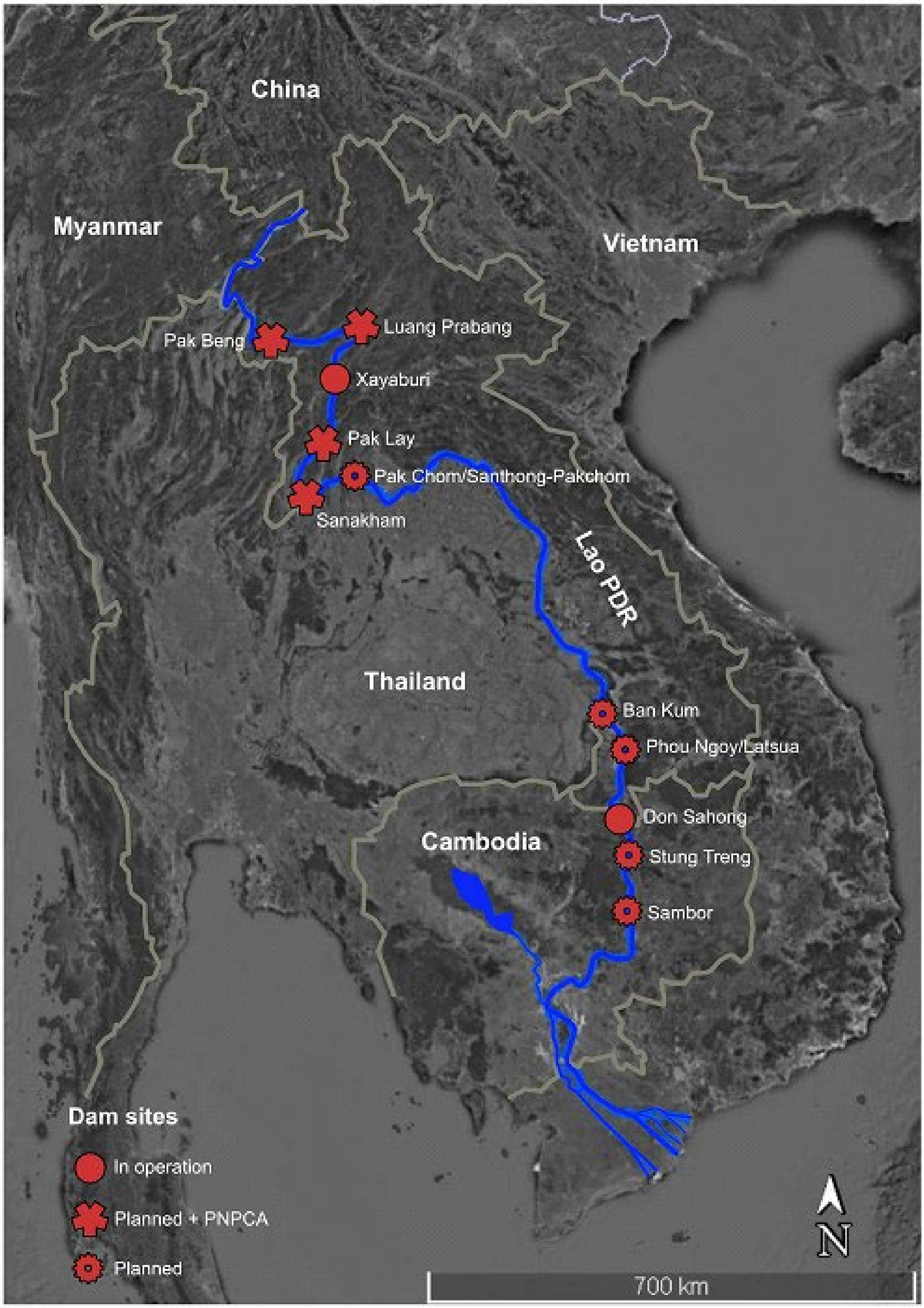

Figure 1. Map of hydropower projects on the mainstem of the lower Mekong River that are either planned, planned and at the PNPCA stage, and already in operation.

What do we already know?

ACIAR/DFAT and Charles Sturt University partnered with Xayaburi Power Company Limited to answer the question of whether the upstream fish passage facilities were effective in passing a large proportion of fish numbers and species. A structured research program was initiated (FIS/2017/017), which focused on the effectiveness of the upstream fish pass within a limited line of inquiry (focused largely on the fish pass effectiveness for fish migrating upstream). Nevertheless, initial results are very promising, demonstrating that large numbers of many species are moving upstream with a >80% ascendency efficiency (i.e. >80% of PIT tagged individuals locating the fish pass entrance have been able to ascend all the way to the fish pass exit) (unpublished data – sourced from PIT tagged fish being detected by PIT antennas at the entrance and exit of the fish pass during FIS/2017/017). Twenty-three migratory species have been detected in the fish pass so far, representing a wide range of fishes that are important for supporting the protein requirements and/or livelihoods of LMB riparian communities (with the most common being *Hypsibarbus* spp., *Puntioplites falcifer* and *Sikukia gudgeri*) (FishNet unpub. data from FIS/2017/017).

This initial work was, deliberately, technically focused. The monitoring technology needed to measure fish pass effectiveness had never been used before in SE Asia, nor at a structure of this size. So, the methods needed to be validated (methods included microchipping and electrofishing). Secondly, efficiency trials had never been completed for such a diverse tropical ecosystem. Methods were therefore needed to be refined for a significant number of Mekong fish. Thirdly, the study represented the first time that fisher-independent data relating to fish passage at hydropower facilities had been generated in the Lower Mekong Basin. Therefore, the mechanisms to analyse and interpret such data needed to be developed. These were all achieved as part of FIS/2017/017, which concludes in June 2024. The project has significantly advanced knowledge generation to inform the development agenda. However, several knowledge gaps remain relating to technical aspects such as downstream fish passage, socio-economic aspects such as local fishers' livelihoods, and knowledge transfer aspects about how best to translate the results of the program work into improved policy outcomes, and whether the learnings can be practically applied at other hydropower sites.

What is the current stage of the development cycle?

The Mekong River Commission (MRC) coordinates a 'prior consultation' process under the Procedures for Notification, Prior Consultation and Agreement (PNPCA). This represents an opportunity for MRC Member Countries and other stakeholders to discuss and review benefits and risks of any water-use project proposed for the mainstream, which may have potential significant cross-border impacts on the Mekong River flow regimes, water quality and other environmental and socio-economic conditions (Table 1). This is a highly public, open and transparent process, by which developers submit their plans for hydropower projects and these then become subject to national and international scrutiny. The MRC has concluded prior consultations for five hydropower projects: Xayaburi, Don Sahong, Pak Beng, Pak Lay and Luang Prabang, and is carrying out the consultations for the Sanakham project (Table 1; Figure 1). The outcomes of these PNPCA processes were that the proposed fisheries mitigation strategies, as submitted, were likely to be insufficient and that the developers needed to work harder to identify sustainable solutions.

Xayaburi, Don Sahong and Luang Prabang altered their plans because of the PNPCA and proposed solutions that were otherwise untested in the region. Other developers (for Pak Lay and Pak Beng) are now actively working to amend their submissions in response to PNPCA feedback. The Mekong River Commission is subsequently seeking evidence and data to support these re-designs. The main point here is that there are few new hydropower plants currently under construction; most are in the design, or redesign phase. Those that are already operating have a significant opportunity to influence those about to be designed, or those that are being re-designed (Table 1).

Therefore, there is an extremely limited, but time bound, opportunity to influence the design of future hydropower projects provided that (a) evidence and learnings from existing sites, in terms of fisheries productivity and livelihood protection, can be disseminated; (b) proponents agree to share and incorporate data into new designs; and (c) the need to protect fisheries and livelihoods is accepted and actioned by developers.

Table 1. Expected completion dates for hydropower projects in the Lower Mekong.

Hydropower project	PNPCA date	Expected commissioning year	Installed capacity (MW)	Mean annual energy (GWh)	Height (m)	Crest length (m)	Max reservoir area (km^2)
Ban Kum	TBD	Beyond 2030	1,872	8,434	53	780	132.5
Latsua (Phou Ngoy)	TBD	Planned. COD Unknown.	800	3,504	22	1,300	13
Luang Prabang	2019	2030	1,200	6,500	57.5	318	72.4
Pak Beng	2018	2033	912	4,846	85	943	87
Pak Lay	2018	2032	1,320	720	35	630	108
Sanakham	2020	Planned. COD Unknown.	700	5,015	25	1,144	81
Santhong-Pakchom	TBD	Planned. COD Unknown.	1,079	5,052	55	1,200	80.3
Stung Treng	TBD	Planned. COD unknown.	980	4,870	22	10,884	211

Knowledge gaps in the 'sustainable hydropower' research for development framework

There is insufficient evidence available, in the public domain, or otherwise, for developers to adequately address PNPCA concerns (Mekong River Commission, 2022). There remains significant debate as to what the 'minimum' requirement would be to define a hydropower project as 'sustainable' and there is virtually no data/evidence publicly available, from existing sites, which demonstrate 'best practice standards'. The Mekong River Commission recently released the 'MRC Hydropower Mitigation Guidelines' (HMG) (MRC 2020), which steps through the key considerations for developers. However, the document lacks local evidence and examples in the guidance are largely from other regions (North and South America). In fact, the only data that currently exists regarding mitigating fish migration outcomes in the LMB has been solely generated by FIS/2017/017 at Xayaburi. Nonetheless, that project was limited in scope and identified several key knowledge gaps that require further investigation, and dissemination, in a 'research for development' sense. Indeed, that work, once disseminated will necessitate an update to the MRC document.

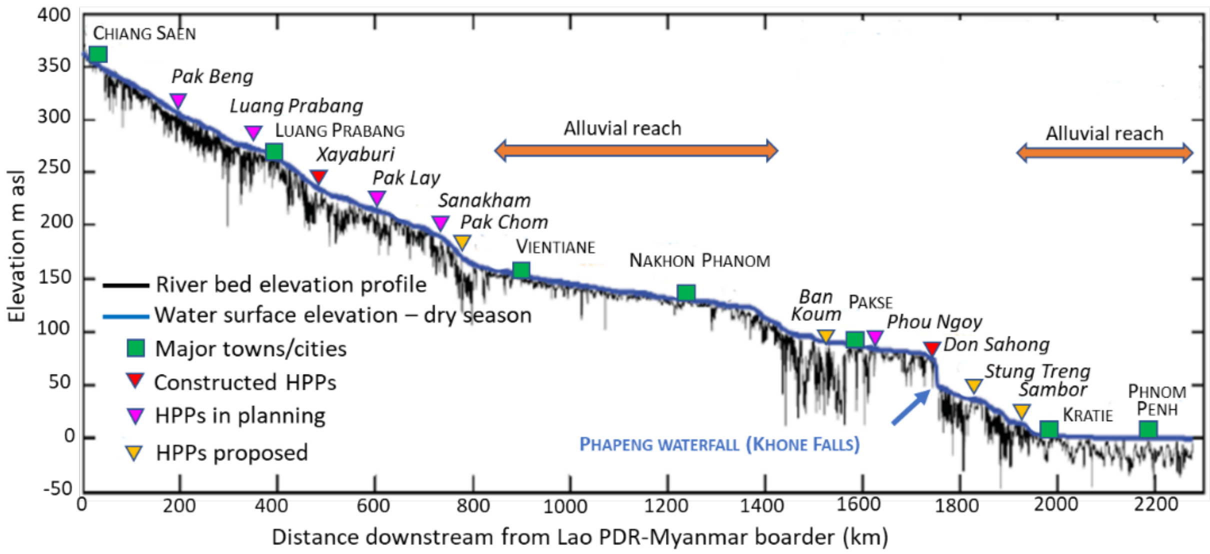

Figure 2. Cross section of hydropower construction along the Mekong River.

Progress so far

Following FIS/2017/017 a knowledge gap workshop was held, comprising of a team with developers, the Lao government, and Charles Sturt University academics. The workshop participants identified scalability of existing results, and any knowledge gaps that remained, to influence the policy and activities of other hydropower planners and developers in the region.

The co-design workshop revealed that:

- The Charles Sturt team is presently the only research group with established relationships, and an active program of fisheries-related work, at all existing mainstem hydropower projects (Don Sahong, Xayaburi and Luang Prabang).
- The team has long-standing (since 2007) and functional links with the Lao government (Ministry of Energy and Mines, Ministry of Agriculture and Forestry and National University of Laos). Additionally, the team actively works with major river development initiatives in association with the Mekong River Commission, the Asian Development Bank and the World Bank.

- The existing project (FIS/2017/017) successfully demonstrated new technology and established trust among partners.
- The existing project only focused on upstream fish pass effectiveness using a single technology at a single site.
- In a ‘research for development’ sense, there is still a need to understand:
  (a) whether the downstream fish passes are facilitating bi-directional fish movement and if upstream migrating fish are delayed (Knowledge Gap (KG) 1).
  (b) changes in river fisheries structure/yield following construction (KG1).
  (c) factors influencing migratory fish in the region, why fish are migrating, where they are migrating to, and the degree that fish pass facilities are assisting (KG1).
  (d) the long-term benefits of the existing facilities at Xayaburi in mitigating fish-related impacts and supporting livelihoods and food security (KG1).
  (e) what the criteria are for designing hydropower turbines that minimise adverse impacts on the passage of Mekong fish species (KG2).
  (f) how best to disseminate and translate the results of the program of ACIAR/DFAT work into improved policy and decision-making outcomes (KG3).
  (g) whether the learnings from Xayaburi hydropower project can be directly applied to other sites, such as the next hydropower plant (Luang Prabang) and others in Table 1 (KG3).

Consolidating the workshop outcomes into the new activity yielded the following focus areas linked to the requirements of the ACIAR project design brief:

<u>KG 1: Fish pass facility effectiveness.</u> The FIS/2017/017 assessment of the fish passage facilities at Xayaburi hydropower project focused entirely on the fish ladder itself and only on upstream migration. This was urgently needed and filled an important knowledge gap. However, this alone is insufficient to demonstrate that a hydropower project has mitigated its environmental impacts. For instance, there is a need to understand if migratory fish are delayed ‘outside’ the fish pass and cannot enter the fish pass at all. Fish also need to migrate downstream, but there have been no studies on downstream passage efficiency at any hydropower project site along the Mekong. There is, therefore, an urgent need to document whether fish can pass both upstream and downstream at Xayaburi. There is also a need to determine if fish approaching the hydropower project are delayed, or unable to locate the fish pass entrance at all. These questions are equally relevant to the next project scheduled for construction, Luang Prabang, and there remains significant international demand for this evidence to be generated. The data then needs to be transferred to other sites.

<u>KG 2: Turbine passage.</u> Understanding the principles of effective turbine passage is essential to ensure improved passage of fish in upstream and downstream directions. This pertains largely to issues associated with rapid pressure change, fluid shear and blade strike. There are techniques available to improve turbine design to minimise fish welfare issues whilst also protecting commercial outcomes. However, there is very little data upon which to base any design decisions for Mekong fish. This study will generate the first critical data needed to feed into future turbine design.

<u>KG 3: Designing effective dissemination pathways.</u> The information generated (in KG 1 and 2) on fisheries outcomes needs to be disseminated to the key actors in the most appropriate format (to be determined here in KG 3).

These knowledge gaps form the central concepts needed to close out an adaptive management theory of change. In this instance, an intervention has been designed and data has been gathered on its performance. Future interventions now need to be improved based on this information. So far, only limited information on KG1 has been generated by

FIS/2017/017. Therefore KG 1 and KG2, require urgent resolution to influence the next hydropower projects, which are scheduled for construction over the next seven years. Filling these essential knowledge gaps, and disseminating the data, remain the most significant barriers to the sustainable hydropower movement in the Lower Mekong Basin.

Novelty and timeliness of this research

There are presently no other efforts underway to address these research priorities in the Mekong region. All learnings from this research are novel, and crucial for providing a standard for fish pass construction and monitoring at other hydropower sites in the LMB. Plans to construct eight other mainstem projects on the Lower Mekong are at various stages of development. The next site, Luang Prabang, will be operational in seven years. Additional sites at Pak Beng and Pak Lay will follow and are presently progressing through concept design review. Each hydropower project will add cumulative impacts on migratory fish populations (Halls and Kshatriya 2009), but there is little to no practical understanding or anticipation of these compounded impacts in the region; in fact, the combined CSU and XPCL team is the custodian of the only practical dataset could realistically influence this agenda.

There remain critical knowledge gaps – across ecological management, policy influence and technical interventions – to achieve outcomes at a whole-of-region scale. Continuing the existing research program (from the ACIAR-DFAT co-funded FIS/2017/017 project) is required to assess the quantum and species mix of fish that are passing at fully operational hydropower sites, both up- and downstream. The ongoing fish monitoring will also allow for stock assessment and the detection of changes in community composition or abundance over the longer term associated with any potential far-reaching impacts. Furthermore, there is an increasing and immediate requirement to disseminate the data to a broader audience. This is urgently needed if sustainable practices are to be incorporated into future hydroelectric power development programs.

There is a time-limited opportunity to develop critical knowledge, which can be translated into actions at these new sites. The research outcomes from this proposal could positively influence development at the remaining sites, by building on a solid foundation of industry-relevant research, and an effective policy influence framework for decision makers.

1.3 Partner country and Australian research and development priorities

Country/regional priorities and commitments

Protecting migratory fish from hydropower infrastructure impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to international conservation advocacy groups. The overarching need for this work is largely driven by the 1995 Mekong Agreement, which explicitly requires Lower Mekong Basin countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). It is also driven by the commitment of the XPLC to set the standard for fish pass infrastructure design and fish pass monitoring in the region.

For hydropower projects in Lao PDR, the Lao government (through the Ministry of Natural Resources and Environment - MONRE, and the Ministry of Energy and Mines – MEM, and Ministry of Planning and Investment) enter into 30-year concession agreements with power companies. During this period, the company owns and operates the site, after which ownership transfers to the Government of Lao PDR.

Hydropower proponents are required, via approval processes led by MEM, to take substantial steps to minimise environmental impacts at the hydropower site, including providing successful passage for fish species. MEM is currently the only agency with an outward facing discussion with all proponents of mainstem hydropower projects. Their role in approving hydropower projects includes reviewing the design of the fish pass component. MEM officials recognise their engineers are not equipped to do this work and have sought to engage with FIS/2017/017, requesting that their staff are trained in sustainable fish pass techniques. The new project will bring MEM into the centre of its strategic partnership engagements, given their influence in effecting change in design in Lao PDR. At a recent co-design process with the project team and stakeholders, MEM officials identified that gaining access to critical skills and data is needed to make more informed choices when decision-makers are given consent for future projects.

Australian Development Objectives and/or Foreign Affairs Agenda

In line with DFAT's international development policy (DFAT 2023a), FIS/2023/013 will support local leadership by employing approaches that increase participation from local actors in all aspects of the project, including planning, design and implementation; and monitoring and evaluation.

DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (DFAT 2017; DFAT 2020a; DFAT 2020b; DFAT 2023a).

FIS/2023/133 is therefore directly related to DFAT's strategies for the four Lower Mekong countries. Hydropower development is the most significant water management issue in the Lower Mekong Basin. The Xayaburi hydropower project, being the first site, remains of particular interest and significance internationally.

Protecting migratory fish from hydropower impacts is a priority for all SE Asian countries with a hydropower development agenda, and is recognised by many foreign aid agencies. Our team members work with ACIAR on fishery-related research in Lao PDR (through active projects FIS/2006/183, FIS/2009/041, FIS/2012/100). Likewise, the recently completed CGIAR Challenge Program on Water and Food commissioned several projects on hydropower sustainability. In addition, the U.S. Agency for International Development (USAID) has an active program, which has identified fisheries sustainability as a priority area for SE Asian countries.

Until the mid-2010s, these programs were largely unilateral, focusing on individual countries, rather than taking a regional collaborative approach as will be the case in this project. USAID recently (in 2019) committed $US600,000 towards an initiative to extend fish passage outcomes (from ACIAR investments FIS/2006/183, FIS/2009/041, FIS/2012/100) to Vietnam, Cambodia and Myanmar. It was agreed that USAID funding would be used to progress initiatives in Cambodia and Vietnam until 2020.

FIS/2023/133 will be designed to ensure the DFAT Design and Monitoring, Evaluation and Learning Standards (DFAT 2023b) are met. A dedicated MEL expert will be engaged from Alinea International at the beginning of the program to assist with refining the program logic and preparing a MEL Plan, within 6 months of program mobilisation, as per the requirements for the DFAT Design and Monitoring, Evaluation and Learning Standards (DFAT 2023b). The MEL System will be fully operational within 12 months of program mobilisation, and baseline data will have been collected (using official data sets) to test the program logic (DFAT 2023b). The MEL expert will also manage all of the ongoing MEL reporting requirements for the remainder of the project. The project team (under the leadership of the MEL expert) will revisit and adapt the program logic continuously, to respond to any contextual changes and new knowledge.

Relevance to ACIAR 10-year strategy

Food security and poverty reduction

SE Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural people are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities.

Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in SE Asia because hard research data does not exist. This project will identify and bridge information gaps, drawing upon data from fishway projects across the region shaping more effective management strategies. Indeed, the knowledge generated from this project will be crucial for sustainably managing SE Asian fisheries in the face of increasing human development and changing climatic conditions.

Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. River development has negatively impacted inland fisheries. This project aims to redress this imbalance and develop win-win scientific solutions so modern river development projects support the sustainable production of fish, rice and energy.

Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. Research has found that women can occupy half of the harvest and post-harvest workforce, and selling fish can provide extra income and offset household needs, and provide extra nutrition with by-catch for the immediate family. This project will document this participation and champion the need to recognise the important role of women and girls in fisheries value chains benefitted by fishway construction (see Section 2.5).

Value chains and private sector engagement

Hydropower modernisation is generally the domain of developers under development bank, or investor, supervision and generally contracting local companies for construction, through local village coordination and then accepting final ownership. The sector is increasingly receptive to considering fish passage during planning and construction activities and is looking to external and private sector experts for assistance. But often solutions that are developed are sub-optimal and based on experiences from outside the LMB. The private sector also plays a key role in shaping government regional decisions and policies. This project will bring both private, developmental and governmental sectors together to recognise the value of fisheries resources and to determine how to maximise those resource returns in sympathy with future growth across the hydropower sector.

Building capacity (individual and institutional)[1]

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner with regional governments, multilateral development banks, regional agencies, and capacity building experts to equip these organisations with capacity to address fish migration challenges beyond the lifespan of the project.

1.4 Relationship to other ACIAR investments and other donor activities

Existing/previous ACIAR work on hydropower sustainability

This research follows on and extends a body of ACIAR research that has developed and tested techniques to assess the performance of the fish pass at Xayaburi – and, to an extent, other future mainstem hydropower projects in the LMB (ACIAR FIS/2017-016 and FIS/2017/017). It also addresses DFAT's Mekong Australia Partnership – Water Energy Climate (MAP-WEC) goal of strengthening the environmental resilience of countries in the Mekong subregion (Cambodia, Laos, Myanmar, Thailand, and Vietnam). FIS/2017/017 engaged with both technical and policy influence change pathways. The project progressed despite COVID-19, but there remains a significant challenge in providing a rigorous validation of the technical aspects of Mekong hydropower fish passes. There also remains a significant challenge to build local capacity in the design of fish pass infrastructure for environmentally sustainable hydropower and influencing decision making to adopt best practice sustainable fish pass technologies. Furthermore, significant research for development challenges remain, as the team in conjunction with management agencies in the Mekong need to find effective processes for translating research findings into improved decision-making, design and management practices.

We learnt in FIS/2017/017 that there is a need to develop strong evidence that the existing investment in fish passage has been successful for application at other sites to be considered. Second, the (FIS/2017/017) project only focused on upstream fish pass investigations. There remain significant gaps in terms of downstream migration, and, more broadly at the ecosystem scale. Third, the most appropriate dissemination and influencing mechanisms, for each key next user, are yet to be understood.

Further, this project adds to (1) SSS/2020/142, which explores the policy impact in Lao PDR and the transition from research to practice, and (2) the (almost finalised) impact evaluation work conducted by ACIAR on the 'Research-Policy Interface: Lessons from Lao PDR'.

Activities of other actors/donors

Substantial investments have been made by ACIAR, DFAT and XPCL in researching the required infrastructure to build effective fish passage systems and in developing new

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[1] relates to components to be funded by ACIAR's Capacity Building section under FIS/2018/153.

technologies to assess fish pass rates when the hydropower facility is operating. Now further research is needed to scale up and scale out the ecological learnings from the Xayaburi hydropower project site; as well as to better understand the cumulative impacts of the Xayaburi and Luang Prabang hydropower project sites on the livelihoods of local communities; and to translate the research outcomes from the Xayaburi and Luang Prabang hydropower project sites into policy. The main additional actors to be brought into this initiative are (a) Lao Ministry of Energy and Mines (as a central partner as opposed to a reference group member like they were in FIS/2017/017), and (b) other hydropower developers who are proposing. The Mekong River Commission is also charged with developing a regional 'Sustainable Hydropower Guidance' document and data generated by the team will be highly relevant to future iterations of that document.

FIS/2023/133 will strengthen the collaboration network established during FIS/2017/017. Critical to this process will be building on our existing collaborations with the Mekong River Commission and making strategic connections to hydropower developers relevant to other projects. The Mekong River Commission has already indicated that they are very motivated to see the outcomes of FIS/2017/017 translated and transferred to other projects. So, there can be an immediate suite of information transfer which can take place whilst other knowledge gaps are advanced.

2. Project Theory of Change (i.e. program logic)

2.1 Overview

Adaptive management is the most appropriate theory of change mechanism applying to 'sustainable hydropower' in the LMB. In this context, adaptive management is described as (Bunnefield, 2015):

"a structured, iterative process for making decisions in 'response to changes in context and new information that promotes intentional learning and minimizes the obstacles to modifying programs."

Relevant to the agenda 'Sustainable Hydropower', adaptive management is fundamentally dependent upon the injection of empirical knowledge and learning at critical phases of the project or programme cycle (Figure's 3 and 4). This would most notably occur during the design and planning phase (to ensure that plans reflect the environment in which they are located, that objectives are relevant and realistic, and that the proposed interventions are feasible and appropriate) and then subsequently during implementation to ensure that experience and lessons are captured and fed back into the next hydropower project, informing adjustments to implementation as required. With respect to fish pass criteria, results determined from FIS/2017/017 could now be, theoretically, directly applied to improve the criteria for fish pass design at the next site, Luang Prabang then the following one at Pak Beng; and so forth. In essence this is occurring, but is also straightforward, because the Luang Prabang hydropower project is owned by the same developer (Xayaburi Power Company Limited). The challenge is establishing dialogue with the other developers and transferring research findings to them in a manner which influences practice change. In this context, we define long term 'practice change' as when a developer proposes a hydropower project which contains a mitigation strategy that is most likely to pass fish, both upstream and downstream, with minimal (or no) impact on fish-dependent livelihoods. We suggest that the ability to do so requires:

(a) technical solutions which are based on robust evidence in the local context.
(b) knowledge of the solutions and how to apply them.
(c) a willingness to adopt, and invest in, the solutions.

(d) a commitment to monitor, evaluate, learn, and apply improved solutions to future situations.

Our Theory of Change (TOC) (Figure 8) approach outlines a specific process and approach to incorporate learning and information into new and ongoing hydropower development activities. In adaptive management frameworks, the TOC needs to be seen as dynamic, allowing stakeholders to review and adapt whenever there is new evidence, or when there are changes in the context that affect assumptions or hypothesized pathways of change. The hydropower agenda in the LMB is dynamic. It is influenced by changes in institutional leadership, investors, developers, ministerial portfolios, government priority setting, and international technology advancements among many factors. Therefore, should a theory of change have been developed in 1995, when the Mekong Agreement was signed, it would have needed revision, over the past 30 years, in response to changing regional and international priorities, technological changes and environmental changes (such as climate change). The TOC presented here reflects our current understanding of the sustainable hydropower development agenda but should be reviewed annually as the project progresses or whenever political, economic, social, technological, legal or environmental factors significantly change.

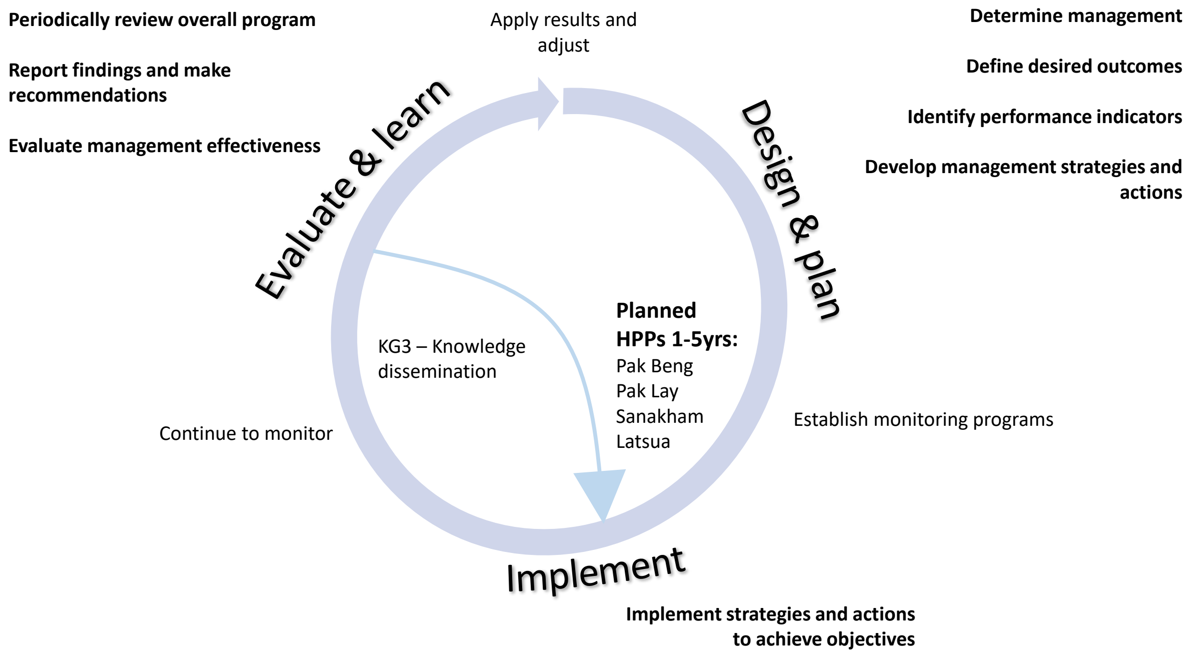

Figure 3. Theoretical adaptive management framework pathways relevant to sustainable hydropower in the LMB.

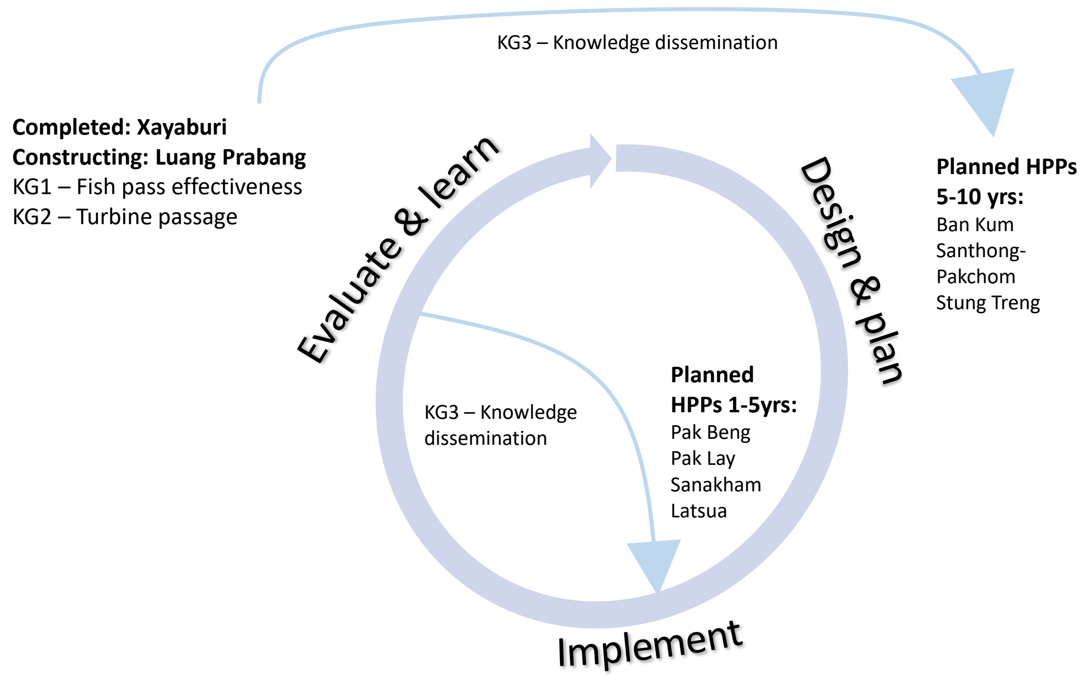

Figure 3. Theoretical adaptive management framework pathways considering the hydropower projects (HPPs) scheduled for design/construction commencement within the next five years (the term of this proposed project activity), with key knowledge gaps (KG's) shown as enablers into a 1-10 year impact pathway. Initially the focus will be on hydropower projects scheduled to commence in the next 1-5yrs; with knowledge dissemination required for hydropower projects on the 5-10 year horizon.

End-of-Project-Outcomes

The overall goal of the ACIAR Fisheries Program is ‘to improve fisheries ecosystem health under climate change. It takes a human rights-based approach to development and aims to improve the lives of aquatic resource-dependent rural people. It does this by investing in R4D that aims to improve the health of the aquatic ecosystems and resources that rural people depend upon’ (ACIAR Research Design Brief). FIS/2023/133 will contribute to the overall goal of the ACIAR Fisheries Program by achieving End-of-Project-Outcome’s (EoPO's) (Figure’s 7 and 8), which explicitly link identified knowledge gaps with hydropower project construction schedules in an adaptive management sense. The main focus here is research for development. This is time-bound as the ability to influence hydropower projects, until the sector enters the ‘development’ stage, is within the next five years.

Consistent with the goals of the ACIAR Fisheries program, our overarching development goal for this activity is: *‘To ensure that hydropower does not negatively impact fish and fish-dependent livelihoods’*.

To achieve that objective, there are two primary EOPO’s that the activity is targeting. The first one focuses on expanding the evidence base on technical solution effectiveness to inform the sustainable hydropower agenda. The second focuses on transferring, and translating, that evidence base into improved policy, decision making and implementation.

- EoPO 1: Central gov’t investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade
- EoPO 2: Technical staff in relevant government agencies and hydropower companies improve their use of design criteria, which foster fish friendly and inclusive hydropower development.

Links between the EoPO's

The technical fish passage research (EoPO 1) evidence will establish the evidence base that is needed to guide the design and planning for the remaining hydropower projects (but currently missing from the MRC PNPCA process). Absence of evidence is presently being propagated, by some developers, as a reason to proceed with sub-optimal technical solutions. Based on our learnings from FIS/2017/017, we already understand key knowledge gaps, what the next steps are to fill those gaps and who the evidence needs to be disseminated to, to facilitate policy and practice change to influence the adaptive management cycle. Therefore, EoPO 2 seeks to design and evaluate the performance of dissemination/policy framework to ensure that the evidence base (EoPO 1) is disseminated to the identified stakeholders. There are functional and structural links between the EoPO’s. The dissemination, policy adoption and capacity building frameworks will subsequently link to meet our overarching development objective of protecting fish-dependent livelihoods.

‘Impact pathways’ in the theory of change/program logic

The program logic will follow the sequence of undertaking ‘Foundational’ and subsequent ‘Influencing Activities’, to achieve ‘Immediate’ and successive ‘Intermediate Outcomes’ that eventually result in the ‘EoPO's’. These are summarised in Figure 8.

EoPO 1

The Foundational Activities for EoPO 1 will involve continuing the technical research at Xayaburi and Luang Prabang needed to implement solutions which maximise benefits to fisheries. These Foundational Activities will underpin the Influencing Activities of generating empirical evidence to support the inclusion of fish passage in hydropower developments, and disaggregating the fisheries data to allow analyses via a GEDSI twin-track approach. The Immediate Outcome will be that hydropower companies and investment decision makers in central government understand the design criteria needed to build, and the business case for investing in, fish friendly and inclusive hydropower. This should subsequently translate into the corresponding Intermediate Outcome. That is, hydropower companies and government investment decision maker criteria requiring hydropower developments to be fish friendly and inclusive.

EoPO 2

Foundational Activities for EoPO 2 will involve communicating the improved knowledge on the effectiveness of technical solutions to industry and government for incorporation into future development projects. Influencing activities will involve targeted education and dissemination through seminars, workshops, face-to-face meetings, conferences or more formal masterclasses or courses to support fish friendly and inclusive hydropower development. It is important that these activities are targeted towards key stakeholders. This will lead to the Immediate Outcomes of increased individual and institutional capacity to apply technical solutions while also ensuring that outcomes from EoPO 1 are socialised and made publicly available where appropriate. The subsequent Intermediate Outcome will be that individuals are capable of actively applying these outcomes to on-ground projects, and that developers and the MRC provide responsible and appropriate decision-making regarding hydropower sustainability.

The Foundational Activities, Influencing Activities, Immediate Outcomes and Intermediate Outcomes for each EoPO will be used as progress markers for these EoPO's.

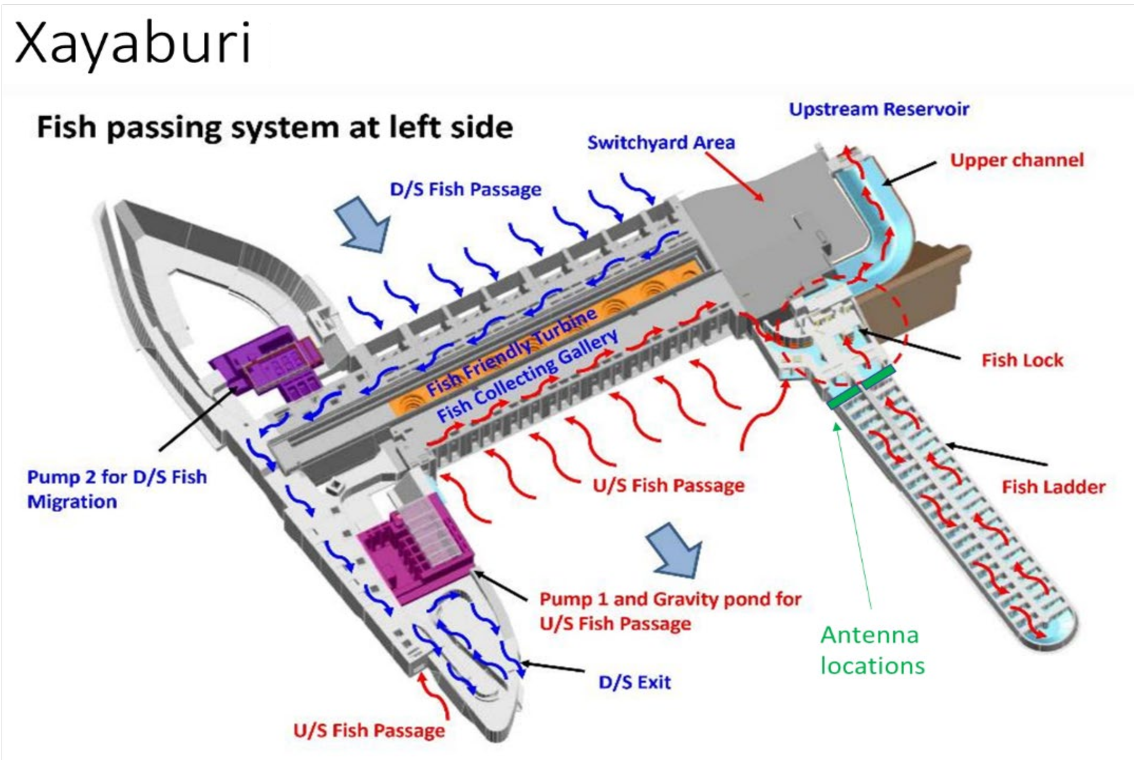

Figure 5. Schematic of the fish pass facilities at Xayaburi hydropower project (top) and an actual aerial photo of the site (bottom) (source: XPCL). In terms of technical data, FIS/2017/017 yielded excellent research data on the upstream fish pass. Matters of downstream migration, delay and turbine passage are still unresolved and are built into FIS/2023/133.

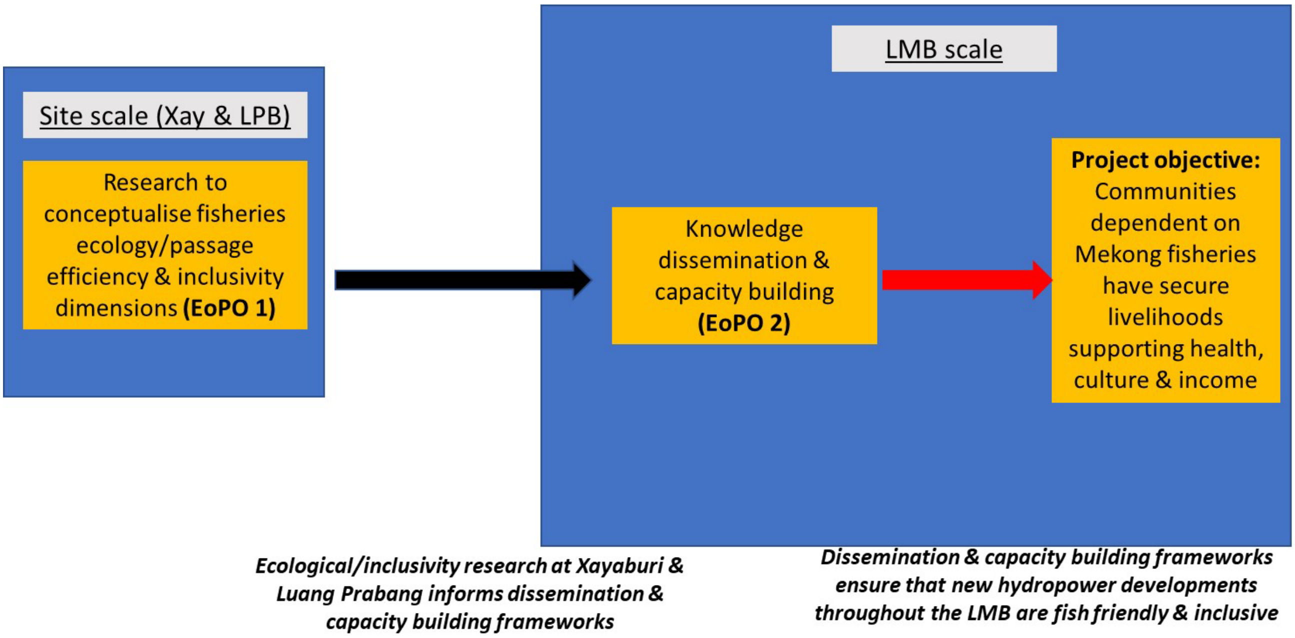

Figure 6. Functional links between EoPO's and the overall development outcome. The activities for EoPO 1 will be conducted at the site scale (at Xayaburi and Luang Prabang), but both project outcomes will transpire at the LMB scale.

Table 2. Impact pathways and functional links to EoPO's.

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
EoPO 1: Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade (linked to KG 1 and KG 2).	Access to XPCL and other facilities Fisheries researchers	Activity 1.1. Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions; and Activity 1.2. Research on fish friendly turbine design Activity 1.1.1. Collect data/evidence on fisheries mitigation measures from existing sites (KG 1 and 2) -Fish pass monitoring at Xayaburi hydropower project -Acoustic fish tracking at Xayaburi hydropower project -Downstream fish monitoring at Xayaburi hydropower project -Barotrauma and shear stress experiments to investigate the influence of downstream turbine passage on Mekong species -Baseline fisheries surveys and preliminary PIT tagging at Luang Prabang, using the electrofishing boat	Scientific data on fish pass effectiveness Scientific manuscripts and reports Policy briefs Meetings and workshops (and proceedings) Baseline fisheries data for Luang Prabang (i.e. the next proposed hydropower project site) Baseline data on best practice turbine design principles	Evidence base is developed Implemented the fish pass to enhance aquatic biodiversity and ecological sustainability Technical solutions have been internationally and independently assessed Benefits and challenges to inform policy decisions are highlighted	Increased knowledge base to facilitate the construction of effective fish passes at other hydropower sites The conservation of productive and diverse fisheries in the LMB Increased knowledge base to enable evidence-based policy formulation that improves lives and fish-dependent livelihoods in tandem with hydropower development

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
		commissioned for FIS/2017/017 -Angler surveys at Xayaburi and Luang Prabang to determine the harvest rates for developing a sustainable PIT tagging model Activity 1.1.2. Disaggregate the fisheries data & analyse via a GEDSI twin-track approach (KG 1 and 2)			
EoPO 2: Technical staff in relevant government agencies and hydropower companies improve their uptake of design criteria, which foster fish friendly & inclusive hydropower development (links KG 1 and KG 2 to KG 3).	Educators Development of curriculum / masterclasses Travel budgets Operational costs	Activity 2.1. Develop a knowledge management system for stakeholders identified in 3.1. Activity 2.2. Deliver capacity building activities Activity 2.2.1. Targeted communication activities and learning opportunities Activity 2.2.2. Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways Curriculum for improved hydropower knowledge within National University of Laos Curriculum Developed for a sustainable	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	Proposed and future hydropower projects have better technical solutions for fisheries sustainability Fisheries and fish-dependent livelihoods are not negatively impacted

EOPO	Inputs / Resources Needed	Activities	Outputs	Outcomes	Impact
			hydropower masterclass		

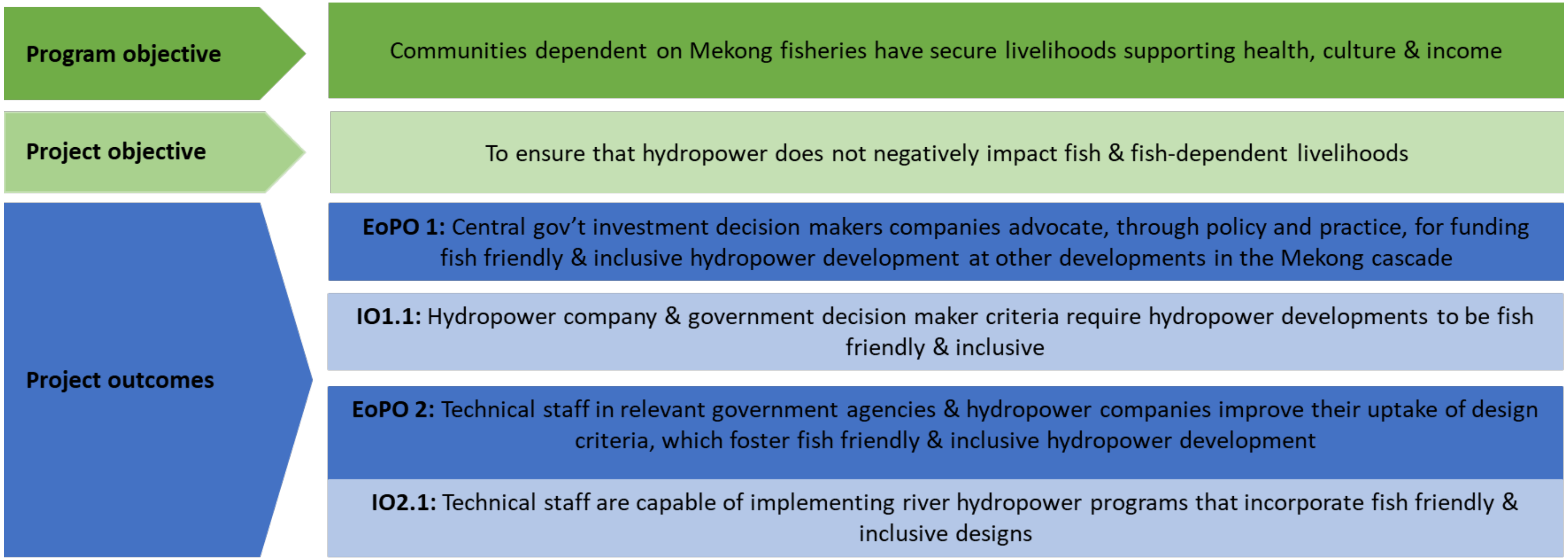

Figure 7. Conceptual overview of End-of-Project-Outcome's (EoPO's) and Intermediate Outcomes (IO's).

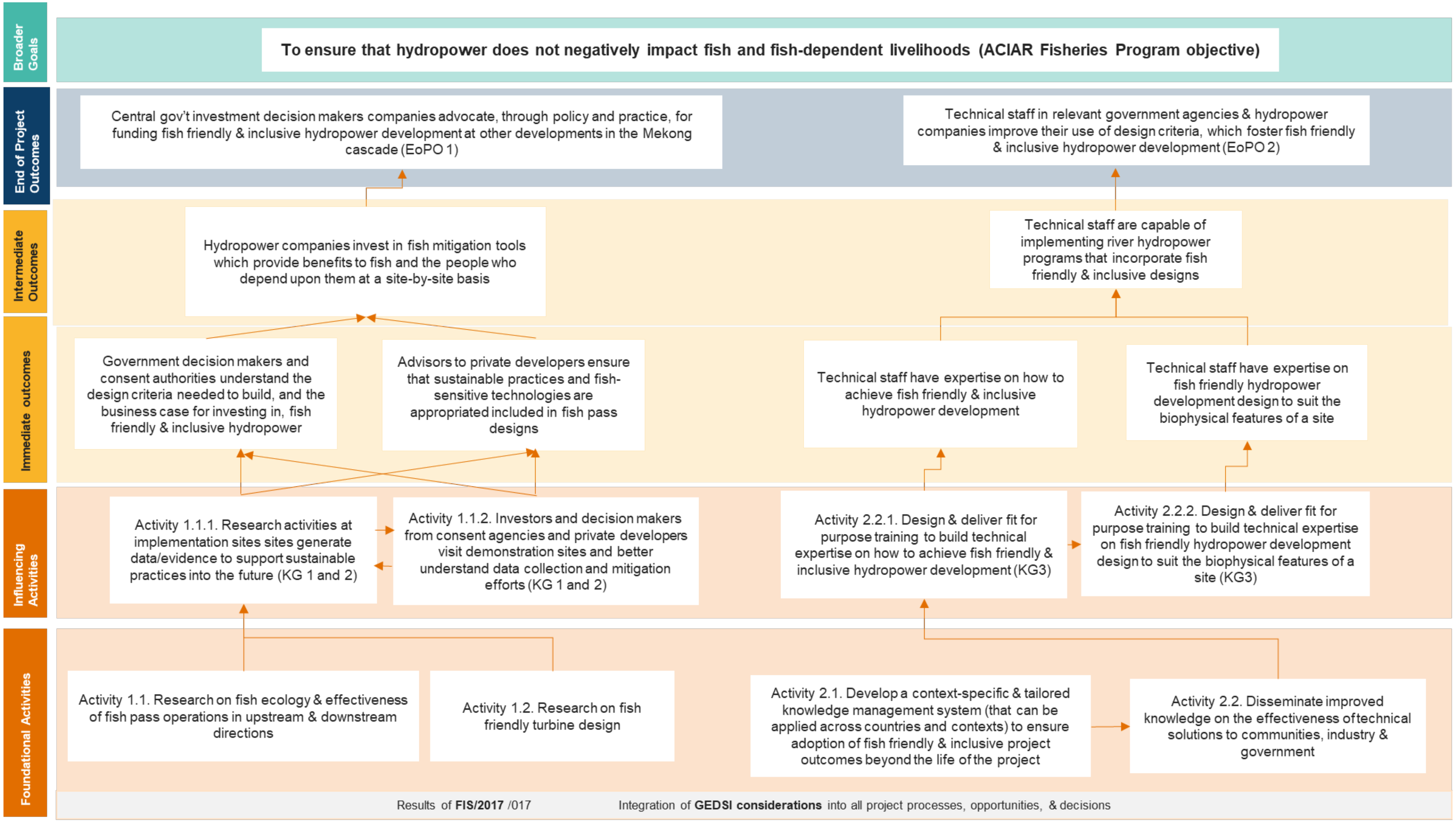

Figure 8. Program logic for FIS/2023/133, showing the impact pathways from the Foundational Acitivities to each End-of-Project-Outcome. Foundational Activities and Influencing Activities are detailed in section 2.6.

Key assumptions

Table 3. Key assumptions underpinning each activity.

EoPO	Activities	Assumptions
EoPO 1: Central gov't investment decision makers companies advocate, through policy and practice, for funding fish friendly & inclusive hydropower development at other developments in the Mekong cascade (linked to KG 1 and 2).	Activity 1.1. Research on fish pass operations in upstream & downstream directions; and Activity 1.2. Research on fish friendly turbine design Activity 1.1.1. Collect data/evidence on fisheries mitigation measures from existing sites (KG 1 and 2) -Fish pass monitoring at Xayaburi hydropower project -Acoustic fish tracking at Xayaburi hydropower project -Downstream fish monitoring at Xayaburi hydropower project -Barotrauma and shear experiments to investigate aspects of improved turbine design -Baseline fisheries surveys and preliminary PIT tagging at Luang Prabang, using the electrofishing boat commissioned during FIS/2017/017 -Angler surveys at Xayaburi and Luang Prabang to determine the harvest rates for developing a sustainable PIT tagging model Activity 1.1.2. Disaggregate the fisheries data & analyse via a GEDSI twin-track approach (KG 1 and 2)	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained Barotrauma units able to be constructed Global supply chains sufficient to facilitate delivery to Lao PDR
EoPO 2: Technical staff in relevant government agencies & hydropower companies improve their use of design criteria, which foster fish friendly & inclusive hydropower development (links KG 1 and 2 to KG 3).	Activity 2.1. Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of fish friendly & inclusive project outcomes beyond the life of the project Activity 2.2. Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government -Deliver capacity building through university curriculum and masterclasses Activity 2.2.1. Design & deliver fit for purpose training to build technical expertise on how to	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments

	achieve fish friendly & inclusive hydropower development (KG3) -Targeted communication activities and learning Activity 2.2.2. Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG3) -Policy brief development -Update to MRC guidance document -Research dissemination think tanks / dissemination events	

Time horizon

The team anticipate this being a 10-year program of work; but with the most urgent need to influence developers between 2023 and 2029. We will apply a theory of change framework (Olsen, 2003; UNEP/GPA, 2006) that can guide project governance and management responses based on sound research and improved capacity, and provide a pathway for change, through the uptake of knowledge and technologies. This framework will set out four ‘orders’ of outcomes (over a 10-year period) in the fishway program responses to changing societal, economic and environmental conditions, leading to the ultimate long-term goal of sustainable forms of energy development.

The first order outcomes (1–4 years) will involve the creation of the enabling conditions for a fish passage governance/policy initiative by linking key stakeholders, performing key research, and policy advances. This will be completely evidence-based. The team will complete the technical investigations at Xayaburi, preliminary investigations at Luang Prabang, and develop a resource base for dissemination to other developers involved with Pak Beng, Pay Lay, Sanakham and Latsua.

The second order outcomes (2–6 years) will involve changed behaviour of resource users and key institutions based on uptake of research outcomes. We will be specifically targeting the hydropower projects, which have been through PNPCA but have been required to make changes to their designs to meet sustainability guidelines (like the MRC’s Hydropower Mitigation Guidelines (MRC 2020)).

The third order outcomes (4–10 years) will involve an increasing adoption of fish-friendly practices, aimed at livelihood protection, at other sites in the Mekong. These will focus on the hydropower projects with a longer time horizon for design and construction (Ban Kum, Santhong-Pakchom and Stung Treng).

The fourth order outcomes (1–10 years) will lead to a more sustainable and resilient inland capture fishery, with fisheries and livelihood considerations being integrated into new and existing infrastructure projects; and any future projects that may be considered.

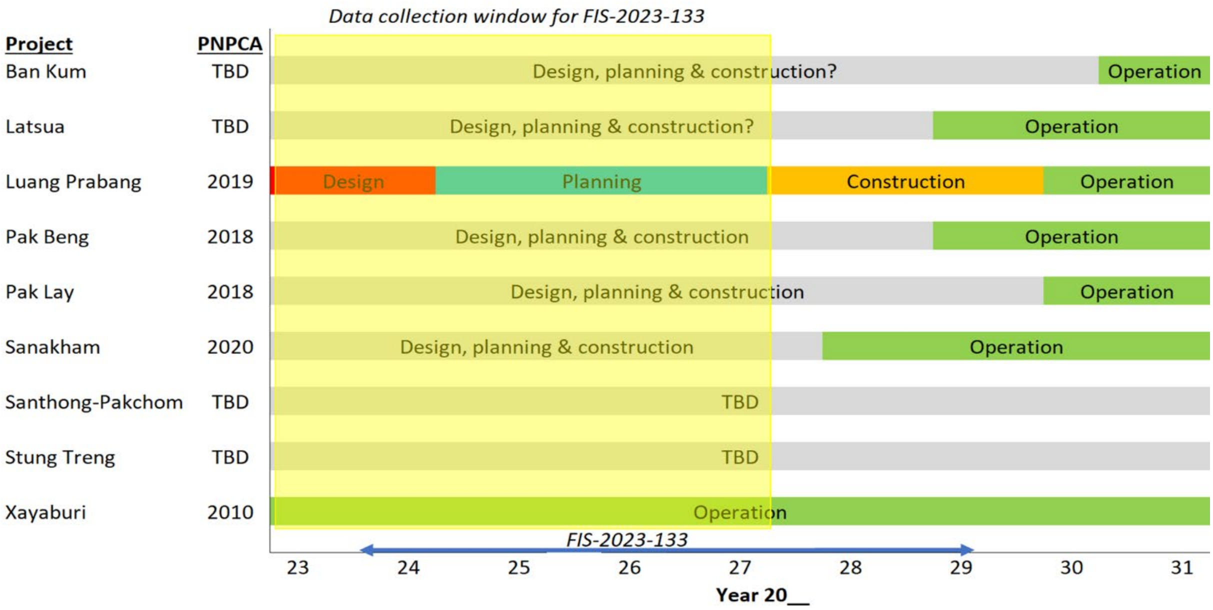

Figure 9. Construction timelines for the nine hydropower sites being built. There is a significant, time-bound opportunity to drive sustainable outcomes if research can be disseminated to the correct stakeholders. NB: Latsua was re-named Phou Ngoy and sometimes the names are used interchangeably.

2.2 Research strategy

2.2.1 Research questions

Question: What are the criteria for fish pass and hydropower turbine facilities to facilitate fish passage at hydropower sites on the Mekong River? (EoPO 1; KG 1 and 2).

Question: How can we apply these criteria to better mitigate the expected cumulative effects of multiple hydropower projects on fisheries migratory ecology? (EoPO 1; KG 1 and 2).

Question: Can we improve the uptake of these criteria into new hydropower projects through targeted in-country individual and institutional capacity building and dissemination programs? (EoPO 2; KG 3).

2.2.2 Addressing research questions

EoPO 1 Research to conceptualise the fish ecology, and passage effectiveness of the fish pass and hydropower turbine designs (technical research)

Specific design parameters were incorporated into the Xayaburi hydropower project design to provide passage for fish through the hydropower site. The fish pass design was engineered to allow the upstream passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter upstream passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) (Table 4) for different seasonal flows and migration patterns.

For upstream migration, the engineering includes a complex fishway system (Figure 10). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Figure 10),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Figure 10),
(c) they then enter a large fish pass facility (left-bank facilities, Figure 10) and
(d) then proceed through a locking system into the weir pool (orange shading, Figure 10); or
(e) alternatively, they can move through the navigation lock.

It is important that fish can successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the hydropower project
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

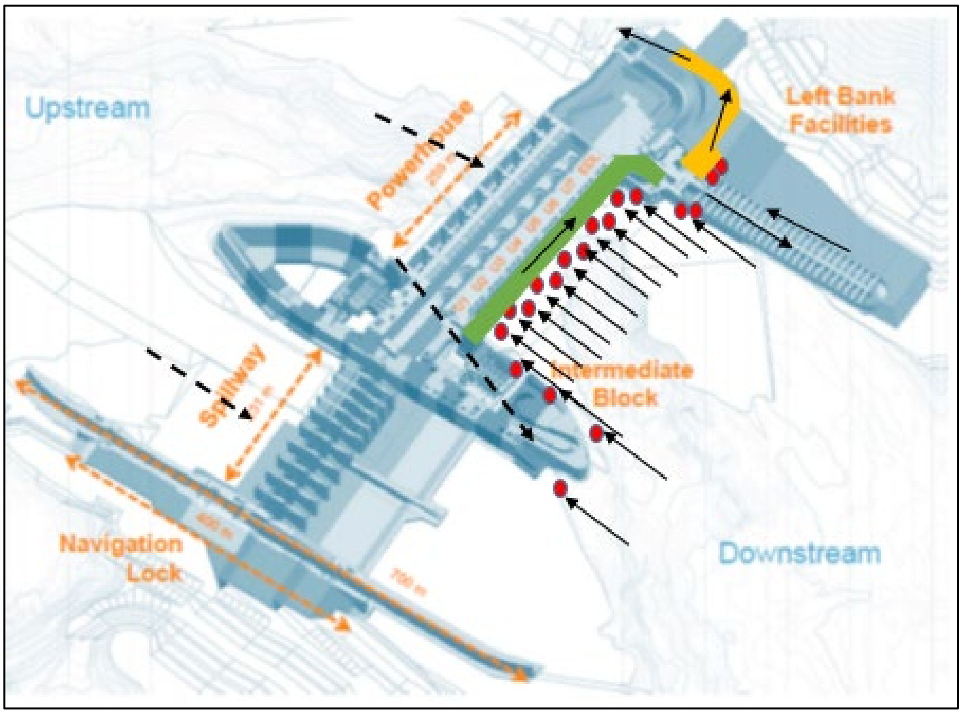

Figure 10. Plan view of facilities at Xayaburi hydropower project. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green, and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

Table 4. List of migratory species found at the Xayaburi site which may be PIT tagged. These are migratory species that were selected for tagging on the basis that they are (1) important for supporting nutrition and/or livelihoods; and/or (2) of conservation significance. Individuals are typically caught using the boat electrofishing method that has been developed and verified during FIS/2017/017. This involves inspecting each individual to ensure that is healthy before re-releasing it to the river. Green-shaded months are based on data from TEAM Consulting and yellow-shaded months are from observations of XPCL fish catch in navigation locks. The list is not definitive.

species	local name	month											
		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Cyclocheilichthys enoplos	Pa Joke												
Cyclocheilichthys repasson	Pa Joke-sai												
Henicorhynchus lobatus	Pa Sroi												
Labeo chrysophekadion	Pa Pia												
Hemibagrus nemurus	Pa Kod												
Mekongina erythospila	Pa Sa-ee												
Sikukia gudgeri	Pa Mang												
Chitala sp.	Pa Tong												
Pangasius macronema	Pa Yorn												
Hemisilurus mekongensis	Pa Dangdaeng												
Phalacronotus apogon	Pa Sa-ngua												
Bagarius suchus	Pa Khae												
Paralaubuca typus	Pa Teab												
Tenulosa thibaudeaui	Pa Mak-pang												
Pangasianodon hypophthalmus	Pa Sway												
Cyprinus carpio carpio	Pa Nai												
Yasuhikotia modesta	Pa Kiaw-Gai												
Macrochirichthys macrochirus	Pa Fak-pa												
Pristolepis fasciata	Pa Chang-yeab												
Pangasius bocourti	Pa Phor												
Pangasius conchophilus	Pa Mong												
Pangasius larnaudii	Pa Thay-po												
Phalacronnotus bleekeri	Pa Sa-ngua												
Wallago attu	Pa Kaow												
Hemibagrus filamentus	Pa Kod-rueng												
Pangasianodon gigas	Pa Buek												

Terms of reference / research questions

A team of Australian, Lao and US fisheries scientists (fish experts) in collaboration with XPCL scoped several key research questions to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags, barotrauma and shear experiments, sensorfish

Turbine design

Research questions	Potential research methods
Question 1 - What are the pressure thresholds for Mekong species?	Targeted barotrauma experiments in specially-designed chambers
Question 2 - What are the shear stress thresholds for Mekong species?	Targeted shear stress experiments in a specially-designed flume
Question 3 - What is the likelihood of blade strike for Mekong species?	Mathematical modelling based on combining Q1 and Q2 with existing models.

Request from XPCL: FIS/2017/017

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was initially requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, was beyond the scope of the available budget so the ACIAR/DFAT team only focused on methods to assess upstream fish passage using PIT systems for FIS/2017/017.

Consequently, the initial research questions posed were:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi hydropower project?

Q2 – Do migratory fish species pass upstream, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for assessments be developed based on the methods we are trialling?

The result of this was that so far there has been no attempt to address the research questions regarding downstream passage, nor about what fish are approaching the dam in either direction. These questions are extremely important, both at Xayaburi and Luang Prabang, and the other hydropower projects under design and planning; and FIS/2023/133 will seek to progress.

PIT tag systems (extension of FIS/2017/017)

The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23 mm or 12 mm long; half or full duplex), which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage, which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date, or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hours a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems were assessed as part of FIS/2017/017 and have proven to be an effective method for assessing upstream fish pass effectiveness. The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It now provides a complete system, which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi hydropower project can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a webpage. Ensuring a standard tagging system is installed at multiple sites will guarantee that fish tagged in other parts of the LMB, can be detected anywhere. The system is online, active and contributing usable data. The team are tracking 4,500 fish so far (but the target was 10,000 to provide statistically meaningful results). The team will continue the existing work and build a longitudinal dataset on fish migration and fish pass efficiency. This data will be directly transferrable to other sites and, if other developers adopt and install this technology, would be the main mechanism for monitoring fish movements once (if) the hydropower cascade is completed. It will provide the largest and most comprehensive transboundary dataset on fish migration in the entire Mekong.

Rationale

FIS/2017/017 provided: (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi hydropower project is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study, the project team were tasked with using PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations, which are all being applied to the work at Xayaburi. So, the team are starting from a strong knowledge and experience base. Our aim is to achieve an increase percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Undertake large-scale tagging to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, we will continue to capture fish downstream of the Xayaburi hydropower project structure as they approach. We will also start a preliminary PIT tagging program at the Luang Prabang site (i.e. the site of the next hydropower project), using the electrofishing boat commissioned for FIS/2017/017. The team is striving to tag approximately 2,000 fish annually at each site. These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate (return rate = percentage of detected fish relative to tagged and released fish). We can make good inferences on passage success rates, with good statistical power for any species where we detect more than 100 fish annually. Because, inevitably, some fish will migrate, shed tags, die or be harvested, there will be a need to tag new fish in every year to maintain a sufficient sized pool of tagged fish. The team will use a model that was developed for FIS/2017/017, to estimate the number of fish that need to be tagged every year to maintain target populations of tagged fish. The model will, however, be enhanced by the addition of a tag harvest program as part of the next project, and tailoring it for specific species.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL operators.

Stage 3. Monitor fish movements through the Xayaburi fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output of mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged) will be plotted per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases to determine if there are flow-related patterns that could be influenced by operations.

Repeat movements: Xayaburi hydropower project includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating efficiently.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to operations, optimization of fish pass operation and XPCL fish passage efficiency reporting requirements back to the government of Laos. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power. This will be achieved by further developing long-term PIT tagging requirement models for key species.

Stage 5: Publication and reporting to other developers and the MRC. Including further development of the MRC hydropower guidance document.

Acoustic systems

<u>*Rationale*</u>

PIT systems will only be suitable for documenting upstream migration rates through the fish pass. Acoustic systems are more flexible than PIT systems in that their listening stations can detect tagged fish from much further away, and do not require a narrow channel to steer the fish past the detection (antenna) system. Nonetheless, they are more expensive than PIT systems, require more maintenance (e.g. they require a battery unlike PIT systems – which do not), and are constrained by the landscapes in which they can be deployed.

Activities

Acoustic systems will be used either instead of (or in conjunction with) PIT tag systems to determine: (a) what fish species and proportion of tagged individuals are approaching (for both up-and downstream passage), (b) what influences which route is taken (spillway, fish collector or turbines), (c) what is the overall upstream and downstream passage efficiency - the percentage of approaching fish that successfully migrate past (includes whether or not they find the fish pass facility AND whether they then ascend or descend successfully), (d) whether there is migratory delay downstream of the structure, or (e) whether fish survive downstream migration in general.

Sensor Fish and turbine passage

Rationale

Sensor Fish are robotic data logging fish that can assess the hydraulic conditions fish may potentially be exposed to while passing through hydropower turbines. A series of Sensor Fish instructional movies were developed as part of FIS/2017/017 by the team during the COVID-19 pandemic, and shared with the in-country project partners. The in-country staff were then later given face-to-face training on the use of Sensor Fish at Xayaburi hydropower project in October 2022, once XPCL eased their COVID-site access restrictions. The training was provided Dr Daniel Deng (a Pacific Northwest National Laboratory (PNNL) engineer who developed the Sensor Fish) and the CSU team. The in-country staff then assisted in undertaking actual trials with dummy Sensor Fish to apply their learnings.

Activities

Sensor Fish trials will be undertaken to further empirically quantify the hydraulic conditions associated with the hydropower turbines to add a range of approach conditions (fish swimming depth) to the initial trials. Turbine-specific pressure change results will be simulated in laboratory conditions, using a barotrauma chamber, to examine the impact of turbine-related pressure changes on fish survival. These comprehensive experiments will include several target Mekong species and at various life stages. The Sensor Fish data will also be used to model the impacts of turbine-related blade strike on fish survival. The information provided by the Sensor Fish will therefore enable us to validate the 'fish-friendliness' of the hydropower turbines and their associated hydraulic conditions. We will compare the measurements of the hydraulic situation to 'dose rate' information from actual Mekong River fish. Linking these together gives an overall indication of survival rates through turbines.

Furthermore, there are no data yet documented for fish using the other downstream passage routes including: the downstream fish passage channel, the spillway, and the navigation lock. We will use the Sensor Fish technology and actual fish to assess the stresses faced by fish in those routes, including barometric trauma (and rapid decompression in particular), impact trauma and fluid shear stress, which are all important factors that potentially affect downstream migrating fish survival.

A hyperbaric chamber (barotrauma chamber) will be used to simulate and define the critical tolerances of key Mekong species to rapid decompression impacts associated with passing downstream through hydropower turbines. We will refurbish a laboratory-based hyperbaric chamber owned by NUoL (constructed as part of MK15 through the Challenge Program for Food and Water) and also have a new chamber made so that we can perform the required number of replicates. Rapid decompression can cause a fish's swim bladder — a pocket of air inside a fish that is used to control their buoyancy — to rapidly expand and has been known to cause injuries and mortality.

Figure 11. The hyperbaric chamber that may be refurbished and used to undertake barotrauma experiments, for better understanding potential turbine-related impacts on Mekong fish species undertaking downstream fish passage. We will also have a new one made so that we can perform the required number of replicates.

The hyperbaric chamber experiments will focus on the key species and life stages first. Fish will be collected on site from the Mekong River using the electrofishing boat and held at the Xayaburi fish holding facility. Prior to testing, the fish will be acclimated to surface pressure (where ~101 kPa indicates surface pressure and 0 kPa indicates vapour pressure) (Boys et al. 2016). They will then be rapidly decompressed from this pressure to one of ten discrete nadir (lowest) pressures (outside of those expected from the Xayaburi turbines). This will allow us to examine the impacts of rapid decompression over a range of discrete ratios of pressure change (RPC; i.e. exposure pressure ÷ acclimation pressure; as per Boys et al. 2016), so that a full injury/mortality dose rate curve can be developed. It will then be possible to apply the findings to any scenario that becomes of interest. The focal experimental pressures will be based on those measured by the Sensor Fish from being passed through the Xayaburi turbines. For the analyses, the percentage of individuals injured or dead within a test group of fish will be treated as the dependent variable, and regressions will be undertaken to determine whether the total mortality rate is influenced by RPC (as per Boys et al. 2016).

Fish surveys and sustainable PIT tagging models

Rationale

As previously mentioned, with the exception of that collected during FIS/2017/017, there are currently no empirical data on the fish population and community dynamics at the Xayaburi and planned Laung Prabang hydropower project sites to use as a reference point for assessing future potential changes against. Nonetheless, now is the prime opportunity to gain fish population and community dynamics at the Laung Prabang hydropower project site before the facility is constructed.

Furthermore the long-term PIT tagging programs at the Xayaburi and planned Luang Prabang hydropower project sites will need to be informed by robust quantitative knowledge of the long-term PIT tagging requirements to maintain statistically viable PIT tagged populations of the key species. A preliminary sustainable PIT tagging model was developed during FIS/2017/017 to estimate the annual number of fish needing to be PIT tagged to maintain the PIT tagged fish populations in the wild. However, it is currently only a prototype based on a combination of anecdotal information, expert opinion and/or literature for related fish species (where such literature is available). Consequently, the model is still only indicative and not species-specific. It needs to be tailored for each key species by obtaining species-specific empirical data on key factors such as fish harvest by anglers.

Activities

Background fish population and community dynamics will be systematically assessed up- and downstream of both the Xayaburi and planned Luang Prabang hydropower projects using the XPCL electrofishing boat. The sampling will be spatially and temporally replicated using standardised boat electrofishing methods at both sites. The fish sampled during these surveys will also be PIT tagged, and therefore become part of the PIT tagged populations.

An external tag return program will run in conjunction with surveys of fishers living up- and downstream of the Xayaburi and planned Luang Prabang hydropower project sites. The surveys and tag return program will allow estimation of harvest rates of the key fish species at each site. Harvest rates will then be used for populating the species-specific sustainable PIT tagging models. These angler survey data will also complement the boat electrofishing survey data at each site, by providing another perspective for understanding the changes in the background fish population and community dynamics.

EoPO 2: Capacity building

Rationale

Sustainable hydropower is quite a technical field. It is very difficult to explain concepts using theoretical means, and it is far more effective involving staff in on-ground research in a ‘learning by doing’ environment. Consequently, we will formally interrogate our existing knowledge of the key stakeholders associated with hydropower projects (developed during FIS/2017/017) to yield a list of key capacity requirements of these key stakeholders. These key requirements will underpin targeted capacity building activities implemented through a capacity building through research (CBTR) approach. We need to ensure that the technical data (EoPO 1) is transferred to the most appropriate and influential stakeholders through targeted communication and extension activities and capacity building (EoPO 2).

Approach

We envisage this may comprise three levels of training:

1. **Formally recognised international courses.** In preparation for this project, Charles Sturt University has approved, for entry from second semester 2020, a Graduate Certificate in Fisheries Conservation. This has been developed as an in-kind contribution and will be specifically targeted as a training opportunity for international

staff from developing countries. The course comprises two core subjects (BIO 403 – Fisheries Conservation and BIO 405 – Fish Movement and Management). Fish movement and management (BIO 405) has been based on course material which was developed as part of FIS/2014/041 – Crawford Fund Masterclass in Fish Passage Engineering (Baumgartner et al. 2019). The course has been designed to comprise four subjects with intensive residential schools, meaning it can be taken 6 months full time (four subjects per semester), or 12 months part time (two subjects per semester). The curriculum for this course is flexible and bespoke. The content could be adjusted for a hydropower-focused cohort. We will enrol key staff, from each partner country, into this course to facilitate training and development over the course of the next four years. It will be impossible to export significant numbers of students for overseas training in Australia. So, this training will focus on university academics and mid-high-level officials based within fisheries and energy departments, with adequate English skills and Bachelor-level training. The focus will be on training graduates with potential to be future decision and policy makers.

2. **Targeted and specific short courses.** A key outcome from previous ACIAR investments (FIS/2014/041) was to develop a masterclass in 'Fish Passage Engineering'. The course is focused on in-country learning. It is targeted at in-country fisheries and engineering staff (at the federal, district and provincial level). It is taught by a series of international experts in fish passage and has a practical focus. Each student works in a team equally comprised of engineers and fish biologists and over the course of four days, they are required to develop a working concept for a fish pass at a real-world structure. They then develop a research and monitoring program to measure success. The course has been delivered in both Bangkok (to 60 high level professionals from all Mekong countries) and in Myanmar (to federal, district and provincial level staff). The outcomes of these courses have led to on-ground fish passage implementation in a range of Lower Mekong countries, including Myanmar, Lao PDR, Thailand and Cambodia. An outcome of the co-design workshop was to establish a 'Sustainable Hydropower' masterclass, which could focus on optimising fisheries solutions.
3. **National University of Laos Curriculum Improvement.** A key discussion point at the co-design workshop was that the existing course offerings at the National university of Laos (the major education institution in Lao PDR) does not have any subject offerings for hydropower nor sustainable hydropower. The Lao government officials suggested that this would be a useful focus of any extended project to ensure that future generations of managers and technical staff seeking an interest in the hydropower industry would be able to gain a grounding in based concepts relevant to sustainability in the industry.

<u>Analysis</u>

The research aspect of this component is important as we need to ensure the training is relevant and effective. There are existing frameworks in place to track career trajectories of Alumni following training activities. For (1) and (2) we will apply a system analogous to the Australia Award Alumni Tracer Facility. The Australia Award Tracer performs annual research which:

- conducts an Annual Survey, with online and telephone collection of the views and experiences of Alumni from a range of countries;

- identifies a series of case-studies, involving in-depth interviews with Alumni, employers and other stakeholders;
- collects and updates contact information for Alumni.

For the duration of our project, we will maintain contact with training Alumni and investigate benefits that have accrued. We will hold annual structured surveys which focus on understanding elements like (i) retention of technical information, (ii) technical involvement in development bank projects which have incorporated fish passage, (iii) development of new projects incorporating fish passage, and (iv) extension of training outcomes to other staff and a qualitative assessment of benefits. We will also poll graduates on the learning outcomes to ensure that the course remains fit-for-purpose and industry relevant. Key success (and failure) stories will be highlighted as case studies in our annual and final reporting processes.

Additional approaches for communicating knowledge

Knowledge generated from the project will also be communicated using a suite of approaches, beyond the formal training activities described above. This will include:

- Meetings: Face-to-face and online, including Reference Panel meetings, and annual and quarterly project meetings.
- Communication and extension activities targeted towards end users: Training and promotional videos distributed via YouTube.
- Hands-on training of fisheries scientists, managers and students in Asia and Australia: hands-on training provided to students, interns and volunteers.
- Scientific publications
- Conference presentations and other extension activities: Presentations at international and regional scientific conferences, and project display booths at these conferences.
- Other media: Interviews with TV and radio stations, and articles in media like The Conversation and Catch and Culture.

2.3 Gender & Social Inclusion Strategy

Consideration of gender within affected communities

The construction and operation of the Xayaburi Hydroelectric Power Plant have directly affected 15 villages located on both sides of the Mekong Riverbank in Xayaburi and Luang Prabang provinces. Seven of these villages have required relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) by XPCL required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects, and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP must enhance the quality of life for the project-affected people (PAPs) and minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Taking a twin-track approach to GEDSI

Development practice acknowledges that GEDSI strategies are more effective when they adopt a 'twin-track' approach (DFAT 2016). This means progressing opportunities for <u>mainstreaming</u> consideration of GEDSI across all components of a project, alongside <u>targeted</u> GEDSI activities that concentrate resources and seek new knowledge to address the underlying causes of exclusion or disparities. Targeted interventions typically generate analysis and evidence, and new partnerships and networks that can benefit the overall project. ACIAR and DFAT recommend a twin-track approach in their GEDSI policy guidance.

The proposed project will incorporate GEDSI considerations right from the outset of its design phase, and align with the ACIAR 'Gender Equity and Social Inclusion (GESI) Strategy and Action Plan 2022–2027'.

In particular, the proposed project team recognises that although women are highly active in fishing and marketing activities, engineering, and to a lesser extent fisheries management, are traditionally male-dominated fields (noting that this is a global trend and not just within SE Asia). Yet, women who often catch fish are the ones who prepare the fish for domestic consumption and to sell at the market. Training on safe fish handling for these objectives could enhance the nutritional quality and commercial price of the fish, while lowering the likelihood of food poisoning or unnecessary wastage.

The FIS/2023/133 team will enhance opportunities for women by:

- endeavouring to ensure equal participation of men/women in project meetings and discussions (including representative groups)
- engaging women-only training events for existing experts and students, which will be conceived in collaboration with line-agencies
- incorporating gender sensitive analysis and training into the project (especially SNA and village surveys) to ensure that the roles of both men and women are captured, and by allowing the space for both men and women to make appropriate, informed and targeted policies through gender appropriate activities
- seeking to increase the participation of women in strategic decision-making roles shaping governance and policy development.

These actions will be crucial in gathering equitable, diverse and inclusive input from both women and men, and ultimately in achieving sustainable project outcomes. It is pivotal that this knowledge is used to inform policies and strategies moving forward.

The project team has been actively working in Lao PDR for over fifteen years. Therefore, the gender inclusion strategy is largely derived from (a) our lived experience working and living in the region, (b) outcomes of structured interviews convened in association with existing projects, and (c) feedback on our proposal from reviewers. The team has also been investigating broader elements of inclusivity by including disability groups.

There are high incidences of unexploded ordnance injuries in the Lower Mekong Basin, and disability groups have been established to better-cater for the needs of impacted people. Our initial stakeholder mapping activities have identified a number of these groups that we will need to involve in the co-design process.

Nonetheless, our team has recruited a highly qualified GEDSI specialist from Alinea International, who will guide incorporation of these additional initiatives to ensure GEDSI is integrated into all levels of activity implementation. The GEDSI specialist (Mia Urbano) has already been recruited for the FishTech (FIS/2018/153) initiative, and has been helping the project team develop and endorse principles to make explicit a range of GEDSI values and actions. We will apply an analogous mechanism to the current project because the GEDSI considerations (of hydropower and irrigation development) are relatively similar in terms of their impacts on fisheries and fish-dependent livelihoods. During the design phase of FIS/2023/133, the GEDSI specialist will work with the team to adopt and adapt this approach to the context of this project.

Similarly to that for the FishTech project, the GEDSI specialist will guide the team in:
(a) developing a Mekong Women in Science Technology Engineering and Mathematics (STEM) internship (through NUOL); (b) organising ‘female-only’ masterclasses (to overcome male power dynamics); (c) providing targeted scholarships into Australian-based courses; and (d) ensuring equal participation of men/women in project meetings and dialogues. This will involve including women’s and disability groups in the co-design of any activities to make sure that these activities benefit a wide demographic of stakeholders. The project team (under the guidance of the GEDSI specialist) will adopt these additional initiatives as part of the project design process. That way GEDSI will be a common thread across all implementation areas, and ultimately become a thematic endpoint.

2.4 Capacity building strategy

The need for this project primarily arose because Lower Mekong partners were seeking advice and skills from international professionals with demonstrated expertise in fish passage and in fisheries monitoring using novel techniques (FIS/2017/017). Project EoPO 2 was specifically designed to enhance capacity in key hydropower development stakeholders so that they can make more informed decisions around hydropower planning and implementation.

Other partners and agencies in the region have recognised the value of the information generated from FIS/2017/017 and the demand for knowledge has grown. Despite the need, there are no systemic 'sustainable hydropower' capacity building programs being implemented. This project aims to create a platform for such a strategically orientated program of skill development across influencing actors.

The project team will initially conduct Menti surveys to assess the nature of the skills and/or capacity problem and the institutional environment in which the project will operate.

- The team will also assess the 'critical mass' in terms of training needs and key skill requirements to achieve institutional capacity, by employing systematic approaches like institutional motivation-ability (MOTA) analysis.
- These findings will be used to design capacity-building programs with the project partners.
- The design approach will be critical to assist with cultivating project partners' ownership of, and commitment to, the capacity building agenda.
- Upon running these capacity building programs, the team will conduct further Menti surveys to review the appropriateness of the skills and/or capacity building approaches, and make changes where necessary.

The project team's capacity building approach will be tailored to strategically enhance capacity in four key stakeholders:

Xayaburi Power Company

The organisation employs a small team of regional fisheries scientists who are tasked with implementing research and monitoring on site. FIS/2017/017 partnered with this team and built their capacity for fish collecting, tagging, tagged fish monitoring and data analysis of fish passage. This team will broaden its responsibility for generating scientific data to inform operations at the new site at Luang Prabang.

The project will build the technical capacity of the XPCL (and research personnel in the Laos government) through peer-to-peer learning with the Australian research team, and via a range of appropriate skills development approaches, such as on-site training, online training videos (as developed during COVID-19), and workshops.

Educational institutions

A recurring discussion with universities in partner countries is their limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach, resulting in poor learning outcomes for graduates. This issue has largely arisen because academics (lecturers) have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. In response to this capacity gap, we will focus on educating these lecturers and researchers by delivering a master program through CSU (as done in FIS/2017/017 for fish pass design courses targeted at engineers in government and in donor agencies). We anticipate that, over the longer-term, some will potentially take up an international PhD (via CSU scholarships or the Australia Award platform).

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop CSU's newly developed Master's program on fish pass design. Our project team members will then help build capacity (1) through support in designing curriculums in the tertiary sector; (2) by holding targeted faculty masterclasses in Lao PDR and implementing research projects focusing on sustainable hydropower; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host Masters' students as part of the on-site project team. These local students, and their embeddedness within our project team, will be an important capacity-building strategy.

Government departments

A flow-on effect from poor educational institution capacity is that graduates entering the public sector have a poor capacity to effectively engage with fish passage issues in their professional life as public servants. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, there is little historical institutional capacity and no mentoring opportunities for graduates. This results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the contemporary approaches and learnings on fish passage in a hands-on way. Staff will be trained on-site at locations both in Lao PDR and Australia. The second approach will be targeted and opportunistic, by focusing on the most promising graduates within Lao PDR educational settings and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

Other developers

Hydropower developers are funding and implementing a series of new hydropower projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity of, many developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this proactively by building on our trusted relationship with the Ministry of Energy and Mines, whilst engaging with key developers in the region as required. The MEM and hydropower developers both play key roles in influencing the decision making for hydropower project designs. We have a highly effective masterclass approach to training such stakeholders. This has led to direct outcomes for fish passage design in their institutions when they return and apply their learnings to construction projects under consideration.

2.5 Knowledge exchange strategy

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team, which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish in both directions. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream and downstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future hydropower projects will benefit from improved fish passage design and fish monitoring, and associated river communities enjoy maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and developers
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool, which could be applied across the Lower Mekong Basin
- Capacity building of developers into sustainable hydropower practices
- Training of Lao and Thai scientists and managers.

The project outputs will include:

- Publications in high-ranking journals; the team anticipates;
  (a) Modelling numbers of refresh fish for annual PIT tagging required in long-term fish migration monitoring programs
  (b) Behaviour of Mekong River fish when approaching a hydropower plant (swimming depths, movement types, etc).
  c) The effectiveness of downstream fish migration facilities in a tropical river
  d) Limits of tolerance in Mekong fish species to pressure changes and shear stress and subsequently blade strike
  (e) Improved turbine design criteria for Mekong fish species and fish friendly turbines in the LMB
- Annual reports
- A project final report
- Abstracts published in conference proceedings
- A series of online instructional videos
- Submitted manuscripts based on the findings
- Minutes and action plans formulated by the project advisory reference group
- Final report to ACIAR.

Intellectual property and other regulatory compliance

The key stakeholders and end-users of the knowledge generated through this project will consist of the XPCL, educational institutions (e.g. NUOL and CSU), government departments and other hydropower developers. XPCL, educational institutions and government departments were engaged during the project inception stage, while the project was being co-designed. Other developers will be engaged later during the project at targeted knowledge exchange events.

XPCL and CSU have a confidentiality agreement in place (see attachments). This agreement states that neither partner will release information without the approval of the other. This agreement worked well through the FIS/2017/017 phase of the project and will continue into the new activity.

Other cross-cutting program themes

Climate change considerations

FIS/2023/133's activities will be carried out in partnership with private and public agencies to achieve significant climate resilience outcomes, in addition to livelihood and food security outcomes throughout the LMB. The impacts of modelled climate scenarios on streamflow conditions in the LMB have been considered and will be incorporated in the program design phase. As part of the analysis for EoPO 1, we will investigate the relationship between fish movements and changes in river hydrology or different flow conditions. This will enable us to model the impacts of different climate scenarios on fish movements via changes to flow regimes.

The impacts of modelled climate scenarios will also be included in the program risk register and therefore regularly reviewed along with all of the other program risks. Furthermore, the focus on hydropower development is only likely to increase in the coming decade as governments increasingly switch to renewable energy sources in response to escalating climate change impacts and associated political pressure.

Program risks and safeguards

This program has been developed in accordance with DFAT's *Environmental and Social Safeguard Policy.* A risk and safeguard tool has been incorporated into the program design and will be regularly reviewed throughout the program (Appendix C). The tool considers whether the program will have potential adverse environmental and/or social impacts, and assigns risk classifications accordingly. These risks relate to environmental protection; sexual exploitation, abuse and harassment; children, vulnerable and disadvantaged groups; displacement and resettlement; indigenous peoples; and health and safety.

Sustainability

The entire premise of the project is that an evidence-based approach will lead to better knowledge through an adaptive management framework. We will be directly leveraging other sources of finance through XPCL into this project. This is explicitly stated in the project budget construct (that XPCL will provide equipment and access to accommodation) towards the end of this proposal. In the longer term, it will be hydropower proponents that self-fund sustainable aspects of hydropower design. They will need to meet standards, informed by this activity, in order to proceed. That is a fundamental aspect of the theory of change proposed here.

Table 5. Success indicators linked to the long-term outcomes expected to emanate from this project. ACIAR strategic plan outcomes are summarised as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity. MAP-WEC intermediate outcome indicators are:

(1) Regional cooperation: Australian assistance strengthens Mekong institutions that support regional cooperation on clean energy, water security, and climate action
(2) Bilateral partnerships: Australian assistance strengthens our bilateral engagement with Mekong governments to implement policies/practices on clean energy, water security and climate action
(3) Social Inclusion: Australian assistance facilitates participation and leadership of women, marginalised groups in governance related to clean energy, water security and climate action
(4) Evidence and analysis: Australian assistance provides evidence for improved understanding and policy advice on clean energy, water security and climate action
(5) Environmental and social safeguards: Australian assistance enhances application of environmental, social and governance (ESG) standards for energy, water and climate resilient infrastructure
(6) Sustainable electricity: Australian assistance bolsters capacities of Mekong countries in planning and policymaking for clean energy transitions
(7) Agriculture: Australian assistance enhances the adoption of sustainable and climate-sensitive agricultural methods
(8) Urban: Australian assistance enhances the uptake of water-sensitive, nature-based solutions, and climate sensitive approaches, in urban design
(9) Ecosystems: Australian assistance reduces social vulnerability and improves ecosystem health, with respect to the impacts of climate change, and a focus on riverine pollution, plastics, and coastal ecosystems.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi hydropower project	Develop technical guidelines for acoustic or radio tracking at LMB hydropower plants (HPP) (targeted for the hydropower developers, MRC and GoL).	Targeted and relevant research Improved knowledge base Robust science informing decision making	Criteria accepted by MRC and used by other HPP (ACIAR vi) (MAP-WEC 1, 2, 4, 5) Manuscripts produced and citations (ACIAR ii) (MAP-WEC 1, 3, 4)

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
	Revised criteria for fish friendly turbine pressure changes based on Mekong species tolerances Methodology for assessing downstream migration by fish at a large tropical river hydropower project	Ensure best available science is used Improved environmental outcomes	Guidelines obtained and reviewed (ACIAR vi; ii) (MAP-WEC 4, 5, 6, 9) Agencies consulted (ACIAR vi) (MAP-WEC 1, 3
Determining effectiveness of Xayaburi hydropower project facilities	Annual fish tagging Sensor fish trials Barotrauma experiments Data analysis Linking fish movements to real-time operations	Mainstem passage rates quantified in upstream and downstream directions Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC-NAFRI, NUOL, DLF)	% success of fish ascending (ACIAR vi; iv; ii) (MAP-WEC 4, 5) Average time for fish to ascend (ACIAR vi; iv; ii) (MAP-WEC 4, 5) % of tagged fish detected (ACIAR vi; iv; ii) (MAP-WEC 4, 5) Number of fish tagged annually (ACIAR ii; vi; iv) (MAP-WEC 4, 5) Fish pass operation integrated into operation (ACIAR vi; iv) (MAP-WEC 5, 6)
Scale out of methods and fish pass design to other mainstem projects	Contribute to MRC guidelines development Engage with other developers Install PIT systems within fishways at other hydropower sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ACIAR ii; vi; v) (MAP-WEC 4, 5, 9) No. new mainstem projects with functional fish ladders (ACIAR ii) (MAP-WEC 5, 6) No. new tagging studies implemented using the developed methods (ACIAR v) (MAP-WEC 4, 5) No. of Australian-patented PIT systems installed in the Mekong catchment (ACIAR v) (MAP-WEC 1, 4, 5)

2.6 Research activities, approaches, and outputs

EoPO 1

No.	Activity		Output(s)	Milestone date of output(s)
1.1 **and 1.2**	Research on fish ecology & effectiveness of fish pass operations in upstream & downstream directions (1.1); & research on fish friendly turbine design (1.2)		Data and knowledge to inform fish-friendly hydropower development	2024 - 2027
	Approach	Fish pass monitoring at Xayaburi hydropower project in upstream and downstream directions Acoustic fish tracking above and below Xayaburi hydropower project Monitoring fish that pass through turbines, the spillway, the downstream fish pass channel or the navigation lock at Xayaburi hydropower project Modelling limits of tolerance of Mekong fish species to changes in pressure, blade strike and fluid shear stress associated with HPP		
	Risks/Assumptions	Access to the Xayaburi and Luang Prabang sites is possible Lao government provides permits for equipment Animal ethics is obtained		
	Application of outputs	Knowledge sharing and influencing the design and planning of other developments		
1.1.1	Collect data/evidence on fisheries mitigation measures from existing sies (KG 1 and 2)		Manuscripts on (1) Mekong fish species behaviour at HPP, (2) PIT tag refresh rates required for Mekong species to maintaining statistically robust tagged populations (3) limits of tolerance in Mekong fish species to pressure changes and shear stress (4) Improved criteria for fish friendly turbines and spillways at LMB HPP (5) Attractiveness (% of migrating fish that find) of the upstream fish ladder and downstream fish pass at a large tropical HPP.	2024-2027
	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments		
1.1.2	Data is disaggregated & analysed via a GEDSI twin-track approach (KG 1 and 2)		Manuscripts on GEDSI implications of hydropower developments	2024-2029

	Approach	Research findings worked up into technical reports, scientific publications, workshop proceedings and policy briefs
	Risks/Assumptions	Manuscripts not completed
	Application of outputs	Dissemination to the international scientific community and informing hydropower developments

EoPO 2

No.	Activity		Output(s)	Milestone date of output(s)
2.1	Develop a context-specific & tailored knowledge management system (that can be applied across countries and contexts) to ensure adoption of project outcomes beyond the life of the project		Knowledge management system	2025-2029
	Approach	Develop a knowledge management system for stakeholders identified.		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange		
2.2	Disseminate improved knowledge on the effectiveness of technical solutions to communities, industry & government		Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Deliver capacity building activities		
	Risks/Assumptions	Key stakeholders agree to participate in training. Fit for purpose training can be developed for all proposed developments		
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures		

2.2.1	Design & deliver fit for purpose training to build technical expertise on how to achieve fish friendly & inclusive hydropower development (KG3)	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2026-2029
	Approach	Targeted communication activities and learning opportunities	
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments	
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	
2.2.2	Design & deliver fit for purpose training to build technical expertise on fish friendly hydropower development design to suit the biophysical features of a site (KG3)	Altered hydropower policy Improved inputs into PNPCA discussions Scientific papers validating capacity building pathways	2027-2029
	Approach	Policy brief development, Update to MRC guidance document, Research dissemination think tanks / dissemination events	
	Risks/Assumptions	Key stakeholders agree to participate in training. Fir for purpose training can be developed for all proposed developments	
	Application of outputs	Improved knowledge exchange Increased institutional and individual capacity to apply technical solutions Better capacity for improved decision making and design of future mitigation measures	

Cross-cutting activities

No.	Activity	Output(s)	Milestone date of output(s)
3.1	Approvals to commence	Exa MOU’s and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement

	Approach	Obtain approvals to commence from relevant stakeholders	
	Risks/Assumptions	Salaries and travel secured for Australian partners	
	Application of outputs	Establish the project team	
3.2	Continue PIT tagging more fish in the wild	Increased numbers of PIT tagged fish in the Mekong	Ongoing
	Approach	Continue PIT tagging more fish in the wild using the e-fishing boat	
	Risks/Assumptions	E-fishing boat is operating without issue	
	Application of outputs	Build up the wild PIT-tagged populations of key species to statistically robust numbers (as determined by our PIT tagging requirements models).	
3.3	Update and exchange knowledge with other groups	Sharing of key learnings Minutes from meetings	Opportunistically
	Approach	Liaise with MRC and other interested groups where work overlaps	
	Risks/Assumptions	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	
	Application of outputs	Knowledge sharing and influencing the design and planning of other hydropower developments	
3.4	Annual reporting	Annual reporting to ACIAR and DFAT	31 March 2025
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements	
	Risks/Assumptions	All milestones are met	
	Application of outputs	Project progress is on track and annual report is accepted	
3.5	Hold annual team meeting	Annual team meeting minutes	April 2025
	Approach	Key team members meet to review project progress and plan for the upcoming year	
	Risks/Assumptions	Team members can attend, and all milestones are met	

	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.6	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2025
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.7	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2026
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.8	Hold annual team meeting		Annual team meeting minutes	April 2026
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.9	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2026
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.10	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2027

	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.11	Hold annual team meeting		Annual team meeting minutes	April 2027
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		
	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.12	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2027
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.13	Annual reporting		Annual reporting to ACIAR and DFAT	31 March 2028
	Approach	Report on project progress in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Project progress is on track and annual report is accepted		
3.14	Hold annual team meeting		Annual team meeting minutes	April 2028
	Approach	Key team members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Team members can attend, and all milestones are met		

	Application of outputs	Confirm that project progress is on track and plan for the upcoming year		
3.15	Annual project steering committee meeting		Annual project steering committee meeting minutes	Nov 2028
	Approach	Key steering committee members meet to review project progress and plan for the upcoming year		
	Risks/Assumptions	Steering committee members can attend		
	Application of outputs	Committee is updated on project progress and plans for the upcoming year		
3.16	Final reporting		Final project report to ACIAR and DFAT	June 2029
	Approach	Final project report delivered in accordance with ACIAR and DFAT reporting requirements		
	Risks/Assumptions	All milestones are met		
	Application of outputs	Overview of final project results/outcomes and final report is accepted		
3.17	Hold project final review meeting		Meeting minutes	June 2029
	Approach	Key team members and project stakeholders meet to review final project outcomes and report		
	Risks/Assumptions	Key members can attend, and all milestones are completed		
	Application of outputs	Confirm that project has been satisfactorily completed and recommended changes made to final report		
3.18	Final manuscripts		Published papers	June 2029
	Approach	Complete and submit final manuscripts to target journals		
	Risks/Assumptions	Manuscripts not completed		
	Application of outputs	Dissemination of key findings to the scientific community		

3. Project management

3.1 Project performance and monitoring plan

Strategic monitoring and evaluation plan

The framework for the project's strategic monitoring and evaluation (M&E) approach will be developed within the first 6 months of project implementation, and will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes foundational and intermediate activities, which take the activities and break them down into manageable sub-activities. Each activity has been included includes into the logframe (Figure 8) with defined impact pathways.

Medium-term cycles

The yearly reports and a forum will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place, which will include a facilitated lessons learned workshop, and a written final report.

Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large-scale impacts will accrue with time and may extend beyond the project funding envelope.

3.2 Management aspects

Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Under the contract terms of the first phase of research (FIS/2017/017), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated that the panel meet on an annual basis, at the hydropower site. The Project Reference Panel has advisory status and consists of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited, Ministry of Energy and Mining, plus representation of Lao nationals (Figure 2).

They conduct their business in confidence, which will be defined by a term of reference established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly funded data must be openly available according to ACIAR's contractual requirements, and that that some IP will be required to remain commercial-in-confidence.

Mid- and final-project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR 'mid-project review' (after 24 months) and 'end-of-project review' processes.

Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Lao PDR dating back over ten years). The team will communicate regularly:

- Through face-to-face meetings, on ground and in country visits and networking
- Using Internal information-sharing and communication strategies
- Through bi-annual face-to-face planning workshops
- By developing workplans for achieving each of the EoPO's
- Holding regular work in progress meetings leveraging a full range of technology
- By documenting and distributing meeting minutes and action items
- Through routine monitoring and status reporting of deliverables
- Through the development of instructional videos and manuals as reference items.

Project coordination mechanisms and responsibilities

Project coordination will be undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Gulbali Institute, but he will work closely with Dr Michael Raeder and Thanasak Poomchaivej from XPCL to ensure project activities are realistic and fit within XPCL expectations. Finally, each agency will have a nominated 'leader' who will coordinate activities and partnerships with the agency. Dr Oudom Phonekhampheng will represent the National University of Lao PDR, and Bounsong Vongvichthit will represent Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute. These officers will take on local leadership roles (including managing resourcing and project management) to ensure the project team can effectively operate within local frameworks.

3.2 Avoiding harm

The project will seek to extrapolate and adopt the principles and guidelines of International Organisation for Standardization (ISO) 31000:2018 Risk Management. Detailed risk mapping will be undertaken at the inception meeting. The main aspects of the project will be identified and related to:

- Risk mapping based on previous projects and outcomes in Lao PDR (since institutional frameworks and expectations are well-known to the project team from prior projects)
- A risk management strategy, with defined risks, treatments and mitigation measures, for each key project milestone/activity
- A routine audit of and assurance on activities, which will form a key part of project measurement and evaluation by ensuring that anticipated activities are tracking as expected
- Regular communication and sound project management.

Animal research undertaken in Lao PDR is governed by the provisions of Animal Care and Ethics under Australian Law.

Therefore, the project team will apply for, and maintain, appropriate Animal Care Authorities for the duration of the project to cover all planned animal research.

Any fish research will also be in accordance with the requirements of relevant legislation (i.e. the Environment Protection and Biodiversity Conservation Act 1999, The Australian Code for the Responsible Conduct of Research (2018), and The Australian Code for The Care and Use of Animals for Scientific Purposes 8th edition (2013)).

Likewise, all human research will be conducted in accordance with The National Statement on Ethical Conduct in Human Research (2007)—Updated 2018.

3.3 Data management plan

Research Data Management (RDM) is a recommendation of the Australian Code for Responsible Conduct of Research. To ensure Charles Sturt University researchers follow good RDM practice, Charles Sturt has established an RDM policy. This policy requires all active research projects (whether funded externally or not) to have a RDM Plan which follows a standard template, and that all researchers generating research data must perform compulsory training. The RDM Plan will be provided to ACIAR upon completion.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how operation is portrayed in the public sphere. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support. The data sharing and publication arrangements therefore need to be carefully considered, discussed, and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

In terms of ACIAR good management principles:

Findable: CSU will have cloud-based systems established for most data management. Both PIT tag, and acoustic tag, data will be stored in the Cloud-based database *FishNet,* which is backed up, reliable and robust.

Accessible: Access to NVivo and FishNet is managed at a user-level. Users can be added and deleted by KarlTek Pty Ltd as required.

Interoperable: The cloud-based databases can be accessed via and operating system platform from any location globally provided there is an internet connection.

Re-Usable: The databases have a set of pre-defined '*Queries'* which allow 'clickable' reports to be generated by the user at any time. The reports update whenever new data is added to the database making the data re-usable indefinitely.

3.4 Intellectual property and other regulatory compliance

CSU and XPCL have a confidentiality agreement on matters pertaining to data generated by the project. There is a mutual agreement to publish and disseminate relevant information with the written consent of both parties.

An intellectual property register will be established at the beginning of the project in accordance with ACIAR's requirements. The register will encompass foreground, background and third-party intellectual property, and will include details on proprietary materials, techniques; and other contracts, licenses or legal arrangements.

In addition, the Mid-Term Review will include a review of the use of Background IP in the project to date and any Project IP that is in development and likely to lead to IP that is protectable. The Mid-Term Review team will be tasked with recommending to ACIAR whether additional actions, beyond that defined in the Standard Conditions, are required to clearly define ownership and/or public access to Project IP, that has been funded by Australian taxpayers.

3. Resourcing

3.1 Project team and partnerships

Name	Gender	Organisation	Discipline	[redacted]
Prof. Lee Baumgartner	M	CSU	Professor in fisheries/ river management	
Dr Wayne Robinson	M	CSU	Biometrician and hydropower/ fisheries/ river management	
Dr Nathan Ning	M	CSU	Aquatic ecology and hydropower/ fisheries/ river management	
Mr Tisi Tukuniu	M	CSU	Project co-ordination and management	
Dr Katie Doyle	F	CSU	Fisheries Scientist (hydropower)	
Mr Zac Rolfe	M	CSU	Fisheries Technician	
Casual staff - TBD	M/F	CSU	Fisheries Technician	
Ms Mia Urbano	F	Alinea International	GEDSI-appropriate participatory research	

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Name	Gender	Organisation	Discipline	[redacted]
Ms Ana Ilic/Dr Primatia Romana Wulandari	Both F	Alinea International	MEL experts	
Martin Mallen-Cooper	M	Fishway Consulting Services	Fish passage expert	
Jody Swirepik	F	Consultant	Governance/Water expert	
Daniel Deng	M	Consultant	Hydropower and fisheries expert	
Lizzie Pope	F	Snowy Hydro	Hydropower and fisheries expert	
Secretariat – TBD	M/F	TBD	Manage the advisory reference group	
Mr Karl Pomorin	M	KarlTek Pty Ltd	PIT tag system installation and management	
Mr Garry Thorncraft	M	National University of Laos	Hydropower/ fisheries/ river management and fish passage expert	
Dr Oudom Phonekhampheng	M	National University of Laos	Fisheries/ river management	

Name	Gender	Organisation	Discipline	[redacted]
Mr Thonglom Phommavong	M	National University of Laos	Fisheries/ river management	
Mr Phousone Vorasane	M	National University of Laos	Fisheries technical	
Mr Saluemphone Chantavong	M	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries/ river management	
Mrs Khampheng Homsombath	F	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries/ river management and social dimensions	
Mr Bounsong Vongvichith	M	Living Aquatic Resources Research Centre -	Centre Director	

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Name	Gender	Organisation	Discipline	[redacted]
		National Agriculture and Forestry Research Institute		[redacted]
Mr Khamla	M	Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute	Fisheries technician	[redacted]
Mr Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental engineering and hydropower	[redacted]
Dr Michael Raeder	M	Xayaburi Power Company	Engineering and hydropower development	[redacted]
Lamphone Dimmanivong	M	Ministry of Energy and Mines	Department of Planning Division	[redacted]

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Name	Gender	Organisation	Discipline	[redacted]
Vithounlabandid Thommabout	M	Ministry of Energy and Mines	DDG, Energy Policy, Department of Planning Division	[redacted]
Dr Kaviphone Phoutavong	M	Ministry of Agriculture and Forestry	Department of Livestock and Fisheries	[redacted]
Ms Somphou Phatsulath	F	Ministry of Agriculture and Forestry	Department of Livestock and FIsheries	[redacted]

The hydropower development space is a politically challenging environment. It takes time (years) to establish relationships, trust, and demonstrate an ability to deliver on research outcomes. The FIS/2017/017 project developed trust and a highly productive working relationship among partners. The project team currently includes a private-public partnership team that now has an established track record and positive reputation in the region.

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies involved have the scientific and financial capabilities to successfully complete an international collaboration. Specifically:

Charles Sturt University: Has a long history with ACIAR and in working in the SE Asian region and will lead the project. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. CSU has extensive experience with PIT system data analysis and installations. There are no other universities in Australia with such extensive experience and networks for fishway design and monitoring.

Xayaburi Power Company: Owns and operates the Xayaburi hydropower project. They will own the facilities for the next 30 years under a concession agreement. Their fish monitoring researchers will partner with the CSU team to conduct on-site project activities.

KarlTek Pty Ltd: Is a Melbourne-based, 100% Australian owned and operated company that provides PIT tag-based solutions to a wide range of wildlife monitoring applications. Set up the PIT database for Xayaburi and will continue to manage this PIT database and advise on any new PIT installation works at the new site. Has >20 years of experience in PIT installation projects and successfully completed the installation and database management work for the preceding Xayaburi projects.

National University of Laos (NUoL) and Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute (LARReC-NAFRI – a centre within the Ministry of Agriculture and Forestry): Will both assist with in-country project co-ordination, field work and project delivery.

NUoL: Is the primary university in Lao PDR. Has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum.

Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute (LARReC-NAFRI): Is the leading institute in aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC-NAFRI has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Ministry of Energy and Mines (MEM): Currently the only agency with an outward facing discussion with all proponents of mainstem hydropower projects. Their role is to review and approve hydropower projects.

Department of Livestock and Fisheries (DLF): Is the national regulatory authority for fisheries-related matters in Lao PDR. Their role is to ensure that fisheries sustainability is adequately captured in project delivery and in discussions among government agencies as the project develops.

3.2 Collaboration

The team will collaborate with additional entities who are involved in achieving optimal fish passage outcomes at LMB mainstem hydropower developments. This will require us to work more closely with the Lao Ministry of Energy and Mines (than in the past) and Department of Livestock and Fisheries. It will also require us to work in collaboration with individual companies involved in hydropower project funding and development. Both these actors are engaged in design decision making for planned hydropower projects.

The team will need to engage the Mekong River Commission more strategically, so their hydropower guidelines and recommendations are updated to include new knowledge generated through this project.

Key knowledge gaps will be aided by the team’s use and referencing where appropriate approved fisheries guidance already in the public domain, negotiated and agreed by MRC Member Countries.

The team is aware of the new Preliminary Design Guidance (PDG), approved by MRC Member Countries, published by the MRC in February 2023, that is an updated version of the original PDG introduced in 2009. It incorporates not only what the MRC Member Countries have learnt from their own experience with hydropower, but also from examples and best practices around the world. It also includes the most current knowledge regarding design criteria, science and technology. While the older PDG spanned this range of construction and operation elements (hydraulics; sediment transport; geomorphology; water quality; aquatic ecology; fish and fisheries; safety; and navigation), the new PDG now includes hydrology and socio-economic impact to reflect the greater attention paid today to riparian communities and riverine livelihoods.

MRC’s Hydropower Mitigation Guidelines, approved and published in 2020, includes three technical volumes of 738 pages (vol 1 & 2), addressing a range of known risks during hydropower development through an assessment of five major themes. They include river hydrology and downstream flows, geomorphology and sediments, water quality, fisheries and aquatic ecology and biodiversity, natural resources, and ecosystem services.

According to the MRC’s HMG, during the planning, feasibility study and design process hydropower developers can take various steps to optimise benefits and avoid adverse impacts. They include, for instance, selecting the most appropriate project locations, adopting alternative project scales such as lower hydropower projects, and using alternative energy sources.

The 2020 HMG were an important complement to the 2009 PDG and remain valid. However, the team are aware that the 2023 PDG has further updated and approved guidance, including of most relevance to this project proposal, elaborated guidance on fisheries that ‘raises the bar’ for intending developers.

Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

A panel was developed for the previous project (FIS/2017/017) to oversee and guide the project team. This governance structure proved to work very well, so the same structure will be applied to this proposed project for continuity of knowledge and learnings. We will continue to support the existing panel, which has representative stakeholders from all cash/in-kind investors including Charles Sturt University, DFAT, ACIAR, XPCL plus representation of Lao nationals and independent experts. The panel members each have >10 years' experience each in their respective fields. They will conduct their business in confidence and review their current terms of reference at the project initiation phase.

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Expert advisor	Consultant	Chair the project reference panel	[redacted]
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	[redacted]
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	[redacted]
Michael Raeder	M	Xayaburi Power Company Limited	Owner Representative	Reference panel member	[redacted]
John Dore	M	Department of Foreign Affairs and Trade	Lead Specialist – Climate Resilience & Water Security	Reference panel member	[redacted]
MEM representative	F	Lao government	Local	Reference panel member	[redacted]
TBD	TBD	ACIAR	Fisheries RPM	Reference panel member	[redacted]
Lee Baumgartner	M	Charles Sturt University	Research Professor (Fisheries and River Management)	Project leader and reference panel member	[redacted]

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC-NAFRI, MEM, DLF and NUOL budgets to facilitate this participation.

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3.3 Budget justification

Charles Sturt University

Salaries: [redacted]. A key learning from the co-design workshop was that many of the project staff have been active now for almost 20 years. There is a need for succession planning. Also seeking to recruit a MEL expert (ideally specialising in hydropower matters to extend knowledge from EoPO1 to key stakeholders). It is essential that these staff can spend significant amounts of time, in-country, to connect with stakeholders. Finally, seeking support to cover the costs of the advisory reference panel, especially externally funded experts. This will ensure we have a robust and well-resourced project team with capacity to meet the needs of ACIAR/DFAT and the stakeholders we are trying to reach.

Research operating: Research consumables (each year across the two EoPO's); plus office consumables to assist with project running. Seeking support to develop/publish reports, briefs, posters, infographics and other dissemination materials (especially bilingual outputs). Including an allocation for developing educational materials needed for EoPO 2 when short-courses and masterclasses are developers for stakeholders).

Travel: Allocated to cover advisory reference panel expenses (annual meetings in the region); with a specific allocation for a mid-term review; fieldwork at Xayaburi/Luang Prabang each year with additional support for fisher surveys. Allocated a specific amount to cover participation in final project review.

Capital: Seeking computers for project staff along with field tablets to record fisher survey information, an iPhone for remote fieldwork and printer to support the project team.

Infrastructure: CSU has a compulsory infrastructure levy of 25% but will discount to 13% as per ACIAR guidelines.

National University of Laos

Salaries: [redacted] This is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together and is also connected to MRC, government and developers.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs of the NUOL team. Boat hire and equipment use for remote fieldwork. There is a need for hatchery consumables for fish husbandry and long-term field trials. Have also included support for masterclasses and education materials as NUOL are the main in-country partner for education outcomes and will co-design and implement on ground communication, extension and capacity building activities.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1. Provision made for mid-term review and final project review.

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Capital: Included moderate provision for ICT equipment (Year 1).

Infrastructure: National University of Laos sets the infrastructure recovery at 5%.

Living Aquatic Resources Research Centre - National Agriculture and Forestry Research Institute

Salaries: Mr Douangkham Singhanouvong ([redacted] is an emeritus researcher but is a critical liaison point for the Lao government. He will continue his key role, on a part-time basis in his retirement. [redacted] As with NUOL, this is the core project team which has been servicing the hydropower and fish passage work for several years, seeking to continue this established team which has a long history of working together.

Research operating: Includes vehicle operating costs (visit to field sites is best achieved by vehicle as remote locations are not serviced by air), office consumables to support the local operating costs. LARReC-NAFRI will be organise the mid-term and end of project review and so provision has been made for these important workshops. Hatchery consumables are included to support fish husbandry and other field expenses.

Travel: Significant allocations for field travel and subsistence including regional trips to Bangkok (and Cambodia) for consultation meetings. Generous provision for fieldwork to support EoPO1. Provision made for mid-term review and final project review. $10k per year allocated to travel to support inclusion of MEM staff.

Capital: LARReC-NAFRI purchased a vehicle to cover the ACIAR-suite of work in 2006. It has not been replaced since. The vehicle has been depreciated beyond its effective life and is overdue for replacement. Seeking an allocation. Also included moderate provision for ICT equipment (Year 1).

Infrastructure: LARReC-NAFRI sets the infrastructure recovery at 5% (which is mandated by its head institution, NAFRI).

Ministry of Energy and Mines (to be included within the LARReC-NAFRI budget)

Salaries: [redacted]

Research operating: No operating expenses required

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: No capital required.

Infrastructure: Infrastructure recovery at 5% through LARReC-NAFRI.

Department of Livestock and Fisheries

Salaries: [redacted] For the first two years, Ms Somphou will undertake a Masters in Sustainable Hydropower through an Australia Award scholarship.

Research operating: Included a consumables provision to cover expenses whilst assisting with fieldwork.

Travel: Included costs to attend annual meetings, daily subsistence allowance provision, attending co-design meetings and fieldwork participation.

Capital: Provision for a laptop from project staff.

Infrastructure: DLF sets the infrastructure recovery at 5%.

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Xayaburi Power Company Limited

Salaries: Xayaburi Power Company Limited will provide four staff members, based on site, who will collaborate with the team and contribute to fieldwork. [redacted]

Research operating: Access to a boat, operating of the fish research facility, maintenance and expansion of the PIT system, including procurement of an acoustic system, will be covered as a cash contribution.

Travel: Any travel-related costs for XPCL staff will be borne by the company. Staff visiting XPCL-controlled sites will be provided with accommodation by XPCL.

Capital: XPCL will purchase any significant equipment and plant needed for the project.

Infrastructure: N/A. XPCL will not be receiving any funds.

3.4 Additional resourcing requirements

The FIS/2017/017 project was based on the premise that the Charles Sturt University team would source their salary and travel, and developers would cover all required equipment. This agreement will extend into the new project and so significant in-kind is provided from hydropower developers. CSU will also make contributions to Masters' courses, student stipends and masterclasses as needed throughout the project.

FIS successfully facilitated, through Clear Horizons Consulting, a co-design process for project logic and a theory of change framework that culminated in a Monitoring-Evaluation-Learning plan for the FishTech project. The project team would see great benefit in extending this approach to the project development phase of FIS/2023/133 should this proposal be accepted. We will also engage an MEL expert to guide the MEL reporting.

DFAT and ACIAR also implemented a MSA between the Australian and Lao governments, which acted as a template for the project team to operate in a complex political environment. This included the establishment of a project reference panel to oversee and guide the project. Renegotiating this MSA, and maintaining support for the project reference panel, will be critical.

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Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to [redacted]

Administrative details

[redacted]

Plant or animal germplasm exchange

[redacted]

If 'yes' to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

[redacted]

Proprietary materials, techniques and information

[redacted]

'Data' means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical expertise and information reduced to material form by that Party. If 'yes' to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

Country	Details of proprietary materials, techniques and information

FOI Act s. 47

[redacted]

Other agreements

[redacted]

If 'yes' to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

Project, background and third-party Intellectual Property

This includes but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Project IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

FOI Act s. 47f

Project IP (IP that is expected to be developed during the project)

The following material is to be developed as part of the Project:

[redacted]

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If 'yes', for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

FOI Act s. 47f

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If 'yes', for each applicable country provide brief details.

[redacted]

FOI Act s. 47f

Appendix B: Project variations

Variations to the project after commissioning should be documented in this section

Variation 1.

Variation Date	Purpose	
Example date	Brief explanation of purpose for variation	
Changes (omissions, substitutions, inclusions)	i.	Page 8, line 16-18. - **Omitted line**: '…*example*…' - **Substituted line**: '…example…'
	ii.	Page 9, line 12. - **Included line**: '...example...'
	iii.	
	iv.	
	v.	
	vi.	
	vii.	
	viii.	
	ix.	

Appendix C: The risk and safeguard tool

Safeguard Screening and Rating Instructions

All aid investments must be screened against DFAT's five environmental and social safeguards using the Safeguard Screening Checklist (the table on the left hand side of this tab). Risks identified during this screening are recorded in the risk register (the next tab).

Safeguard Screening

Familiarise yourself with the Environmental-and-Social-Safeguard-Policy. Consider whether the investment will have potential negative environmental and/or social impacts, taking into account:

- both direct and indirect impacts

- impacts of activities associated with the investment

- impacts that are reasonably foreseeable, given the nature of the proposed investment, and any activities.

In the table to the left record answers to all of the safeguard screening questions with either, 'yes', 'no' or 'unsure'. Where the answer to any screening question is:

- 'no', the investment is not likely to cause adverse environmental and/or social impact, and the safeguard risk rating is likely to be 'low'.
- 'yes', the investment is likely to cause adverse environmental and or social impacts.
- 'unsure', the investment will require further consideration of potential environmental and social impacts.

Rate the Safeguard Risk

Estimate the level of risk: If you answer 'yes' or 'unsure' for one or more of the questions, estimate the level of risk for the corresponding safeguard using the Aid Risk and Safeguard Matrix (see relevant tab) and include the risk in investment risk register (the next tab).

Note: Investments must be screened for their inherent environmental and social risks and impacts (i.e. before controls, treatments or management measures are put in place).

Consider the need for review by safeguard teams. Where investments have a 'high' or 'very high' safeguard risk please contact the safeguard team (aidsafeguards@dfat.gov.au). FOI Act s. 47f

Note: The *Environmental and Social Safeguard Policy* mandates that a proportional impact assessment of safeguard risks, must occur during investment design, where the safeguard risk rating is 'high' or 'very high'.

For further information, refer to the Environmental and Social Safeguards Intranet page, and safeguard operational procedures and guidance.

Safeguard screening

	Safeguards Screening Checklist				
	Environmental and Social Safeguards	No Yes Unsure	If 'Yes' or 'Unsure'		Inherent risk rating (before controls)
			Likelihood	Consequence	
1	Environmental protection				
1.1	Could the investment have an adverse impact on the environment? For example, by supporting or providing advice on any of the following: • infrastructure development, such as roads, bridges, airports, railways, ports, dams, water, sanitation and hygiene (WASH), waste management, telecommunications, energy production and distribution facilities, urban development. •construction/renovation/refurbishment/demolition of buildings such as schools, hospitals, health facilities or any of the infrastructure above • diversion of water, including for water supply, irrigation, flood-mitigation, or aquaculture • rural development, agriculture, food production, or forestry activities • activities in the extractives (oil, gas, mining), manufacturing, transportation and tourism sectors • activities on top of or close to sites of cultural significance and require special measures.	No	Rare	Limited	Low

			Likelihood	Consequence	
1.2	Could the investment increase environmental, climatic and/or social vulnerability, including by (but not limited to): • increasing emissions of greenhouse gases (e.g. energy intensive process will lead to an increase in Green House Gas production) • reducing incentives to adapt (e.g. change in social norm away from responsible water conservation to increased consumption) • increasing the vulnerability of people (particularly the most vulnerable) or the environment to climate change (e.g. pesticides, used to eradicate mosquitoes that carry dengue fever, damage native insect populations which reduces agricultural productivity, leading to food insecurity) • increasing the impact of disasters, e.g. will infrastructure building codes and specifications be adequate for the intensity of disasters/hazards experienced in the investment area (e.g. floods, earthquakes, cyclones), will the investment impact the food security of a vulnerable population • setting paths that limit future choices (e.g. large capital and institutional commitment reduces portfolio of future adaptation options).	No	Rare	Limited	Low

			Likelihood	Consequence	
2	**Sexual exploitation, abuse and harassment**				
	Is there a risk of sexual exploitation abuse or harassment occurring in any aspect of the delivery of this DFAT activity (including DFAT activities implemented by downstream partners)?	No	Rare	Limited	Low
	Does this activity include risk factors that exacerbate the SEAH risks	No	Rare	Limited	Low
	Children, vulnerable and disadvantaged groups				
	Could the investment have an adverse impact on vulnerable and/or disadvantaged groups including children, women, people with disabilities, minority groups, or the elderly?	No	Rare	Limited	Low
	Could the investment involve contact with children or working with children?	No	N/A	N/A	
	Displacement and resettlement				
	Could the investment involve activities or provide advice about an activity that will: • displace people, either physically or economically • exclude or reduce people's access to land they live on or used to generate livelihoods • exclude or reduce people's access to land that is of cultural or traditional importance to them?	No	Rare	Limited	Low

FOI Act s. 47f

If you answer 'yes' or 'unsure', a risk assessment must be undertaken and appropriate minimum standards applied consummate with the level of risk. Please refer to the PSEAH risk guidance note for instructions. Please contact [redacted] for further advice.

Type text here

Complete Steps 1-3 of the Guidance Note: Establishing Child Protection Risk Context to assess the overall child protection risk. This will help determine the risk level for this question.

Safeguards Screening Checklist					
	Environmental and Social Safeguards	No Yes Unsure	If 'Yes' or 'Unsure'		Inherent risk rating (before controls)
			Likelihood	Consequence	
5	Indigenous peoples				
5.1	Could the investment involve activities that adversely impact the: • dignity, human rights, livelihood systems or culture of indigenous peoples • land or natural and cultural resources that indigenous peoples own, use, occupy or claim?	No	Rare	Limited	Low
6	Health and safety				
6.1	Could the investment involve activities that adversely impact the health and safety of workers and/or others?	No	Rare	Limited	Low
6.2	Could the investment involve DFAT workers?	No	If yes, follow relevant departmental WHS policies and contact [redacted]		
6.3	Could the investment involve risk of exposing workers and/or communities to asbestos?	No	If yes, ensure that this investment complies with the Department's policy on managing asbestos risk in the aid program.		
Overall Safeguard Risk Rating			Low		

FOI Act s. 47f

If you answer 'yes' or 'unsure', DFAT's health and safety obligations may be shared with others depending on the nature of the investment. DFAT must satisfy itself that the relevant delivery partner's health and safety management processes are adequate to ensure the health and safety of workers and others, so far as is practicable in the circumstances. Please contact [redacted] further advice.

Refer DFAT's Managing asbestos risks policy and guidance note. Please note you do not need to rate the risk. If your answer is 'yes' or 'unsure' you must assess the risk associated with asbestos containing material at investment design

This field is automatically calculated.

Risk register

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	23/11/2023	**Date of Next Review:**	1/07/2024	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Operating environment	Timeline and budgets are not achieved	Covid delays, contracting issues, financial transfer delays, recruitment	May be unable to complete project on time	Project Team	Possible	Moderate	Medium	Workplans, payment schedules, regular meetings, project planning and shared expectations	Unlikely	Moderate	Medium	N/A. Project planning will be OK to manage this.			Unlikely	Minor	Low	No
Partner capacity and relations	Program activities not aligned with community and industry expectations	Poor engagement, Covid delays, language barriers	Unable to source approval for research to commence	Project Team	Possible	Moderate	Medium	Stakeholder analysis, regular consulations and co-design with stakeholders, follow partner frameworks	Rare	Moderate	Low	N/A. The team has a good process for consultation already proposed			Unlikely	Minor	Low	No
Other	Hydropower developer will not allow for the sharing or publishing of results	Sensitive or unfavourable findings from the research	Unable to share results with MRC and other stakeholders; or unable to publish results	Project Team	Possible	Major	High	Legal agreements in place to allow for key findings to be shared	Unlikely	Major	Medium	Existing treatments plus exploring the reasons behind the lack of willingness to share data and negotiating to find a compromise.						

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Other	Non-use of research learnings/existing guidance by hydropower companies, and/or failure to insist on compliance by Mekong governments and some financiers	Sensitive or unfavourable findings from the research	Hydropower developers fail to adopt fish friendly, socio-economic and inclusive practices	Project Team	Possible	Major	High	Empirically demonstrating the ecological benefits of making hydropower developments fish friendly	Unlikely	Major	Medium	Existing treatments plus empirically demonstrating the socio-economic benefits of using the research findings to guide fish-friendly, socio-economic and inclusive hydropower development in the LMB. Also normalisation of support for and compliance with the MRC's hydropower mitigation guidelines and recommendations already negotiated, packaged and approved.						
Resources, management and planning	PL or key staff resign	A range of sources but usually individual preference	Could delay works depending on the skillset which has departed	Project Leader	Possible	Minor	Medium	We have a large team with some degree of redundancy to counter and staff departures.	Possible	Minor	Medium	N/A. Planning for team structure has assumed that some staff may depart.			Possible	Limited	Low	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods		AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review: 1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate: MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:				

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Partner capacity and relations	A partner(s) becomes misaligned with the aims and objectives of the activity	Changing agency priorities, political pressure, lack of understanding	Could delay works or mean the project moves in a different direction	Project leader	Possible	Major	High	Several levels of project agreement. Milestones and timelines in place. In-country leaders to keep items on track.	Unlikely	Minor	Low	N/A			Unlikely	Minor	Low	No
Operating environment	Legislative workplace requirements - WHS, Human resources, etc	Fieldwork, construction or operation accidents	Staff injury, slowed project progress	All staff	Possible	Minor	Medium	Risk assessment framework, staff training, masterclasses and ongoing information sharing. Contractors responsible for their own WHS	Unlikely	Minor	Low	N/A. Existing treatments should be sufficient.			Unlikely	Minor	Low	No
Resources, management and planning	Access to data / cyber security issues; Privacy; contact lists, data information of members etc	Data loss or loss of control over data	Inability to report, data used by third parties, potential for financial loss	CSU and partners	Rare	Minor	Low	Data management plan required by CSU and will be signed by all partners	Rare	Limited	Low	Existing controls should be sufficient			Rare	Limited	Low	No

Investment Name:		**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**									**AidWorks Number:**						
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Investment Manager:		**Thipphavone Chanthapaseuth and Mali Walker**			**Delegate:**			MAP WEC Team - Vientiane office			**Sector/s:**	Water					
Objective/s:																	
Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**		
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix
Partner capacity and relations	Partner(s) leave the activity	Changing agency priorities, political pressure, lack of understanding	Inability to deliver particular in-country components	CSU and partners	Rare	Moderate	Low	Partners required to enter into MOU, ACIAR ensure that MOU agreed and signed at high level	Rare	Moderate	Low	Existing controls should be sufficient			Rare	Moderate	Low
Political	Low traditional owner buy-in / acceptance / participation	Covid delays, lack of interest/influence, village chief not inclusive	Reduced benefits of activity as not all stakeholders included	Project Team	Unlikely	Minor	Low	Strong approach to GEDSI will mitigate this risk and seek to mitigate risks.	Unlikely	Minor	Low	GEDSI advisor will help advise and ensure project design is sound			Unlikely	Minor	Low
Environment and social safeguards	Covid and travel interruptions	Global pandemic and government response	Unable to hold meetings, forums, access sites	Project Team	Possible	Major	High	Government agencies becoming exempt from travel restrictions, international experts able to resume travel, need to have this activity listed as a nationally significant activity	Unlikely	Minor	Low	High level engagement to ensure project is listed as a high priority activity and exempt from restrictions where possible	DFAT/ACIAR/CSU	On commencement	Unlikely	Minor	Low

Does this risk need to be escalated?
No
No
No, but a watching brief on covid situation

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Fiduciary and fraud	Misuse of project funds	In-country touch points, contractors, departmental staff	Main risk is fraud, misappropriation of activity funds	Project team	Rare	Major	Medium	Financial auditing will take place every six months, activities linked to payments, formal procurement processes need to be followed	Rare	Major	Medium	N/A. ACIAR has strong financial reporting and acquittal processes in place.	ACIAR/CSU	On commencement	Rare	Major	Medium	No, would only escalate if circumstances required
Resources, management and planning	GEDSI targets in terms of involvement, attendance and equal participation are not met	Institutional barriers, lack of engagement, poor consultation	Project advances but without GEDSI considerations captured	Project team	Possible	Moderate	Medium	Specific GEDSI budget included, training of project team, undertake GEDSI analysis, employ GEDSI advisor	Unlikely	Moderate	Medium	N/A			Unlikely	Moderate	Medium	No
Environment and social safeguards	Project budget insufficient	AUD significantly de-values against USD	Reduced ability to deliver	Project team	Possible	Major	High	Flexible workplan budget advanced at known rate	Possible	Moderate	Medium				Possible	Moderate	Medium	No, would only escalate if circumstances required

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
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Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Operating environment	Large scale weather (e.g. flood) events damaging data-capturing equipment (especially the PIT antennas)	Weather	Loss of fishway efficiency data	In-country leads	Possible	Major	High	Agile and responsive team members in place. Protocols for removing equipment when water levels reach trigger values.	Possible	Moderate	Medium	Manage to have contingencies for unforseen disruptions.			Possible	Moderate	Medium	No
Operating environment	Faults/power loss in PIT antenna systems	Weather, faulty equipment, flat batteries	Loss of fishway efficiency data	In-country leads	Possible	Major	High	Agile and responsive team members in place. Protocols for replacing batteries etc at set intervals. Having backup/spare batteries and other key equipment on standby.	Possible	Moderate	Medium	Manage to have contingencies for unforseen disruptions.			Possible	Moderate	Medium	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
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Operating environment	Lack of continued agency and/or financial support	Changing government and/or government commitment, policies and priorities in the recipient countries; or changes in diplomatic relations between countries.	May be unable to complete project on time	Project Team	Possible	Moderate	Medium	Agile and responsive team members in place.	Possible	Moderate	Medium	Manage to have contingencies for unforseen delays and other disruptions/changes in political context.			Possible	Moderate	Medium	No
Operating Environment	Structures are not maintained or operated effectively	Operating budget for weir-dam does not include adequate budget for maintenance of PIT antenna equipment or training of staff	PIT tagging antennas would be less effective at assessing fish pass efficiency	Project team, in-country partners	Possible	Major	High	Ownership, long-term maintenance, training is part of hydropower dam owners mandate	Possible	Moderate	Medium	Include in project planning and execution of project contract			Possible	Moderate	Medium	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
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Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Environment and social safeguards	Women don't participate in the project	Challenging gender norms creates risks for women to participate	GEDSI targets are not met; the project's inclusion of gender equality is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI ewxpert has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis to ensure approaches are gender and culturally sensitive & address risk to women caused by challenging existing norms	Unlikely	Limited	Low	Complementary to women only internships and trainings will be training for staff (men and women) to understand why women are being targeted and their role in ending gender inequality; to ensure equal participation of women in meetings, the project team will address participation in a culturally and gender sensitive way so women's attendance and use of her time is not tokenistic but productive		FOI ACT	Unlikely	Limited	Low	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate:	MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
					L Refer to matrix	C Refer to matrix	RR Refer to matrix		L Refer to matrix	C Refer to matrix	RR Refer to matrix				L Refer to matrix	C Refer to matrix	RR Refer to matrix	
Environment and social safeguards	Women's risk of violence increase	Challenging gender norms creates risks for women to participate	GEDSI targets are not met; the project's inclusion of gender equality is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI advisor has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis to ensure approaches are gender and culturally sensitive and address risk to women caused by challenging existing norms	Unlikely	Limited	Low	Complementary to women only internships and trainings will be training for staff (men and women) to understand why women are being targeted and their role in ending gender inequality; to ensure equal participation of women in meetings, the project team will address participation in a culturally and gender sensitive way so women's attendance and use of her time is not tokenistic but productive			Unlikely	Limited	Low	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	23/11/2023	**Date of Next Review:**	1/07/2024	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Environment and social safeguards	Disability approaches lack sensitivity or cultural application.	Lack of awareness of disability inclusive development	GEDSI targets are not met; the project's inclusion of disability is perceived as shallow	Project leader	Possible	Moderate	Medium	GEDSI advisor has been recruited, responsibility for GEDSI mainstreaming will sit with the most senior staff/project leader in order for the project team to prioritise GEDSI; activities will be based on a GEDSI analysis that includes entry points for the project to conduct meaningful disability work with organisations for people with disabilities.	Unlikely	Limited	Low	GEDSI analysis will take into account the intersectional gender equality approach rather than interpreting Gender Equality, Disability and Social inclusion as siloed identities.			Unlikely	Limited	Low	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	23/11/2023	**Date of Next Review:**	1/07/2024	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Environment and social safeguards	Sexual harassment or exploitation occur within the project.	Societal gender inequality in the project team and targeted communities	Reduced ability to deliver	Project leaders	Possible	Moderate	Medium	Prevention of Sexual Exploitation, Abuse and Harassment training is required for all staff and partners through the CSU ELMO system. Training should include discussion around consent and other concepts which may be new in the Asia context	Possible	Moderate	Medium	Confidential complaints mechanisms are established and are gender and culturally sensitive; a series of mandatory gender and inclusion related trainings (one-off trainings are not enough to change behavioural norms)			Possible	Moderate	Medium	No
Environment and social safeguards	Fishway incorectly operated	Inadequate training in operations and maintenance	Fish pass operates inefficiently, fisheries resources impacted	Project team	Possible	Major	High	Sufficient operations and maintenance training	Possible	Moderate	Medium	Existing controls should be sufficient			Possible	Moderate	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate:	MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
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Environment and social safeguards	Uncertain fishway ascent performance	Inadequate monitoring end evaluation	Fish pass operates inefficiently, fisheries resources impacted	Project team	Possible	Major	High	Sufficient fish pass evaluation design for the project	Possible	Moderate	Medium	Existing controls should be sufficient			Possible	Moderate	Medium	No
Environment and social safeguards	Construction of the fishway (for new hydropower dams) caused environmental damage	Fuel spill, vegetation removal, erosion	Habitat destruction, loss of terrestrial or aquatic biota, reduced water quality	Project team	Unlikely	Minor	Low	Pre-construction site specific Risk Mitigation Plan	Rare	Minor	Low	Existing controls should be sufficient		FOI Act s. 47f	Rare	Minor	Low	No
Environment and social safeguards	Operation of fishway increases risk of disaster	Unsafe fishway design for new hydropower dams	Drownings, injuries	Project team	Rare	Severe	Medium	Fishway Safety Management Plan	Rare	Major	Medium	Existing controls should be sufficient			Rare	Major	Medium	No

Investment Name:	**Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods**			**AidWorks Number:**	
Date of Last Review:	**23/11/2023**	**Date of Next Review:**	**1/07/2024**	**Country:**	Greater Mekong Region
Investment Manager:	**Thipphavone Chanthapaseuth and Mali Walker**	**Delegate:**	MAP WEC Team - Vientiane office	**Sector/s:**	Water
Objective/s:					

Risk Category	**Risk Event** What could happen?	**Risk Sources** What could cause the event to happen?	**Risk Impacts** What would happen if the event occurs?	**Risk Owner** The person responsible for ensuring this risk is managed?	**Inherent Risk Rating**			**Existing Controls** What's currently in place?	**Current (Residual) Risk Rating**			**Proposed Treatments** If no further treatment required or available, please explain why.	**Treatment Owner** Person Responsible for Implementing Treatment/s	**Treatments Implementation Date**	**Target Risk Rating**			**Does this risk need to be escalated?**
					L Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix		**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix				**L** Refer to matrix	**C** Refer to matrix	**RR** Refer to matrix	
Environment and social safeguards	Construction of fishway (for new hydro dams) involves children or fishway operation poses risks to disadvantaged	Poor management of fishway construction	Exploitation of children or disadvantaged groups	Project team	Rare	Moderate	Low	Before construction site specific Risk Mitigation Plan and Fishway Management Plan	Rare	Moderate	Low	Existing controls should be sufficient			Rare	Moderate	Low	No
Environment and social safeguards	Construction of fishway (for new hydro dams) displaces people	Poor management of fishway construction	People's homes and/or water or fisheries resources impacted	Project team	Rare	Moderate	Low	Pre-construction site specific Risk Mitigation Plan	Rare	Major	Medium	Existing controls should be sufficient			Rare	Major	Medium	No
Resources, management and planning	Team staff are over-allocated and are no longer able to assess fishway effectivness effectively and/or efficiently	Staff member's workloads increase as demand for their expertise increases (i.e. more agencies request assistance with fishway assessments).	Poor quality fishway outputs, staff burnout, inefficient work practices, missed opportunities to scale out further to new hydropower dams	Project team	Likely	Moderate	High	Minimising overallocations in workload by capping the work taken on by the team	Possible	Moderate	Medium	Re-allocating budget to increase staffing resources to be able to take on more work in a sustainable manner	Team and DFAT/ACIAR		Unlikely	Moderate	Medium	No

Investment Name:	Sustainable Hydropower in the Mekong: Focusing best-practice technological interventions into dam designs for sustainable fish-based livelihoods			AidWorks Number:	
Date of Last Review:	23/11/2023	Date of Next Review:	1/07/2024	Country:	Greater Mekong Region
Investment Manager:	Thipphavone Chanthapaseuth and Mali Walker	Delegate:	MAP WEC Team - Vientiane office	Sector/s:	Water
Objective/s:					

Risk Category	Risk Event What could happen?	Risk Sources What could cause the event to happen?	Risk Impacts What would happen if the event occurs?	Risk Owner The person responsible for ensuring this risk is managed?	Inherent Risk Rating			Existing Controls What's currently in place?	Current (Residual) Risk Rating			Proposed Treatments If no further treatment required or available, please explain why.	Treatment Owner Person Responsible for Implementing Treatment/s	Treatments Implementation Date	Target Risk Rating			Does this risk need to be escalated?
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Resources, management and planning	The available budget becomes insufficient to deliver on the original project plan	Currency fluctuations and/or inflation; having to pay more for contractors if activities not completed on schedule	Reductions to the project's abilty to scale out and scale up fishway developments at new hydropower developments	Project team	Likely	Major	High	Having 'Plan B' options to undertake fewer project activities	Likely	Minor	Medium	Re-allocating budget to have a buffer for currency fluctuations and/or inflation	Team and DFAT/ACIAR		Unlikely	Moderate	Medium	No

Risk summary

Investment Risk Summary	Highest individual inherent risk rating in each category (before controls)	Highest individual residual risk rating in each category (after controls but before treatments)
1. Operating environment: What factors in the operational or physical environment (security, lack of essential infrastructure, gender inequality, land tenure etc.) might impact directly on achieving the outcomes? Is the investment or intended outcomes exposed to disasters that typically occur in the investment area and/or country? Will the investment be exposed to climate change risk?	-	-
2. Partner capacity and relations: Could a relationship breakdown occur with key partners or stakeholders and would this prevent the outcomes from being achieved? Does the intended partner/s (if known) have the capacity and capability to manage their role/work involved in this investment, including risks? Are there governance mechanisms (in the design and agreement) in place to ensure adequate ongoing communication and reporting between DFAT and the investment partner?	-	-
3. Fiduciary and fraud: Are there any significant weaknesses that mean funds may not be used for intended purposes, not properly accounted for or do not achieve value for money? Is there a risk that DFAT aid program funding could be diverted for use by terrorists?	-	-
4. Political: Is there a likelihood that political instability, changes to a partner government's strategy or policy may jeopardise the investment outcomes? Change in government? Might this negatively affect DFAT's relationship with the partner government?	-	-
5. Resources, Management and Planning: How realistic are the outcomes and can they be achieved within the timeframe? Are the outcomes sustainable? What factors may prevent the outcomes being met? Are there adequate resources, including budget and people allocated to implementation (within DFAT and/or the partner government)?	-	-
6. Environment and Social Safeguards: Do any of the activities involved in this investment have the potential to cause harm to the environment and people - (environmental protection; children, vulnerable and disadvantaged groups; displacement and resettlement, indigenous peoples; health and safety)?	-	-
7. Other: Are there any other factors specific to this investment that would present a risk (e.g. this is a new area of activity or it is an innovative approach?	-	-
	Use this overall inherent risk rating during planning and concept.	Use this overall residual risk rating during design and implementation.
Overall Risk Rating	-	-

Risk matrix classifications

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Operating environment	Limited impact on investment objectives and beneficiaries, including from operating environment, disaster, reputational, fraud/ fiduciary, partner, resourcing and/or other risks factors.	Political, governance, social and/or security (conflict or violence) factors threaten investment effectiveness but can be dealt with internally.	Political, governance, social and/or security (conflict or violence) factors creates moderate disruption to one or more investment activities.	Political, governance, social and/or security (conflict or violence) factors creates major disruption to the investment.	Political, governance, social and/or security (conflict or violence) instability severely undermines the investment.
Disaster risk		Minor disaster impacts to investment objectives and outcomes.	Moderate disaster impacts to investment objectives and outcomes. Moderate damage to property.	Significant disaster impacts to key investment objectives or outcomes. Major damage to critical property or multiple properties.	Severe disaster impacts to overall investment objectives or outcomes. Extensive damage or loss of property/or multiple properties.
Development results	Results in consequences that can be dealt with by routine operations.	Delay in achieving investment objectives, resulting in minor impact on service delivery beneficiaries and/or country program.	Delay in achieving investment objectives, resulting in moderate impacts on service delivery, beneficiaries and/or country program.	Delay or failure to achieve investment objectives, resulting in major impact on service delivery and/or beneficiaries. Threaten the continued effectiveness of the country program.	Critical failure to achieve investment objectives, resulting in severe impact on service delivery, beneficiaries and/or country program. Country program stopped as a result of investment.
Partner capacity and relations		Institutional and/ or partner capacities is generally adequate. Some weakness may reduce effectiveness of aspects of the investment.	Institutional and/ or partner capacity is constrained, resulting in moderate impact on investment effectiveness.	Institutional and/ or partner capacity is very weak, resulting in major impact on investment effectiveness.	Critical institutional and/ or partner capacity failure undermines the effectiveness of entire investment.
Fiduciary and fraud		DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money. Fraud threatens the effectiveness of key investment objectives and/or services.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money, affecting achievement of key investment objectives. Systemic fraud perpetrated over a period of time.	DFAT funds are not used for intended purposes, not properly accounted for and/or do not achieve value for money, undermining overall investment viability. Systemic institutional fraud involving multiple organisations over an extended period of time.

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Compliance		Minor breach of investment accountability, legislative/ contractual or security obligations.	Moderate breach of investment accountability, legislative/ contractual or security obligations.	Multiple breaches of investment accountability, legislative/ contractual or security obligations.	Systemic breach of investment accountability, legislative/ contractual or security obligations. Funds are diverted to known terrorists/ terrorist organisations.
Security		Minor damage to national interests.	Significant damage to national interests. Funds are unintentionally diverted to a Terrorist Organisation or individual i.e. goods/funds are ceased.	Serious damage to national interests. Funds are negligently / recklessly diverted to a Terrorist Organisation or Individual i.e. local service providers are not appropriately screened / due diligence completed.	Exceptionally grave damage to national interests. Funds are knowingly and deliberately diverted to a Terrorist Organisation or Individual i.e. Engagement of a Terrorist Organisation to provide security services / access in country. DFAT funds are used to fund a terrorist attack domestically or overseas.
Reputation		Minor impact to relations with stakeholders.	Moderate damage to relations with partners, beneficiaries, or other key stakeholders and media criticism.	Major damage to relations with partners, beneficiaries, or other key stakeholders. Strong media criticism.	Total loss of confidence in DFAT and breakdown of partner relations. Severe public criticism of DFAT.
Other		DFAT resources (budget, people, or timeframes) occasionally constrained.	DFAT resources (budget, people, or timeframes) moderately constrained.	DFAT resources (budget, people, or timeframes) significantly constrained.	DFAT resources (budget, people, or timeframes) critically constrained.
Environmental Protection	Minimal impact on the environment. Impacts are largely undetectable. No or negligible increase to people's vulnerability to climate change impacts, and negligible GHG emissions	Minor impact on the environment. Impacts are temporary and confined to a small area of low environmental sensitivity. Minimal and short term increase to people's vulnerability to climate change impacts, and/or minimal GHG emissions.	Moderate impact on the environment. Impacts may be long lasting, extend beyond the local area and include sensitive environmental communities. Moderate and short term increase to people's vulnerability to climate change impacts, and/or moderate GHG emissions.	Significant impact on the environment. Impacts are irreversible, diverse, over a sensitive geographic area. Significant and long term increase to people's vulnerability to climate change impacts, and/or significant GHG emissions.	Significant impact on the environment. Impacts are irreversible, diverse, with strong cumulative impacts over a large and/or sensitive geographic area. Severe and permanent increase to people's vulnerability to climate change impacts, and very high GHG emissions.

	Consequences				
Areas of Risk	**Limited**	**Minor**	**Moderate**	**Major**	**Severe**
Children, vulnerable & disadvantaged groups	No harm/injury to a child. Minimal social impact, vulnerable and/ or disadvantaged groups. No concern from local community, NGOs, medium or other stakeholders.	Minor injury to a child, requiring first aid. Short-term nuisance or minor social impact on local population, including vulnerable and/or disadvantaged groups. No attention from affected community, NGOs, media or stakeholders beyond the affected population.	Serious harm/ injury to a child. Moderate social impact which effects the majority of the local population including vulnerable and/or disadvantaged groups. Concern from affected community, NGOs, media or stakeholders may cause delay to the investment.	Life-threatening harm/ injury to a child. Significant social impact which extends beyond local population, including vulnerable and/or disadvantaged groups. Concern from affected community, NGOs, media or stakeholders may prevent the investment from continuing.	Fatality of a child. Life-threating injury/ harm of more than one child. Significant social impact which extends beyond local population, including vulnerable and/or disadvantaged groups. Increases conflict and/or social fragility. Concern from affected community, NGOs, media or stakeholders prevents the investment from continuing.
Displacement & resettlement	No displacement and/ or resettlement. Limited impact on potentially affected households.	>5 households/ businesses displaced.	>5<20 households/ businesses displaced.	>20<100 households/ businesses displaced.	>100 households/ businesses displaced.
Indigenous Peoples	Indigenous group living in project area of influence. No adverse impact.	Short-term nuisance to indigenous population. No damage to/ or loss of access to indigenous land, assets, resources, and/or cultural heritage.	Moderate impact on indigenous population. Damage to/ or temporary loss of access to indigenous land, assets, resources, and/or cultural heritage.	Significant impact on indigenous population. Damage to/ or protracted loss of access to indigenous land, assets, resources, and/or cultural heritage.	Significant, long-lasting impact that effects the indigenous population. Permanent loss of/ or access to indigenous land, assets, resources, and/ or cultural heritage.
Health and Safety	Limited worker and/ or community health and safety impacts. Injury requiring first aid.	Short-term worker and/ or community health and safety impacts. Minor injury requiring medical care.	Moderate worker and/ or community health and safety impacts. Serious injury or multiple minor injuries.	Significant worker and/ or community health and safety impacts. Life threatening injury/ multiple serious injuries.	Significant worker and/ or community health and safety impacts. Death or multiple life threatening injuries.

Likelihood	Probability					
Almost Certain	Very likely. The event is expected to occur in most circumstances as there is a history of regular occurrence at DFAT, similar organisations or investments.	**Medium**	**Medium**	**High**	**Very High**	**Very High**
Likely	There is a strong possibility the event will occur as there is a history of frequent occurrence at DFAT, similar organisations or investments.	**Medium**	**Medium**	**High**	**High**	**Very High**
Possible	The event might occur at some time as there is a history of casual occurrence at DFAT, similar organisations or investments.	**Low**	**Medium**	**Medium**	**High**	**High**
Unlikely	Not expected, but there's a slight possibility it may occur at some time.	**Low**	**Low**	**Medium**	**Medium**	**High**
Rare	May occur only in exceptional circumstances. Is possible but has never occurred to date.	**Low**	**Low**	**Low**	**Medium**	**Medium**

Issues register

Issue Register								
Issue No.	Description	Priority (H,M,L)	Proposed Strategies	Reported by	Assigned to	Status	Date resolved	Comments
1								
2								
3								
4								
5								
6								
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12								
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14								

Australian Government

Australian Centre for
International Agricultural Research

Research Agreement

between the

Commonwealth of Australia

represented by the

Australian Centre for International Agricultural Research

and the

Commissioned Organisation

Agreement Details

Project Title	FIS/2023/133 Optimising fish passage at hydropower sites in the Mekong
ACIAR *Name:*	The Commonwealth of Australia represented by the Australian Centre for International Agricultural Research
Australian Business No.	34 864 955 427
Postal Address	GPO Box 1571, Canberra ACT 2601, AUSTRALIA
Physical Address	ACIAR House, 38 Thynne Street, Fern Hill Park, Bruce ACT 2617
ACIAR Contract Manager	Name Ingrid van Putten Position Research Program Manager Tel. [redacted] Email [redacted]
Commissioned Organisation	
Name	Charles Sturt University
Registered Business No.	83 878 708 551
Postal Address	Locked Bag 588, Wagga Wagga, NSW 2678
Physical Address	Boorooma Street, North Wagga, NSW 2650
Australian Entity	Yes ☒ No ☐ ***NOTE****: selection of whether the Commissioned Organisation is an Australian Entity will affect the application of clauses under this Agreement as further detailed in clause 3.*
Commissioned Organisation Contract Manager	Name Dr Lee Baumgartner Position Executive Director Tel. No [redacted] Email [redacted]
Term	
Commencement Date	1 July 2024 or from the date of the last signature (whichever is the later)
Completion Date	30 June 2029
Financial Limitation	[redacted]
Withheld Sum	[redacted]
Project Leader	As detailed in the Project Document.
Key Personnel	The Project Leader and other Personnel of the Commissioned Organisation: either identified as 'Key Personnel' in the Project Document or listed immediately below.
Subcontractors	See table below

Organisation	Name	Role
KarlTek	Karl Pomorin	Advice and management of PIT tag data
Fishway Consulting Services	Martin Mallen-Cooper	Advisory board member
Consultant	Jody Swirepik	Advisory board member
Consultant	Daniel Deng	Advisory board member
Snowy Hydro	Lizzie Pope	Advisory board member
Alinea International	Mia Urbano, Ana Illic, Primatina Wulandari	Manage GEDSI and MEL reporting

Requirement for Personnel to sign confidentiality deeds	Yes ☐ No ☒ ***NOTE****: If the requirement applies, ACIAR may require the Commissioned Organisation's Personnel to sign deeds of confidentiality under clause 14.1(d).*
Reports	
Annual Report(s)	Annual reports are to be provided each Financial Year of the Term by the following 31 March, other than for the final Financial Year of the Project (where a Final Report is required instead).
Final Report	A final report is to be provided within 60 days of completion of the Project.

FOI Act s. 47f

FOI Act s. 47f

FOI Act s. 47g

Other Report(s)	NA
Reviews	
Final Review	To be conducted 8-12 months before completion of the Project.
Mid-Term Review	To be held within the first 12-36 months of the Term.
Special Conditions	N/A
CGIAR IA Principles Apply?	Yes ☐ No ☒ ***NOTE:*** *If CGIAR IA Principles apply, payment arrangements will be in accordance with clause 9.2 and intellectual property arrangements will be in accordance with clause 13.5.*
Complex Activity	Yes ☒ No ☐ ***NOTE:*** *If this Agreement relates to a Complex Activity, the Additional Terms will form part of this Agreement in accordance with clause 2.*
Collaborating Country	Lao PDR
Collaborating Institution	**Living Aquatic Resources Research Centre – National Agriculture and Forestry Research Institute** **National University of Laos** **Department of Livestock and Fisheries** **Xayaburi Power Company Limited**

Table of Contents

Research Agreement between ACIAR and the Commissioned Organisation

BACKGROUND

ACIAR has requested that certain services be carried out pursuant to the Project, and the Commissioned Organisation has agreed to provide the Services on the terms of this Agreement.

THE PARTIES AGREE AS FOLLOWS:

1. Interpretation

1.1 **Definitions.** In this Agreement, unless a contrary intention appears, capitalised terms have the meaning provided in the Agreement Details and:

Acquittal Report has the meaning provided in clause 9.4.

Additional Terms means the additional terms that are included as Annexure B, if the Agreement Details specifies this Agreement as relating to a Complex Activity.

Adverse Event occurs, in respect of a Party, if

(a) the Party is the subject of winding up or liquidation proceedings, whether voluntary or compulsory, otherwise than for the purpose of and followed by, a reconstruction, amalgamation or reorganisation

(b) if the Party has become insolvent, bankrupt or is subject to the appointment of a receiver, manager or an inspector to investigate its affairs, enters into any arrangement or composition with its creditors generally, or is unable to pay its debts as and when they become due, or

(c) if execution is levied upon all or any part of the assets of the Defaulting Party, provided that no breach occurs if the execution is contested in good faith or if within 5 Business Days after it is levied payment is made in full to the judgment creditor in question of all amounts owing to the judgment creditor.

Agreement means this agreement, and includes the Background, the Agreement Details and the documents set out in clause 1.3 (as applicable).

Agreement Details means the details set out in the table at the front of this Agreement.

Approved Subcontractor means a third party to be engaged by the Commissioned Organisation for provision of sub-contracted Services that has been approved in writing by ACIAR, but does not include a Collaborating Institution.

Background IP means IP Rights that are in existence prior to the date of this Agreement, or are brought into existence independently of this Agreement, and which are used in, or is otherwise required for the use of, the Project IP.

Budget means the budget set out in Annexure B of the Project Document.

Commonwealth means the Commonwealth of Australia.

Confidential Information means information of a Party (**Disclosing Party**) that is by its nature confidential and:

(a) is designated by the Disclosing Party as confidential, or

(b) that another Party (**Receiving Party**) knows or ought to know is confidential,

but does not include information which:

(c) is or becomes public knowledge other than by:

(i) breach of this Agreement, or

(ii) any other unlawful means

(d) is in the possession of a Receiving Party without restriction in relation to disclosure before receipt from the Disclosing Party, or

(e) has been independently developed or acquired by the Receiving Party,

and the burden of establishing any exceptions referred to in subclauses (c) to (e) above is on the Receiving Party.

Control means, in relation to a body corporate, the ability of any person directly or indirectly to exercise effective control over the body corporate (including the ability to determine the outcome of decisions about the financial and operating and other policies of that body corporate) by virtue of the holding of voting shares, units or other interests in that body corporate or by any other means.

Deliverables means the deliverables of the Project as specified in the Project Document.

Due Date means the date that a Deliverable is due for submission to ACIAR, as specified in the Project Document.

Exploit means, in respect of IP Rights:

(a) 'exploit' as defined in the *Patents Act 1990* (Cth), and

(b) to the extent that any IP Rights relates to works subject to copyright, to reproduce, modify, publish, adapt and communicate the works to the public.

Financial Year means the period from 1 July to 30 June of the following year.

IP Rights means statutory and other proprietary rights in respect of patents, designs, plant breeders' rights, trade marks, circuit layouts, copyright, confidential information, know-how and all other intellectual property rights as defined in Article 2 of the *Convention Establishing the World Intellectual Property Organisation of July 1967*.

International Arrangements means arrangements that establish the operating framework for the Project including such matters as: intergovernmental arrangements, sub-contracts with Approved Sub-Contractors, contracts between the Commissioned Organisation and any Collaborating Institutions, the arrangements covering matters such as customs assistance, in-country security, indemnities and intellectual property rights.

Moral Rights means the right of attribution of authorship, the right not to have authorship falsely attributed and the right of integrity of authorship granted to authors under the *Copyright Act 1968* (Cth).

Parties means ACIAR and the Commissioned Organisation (and their respective successors and permitted assigns), and **Party** means either one of them.

Payment Period means, unless otherwise specified in the Project Document, the periods:

1 January to 30 June, or

1 July to 31 December,

except that the period will be reduced in length relevantly if the Commencement Date or Completion Date falls within the period.

Payments	means the payments ACIAR will make available to the Commissioned Organisation in consideration of receipt of the Services as specified in the Budget, to be made available by ACIAR in accordance with the terms of this Agreement, and **Payment** means any one of those payments.
Personnel	means, in respect of a party, the: employees, officers, agents, students and sub-contractors of that party and, in respect of the Commissioned Organisation, includes the Key Personnel.
Primary Terms	has the meaning provided in clause 1.3.
Project Document	means the document set out in Annexure A to this Agreement, as amended from time to time in accordance with this Agreement.
Project IP	means IP Rights created by or on behalf of the Commissioned Organisation as a result of performing the Services or otherwise in the course of expending the Payments.
Services	means the services (including Deliverables) that the Commissioned Organisation is required to provide under this Agreement.

1.2 **Interpretation.** Unless a contrary intention appears, in this Agreement:

(a) words imputing a gender include any other gender

(b) a business day means a day which is not a Saturday or Sunday or a public holiday in the place where a notice is to be received or a particular activity is to be performed, and if a day on or by which an obligation must be performed or an event must occur is not a business day, the obligation must be performed or the event must occur on or by the next business day

(c) the singular includes the plural and vice versa

(d) another grammatical form of a defined word or expression has a corresponding meaning

(e) a reference to a statute or other law includes regulations and other instruments under it and consolidations, amendments, re-enactments or replacements of any of them

(f) a reference to a document includes the document as novated, altered, supplemented or replaced from time to time

(g) a reference to a person includes a natural person, partnership, body corporate, association, governmental or local authority or agency or other entity, and includes and includes the person's permitted successors, substitutes (including persons taking by novation) and assigns

(h) 'including', 'includes', 'such as' and 'in particular' do not limit the generality of the words which precede them or to which they refer

(i) 'month' means a calendar month and 'year' means a calendar year

(j) any agreement, representation, warranty or indemnity by two or more parties (including where two or more persons are included in the same defined term) binds them jointly and severally

(k) any agreement, representation, warranty or indemnity in favour of two or more parties (including where two or more persons are included in the same defined term) is for the benefit of them jointly and severally

(l) a rule of construction does not apply to the disadvantage of a Party because the Party was responsible for the preparation of this Agreement

(m) paragraph headings are inserted for convenient reference only and have no effect in limiting or extending the language of provisions to which they refer

(n) all references to dollars are to Australian dollars, unless otherwise specified, and

(o) a reference to a clause is a reference to a clause of these Primary Terms, and a reference to a Schedule, or Annexure is a reference to a schedule or annexure of this Agreement.

1.3 **Order of Priority.** In the event and to the extent of any inconsistency, the components of this Agreement will be interpreted in the following order of priority:

(a) the Special Conditions (if any)

(b) where applicable under clause 2, the Additional Terms

(c) these clauses 1 to 21 (**Primary Terms**), and

(d) the Project Document.

2. Additional Terms

Where the Agreement Details identify this Agreement as a Complex Activity, this Agreement includes the Additional Terms. Where the Agreement Details do not identify this Agreement as a Complex Activity, the Additional Terms do not form part of this Agreement.

3. Country Specific Clauses

The Parties acknowledge and agree that:

(a) if the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details, clauses 15.6, 19.9, and 19.20 will apply to this Agreement and clause 19.10 will have no effect, and

(b) if the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details, clause 19.10 will apply to this Agreement and clauses 15.6, 19.9, and 19.20 will have no effect.

4. Term

4.1 Subject to clause 4.3, the term of this Agreement will commence on the Commencement Date and, subject to extension under clause 4.2 or earlier termination under clause 16, will end on the Completion Date (**Term**).

4.2 The Term may be extended upon the mutual agreement of the Parties, including in circumstances where ACIAR has granted an extension of time under clause 7.2.

4.3 If the International Arrangements enabling the Project have not been established to the satisfaction of ACIAR prior to the Commencement Date, the term of this Agreement shall commence upon ACIAR being satisfied (in its absolute discretion) that such International Arrangements have been established.

5. Services

The Commissioned Organisation will perform the Services:

(a) in a proper and professional manner exercising all appropriate care, diligence and attention, and in accordance with ethical scientific practice

(b) in furtherance of the objectives of the Project

(c) so as to provide any Deliverables and reports by the Due Dates and otherwise as required under this Agreement (including as specified in the Project Document)

(d) without limitation to clause 10, using Personnel of the requisite scientific calibre

(e) at the times and in the manner specified in this Agreement (including as specified in the Budget and the Project Document more generally) or otherwise agreed by the Parties, and

(f) in accordance with:

(i) applicable law, and

(ii) the reasonable directions of ACIAR.

6. Project Leader

In addition to any tasks designated for the Project Leader in the Project Document, the Project Leader will be responsible for coordinating all Services to be provided by the Commissioned Organisation and will liaise with ACIAR regularly regarding Project progress.

7. Delays

7.1 Notwithstanding clauses 9.4(a)(iv) and 9.5(c), upon becoming aware of any (actual or potential) delay in provision of Services the Commissioned Organisation will immediately notify ACIAR in writing of: the relevant background circumstances, the likely length of delay, and the steps the Commissioned Organisation has and will take to minimise the length and effect of the delay (**Delay Notice**).

7.2 Following receipt of a Delay Notice, ACIAR will determine, acting reasonably, whether to grant an extension of time to perform all or part of any remaining Services.

8. Subcontracting

8.1 The Commissioned Organisation will not subcontract performance of Services other than to Approved Subcontractors. For the purposes of this clause 8.1, the subcontractors specified in the Project Document and the Subcontractors listed in the Agreement Details constitute Approved Subcontractors.

8.2 The Commissioned Organisation remains responsible for performance of the Services by its subcontractors, including Approved Subcontractors.

9. Payment

9.1 In consideration of performance of the Services, ACIAR will make the Payments to the Commissioned Organisation, in advance and in accordance with the Budget.

9.2 If the Agreement Details specify that the CGIAR IA Principles apply, then the Parties acknowledge that Payments shall be made pursuant to clause 9.1 according to the following process:

(a) all Payments shall be made to the Commissioned Organisation via the International Bank for Reconstruction and Development (**IBRD**) as the Trustee of the CGIAR Fund for this Agreement

(b) in respect of each of the Payments, ACIAR will seek an invoice from IBRD, and

(c) following receipt of an invoice from IBRD, ACIAR will make the relevant Payments to IBRD with instructions to disburse those Payments to the Commissioned Organisation.

9.3 The Commissioned Organisation acknowledges it is responsible for payment of, and accounting to ACIAR for, all expenditure of Payments and all costs and expenses incurred in performing the Services.

9.4 Within 30 days of the end of each Payment Period or receiving a Withheld Payment under clause 9.5(e), the Commissioned Organisation will provide ACIAR (in a format as specified by ACIAR from time to time) a report including the following details:

(a) for the relevant Payment Period and detailed on an item-by-item basis, an accurate account of:

(i) Payments received

(ii) Payments expended, including details of how Payments have been expended

(iii) Payments not expended, and

(iv) if the amount of Payments not expended exceeds 20% of Payments made available for the relevant Payment Period, the reasons for any delay in spending or committing Payments, and

(b) sign-off by the Project Leader, and certification of the accuracy of details provided in acquittal report by an authorised officer of the Commissioned Organisation, together an **Acquittal Report.**

9.5 Notwithstanding clauses 9.1 and 9.2:

(a) Payments are subject to appropriation being made by the Parliament of the Commonwealth for those Payments

(b) ACIAR will only advance Payments for the next Payment Period following:

(i) receipt of a satisfactory Acquittal Report for the previous Payment Period, and

(ii) if the Commissioned Organisation is required to provide ACIAR reports under clause 15.1 during earlier Payment Periods, satisfactory provision of such reports.

(c) in respect of any previously advanced Payments (or part thereof) not expended during earlier Payment Periods (**Unspent Payments**), ACIAR may reduce the Payment for the next or a future Payment Period, and the Financial Limitation, by all or part of the amount of the Unspent Payments.

(d) unless otherwise agreed in writing by ACIAR:

(i) Payments will not exceed the Financial Limitation

(ii) ACIAR will not be liable for expenses incurred other than as provided for in the Budget, for any services other than Services, or for any services performed (including purported Services) or expenses incurred after the Completion Date, and

(iii) the Commissioned Organisation must return any Payments not properly earned or expended within 30 days of ACIAR accepting the final Acquittal Report.

(e) ACIAR will withhold the Withheld Sum from the final Payment pending acceptance of a satisfactory Final Report, following which:

(i) ACIAR will provide the Commissioned Organisation the Withheld Sum within thirty (30) days of ACIAR accepting the Final Report, and

(ii) the Commissioned Organisation must provide ACIAR a final Acquittal Report for the Project within thirty (30) days of receipt of the Withheld Sum.

10. Personnel and Personal Property

10.1 The Commissioned Organisation will provide adequate and competent Personnel to perform the Services.

10.2 The Commissioned Organisation will notify ACIAR immediately if any Key Personnel become unavailable to continue performance of Services or otherwise progress the Project.

10.3 ACIAR may require the Commissioned Organisation to, at the cost of the Commissioned Organisation, promptly replace Personnel with replacement Personnel approved by ACIAR if:

(a) the circumstance set out in clause 10.2 arises, or

(b) ACIAR has any reasonable grounds to require removal of Personnel from the Project, including in circumstances where Personnel perform Services in another country and, while not citizens of that country, become involved in the political affairs of that country.

10.4 As between the Parties, the Commissioned Organisation will be solely responsible for the remuneration and the work, health and safety of its Personnel, and must ensure that such Personnel comply with the Commissioned Organisation's obligations under this Agreement (including in relation to the ownership of IP Rights and obligations of confidentiality).

10.5 The Commissioned Organisation is responsible for its personal property (and the property of any of its Personnel involved in performing the Services, including any Key Personnel) and for any loss of property or damage caused to it.

11. Project Supplies

11.1 The Commissioned Organisation will arrange the procurement and delivery of all equipment and supplies required for the Project, including those specified in the Project Document (**Supplies**), and may apply Payments to do so where specified in the Project Document.

11.2 The Commissioned Organisation will: exercise administrative control over, manage the security, maintain and keep in good repair, and (where applicable) repair or replace, the Supplies.

11.3 Ownership of Supplies will vest in the Commissioned Organisation from the date of purchase.

12. Travel

12.1 For all travel of Commissioned Organisation Personnel pursuant to this Agreement:

(a) the Commissioned Organisation is responsible for arranging and paying for the travel and allowances of the Personnel, which may be paid from the Payments if allocated for in the Budget, and provided that all air travel is purchased in economy/excursion class or lower fares and for the most direct and economical routing (the Commissioned Organisation may reroute or upgrade at its expense)

(b) without limitation to clause 10.4, the Commissioned Organisation is solely responsible for the security and safety of its Personnel and must make its own enquiries in relation to travel advice. ACIAR has no responsibility or liability for any injury, death, loss or damage suffered or expenses incurred relating to travel undertaken by Commissioned Organisation Personnel

(c) the Commissioned Organisation will provide prior written notice to ACIAR, including a travel schedule and details of its Personnel undertaking the travel (and of any accompanying dependants), in the form of a 'Travel Advice Note' as available on the ACIAR website accessible at http://aciar.gov.au/travel, and

(d) the Commissioned Organisation will provide a travel report in accordance with clause 15.3.

13. IP Rights and moral rights

IP Rights

13.1 ACIAR and the Commissioned Organisation will have regard to the provisions of and fulfil all relevant obligations under international arrangements to which Australia is a signatory relating to intellectual property and biological resources including:

(a) the *International Treaty on Plant Genetic Resources*

(b) the FAO trustee arrangements with international agricultural research centres

(c) the *Convention on Biological Diversity*

(d) the *Agreement on Trade Related Aspects of Intellectual Property Rights*, and

(e) and the provisions of the *International Union for the Protection of New Varieties of Plant*.

Transfer and exchange of germplasm by the Commissioned Organisation and/or sub-contractors will be subject to materials transfer and acquisition agreements and in accordance with the Convention on Biological Diversity. This clause 13.1 will be interpreted such that the relevant obligation is that which was in effect at the time of the action in question.

13.2 ACIAR and the Commissioned Organisation agree, in respect of any Project IP, that:

(a) in a Collaborating Country, the Project IP shall vest upon creation in the Collaborating Institute that is located within the relevant Collaborating Country, and if there is more than one Collaborating Institute located in that Collaborating Country, those Collaborating Institutes shall own the Project IP in that Collaborating Country as joint owners;

(b) in Australia, the Project IP shall vest upon creation in the Commissioned Organisation (and clause 13.3 shall apply);

(c) in respect of all countries and territories outside Australia and any Collaborating Countries, in accordance with the cooperative nature of the Project and recognising that it will be desirable to use or exploit advances or discoveries which may be made in the course of the Project and under this Agreement, ACIAR and the Commissioned Organisation will discuss and will jointly determine:

(i) the equitable apportionment of ownership of any Project IP arising from the Project

(ii) the management, control and payment of costs in respect of any steps to obtain and maintain registration of IP Rights in respect of Project IP

(iii) the equitable apportionment of profits, royalties or licence fees relating to such Project IP

(iv) the equitable licensing of such Project IP

(v) the equitable licensing of any Background IP of a Party as necessary to enjoy the full benefits of the Project and the Project IP, and

(vi) where it is within their power, the equitable licensing of such other IP Rights (including third party IP Rights) as is necessary to enjoy the full benefits of the Project and the Project IP

and clause 13.4 shall apply.

13.3 Unless otherwise agreed pursuant to clause 13.2(c), where ownership of the Project IP vests in the Commissioned Organisation, the Commissioned Organisation grants to ACIAR a permanent, irrevocable, royalty free, world-wide, non-exclusive licence (including a right to sublicense) to exploit, use, reproduce, modify, publish, adapt and communicate to the public the Project IP.

13.4 In fulfilling their obligations under the clause 13.2(c), ACIAR and the Commissioned Organisation will have regard to relevant considerations including:

(a) their respective intellectual and other contributions

(b) their respective contributions of Background IP, material, research effort and proprietary work

(c) the facilities and funding provided by the Parties, and

such other relevant considerations as they may mutually determine.

13.5 If the Agreement Details specify that CGIAR IA Principles apply:

(a) clauses 13.2 to 13.4 will not apply

(b) the Parties agree that all Intellectual Assets, as defined in the CGIAR Principles on the Management of Intellectual Assets (**CGIAR IA Principles**) and Project IP will be dealt with in accordance with CGIAR IA Principles and that all Project IP will be used for the public good

(c) the Commissioned Organisation acknowledges that:

(i) as a member of the Consortium of International Agricultural Research Centres, the Commissioned Organisation must ensure that all agreements and contracts it enters (including any confidentiality, partnership, collaboration, development, licensing, distribution, material transfer agreements), comply with the CGIAR IA Principles

(ii) ACIAR supports the vision and objectives of the CGIAR, and supports the dissemination of the results of research as a public good, and

(iii) accordingly, Project IP will be managed in a manner consistent with CGIAR IA Principles

(d) ACIAR, the Commissioned Organisation will consider whether to register/ apply for (or allow third parties to register/apply for) patents and/or plant variety protection (**IP Applications**) over the Intellectual Assets. In accordance with CGIAR IA Principles, the Parties agree that no such IP Applications will be made unless they are necessary for the further improvement of such Intellectual Assets or for the public good. The Parties acknowledge that all IP Rights will be exercised consistently with Articles 6.1 to 6.3 of the

CGIAR IA Principles

(e) ACIAR and the Commissioned Organisation will grant or will secure the grant to each other of a permanent, irrevocable, royalty free, worldwide, non-exclusive licence (including a right to sublicense its rights to third parties) to Exploit the Project IP. Where Parties propose to sublicence its rights under this clause 13.5(e), they will ensure that any sublicence will be on the same or substantially the same terms and conditions as the licence such party has from the other.

13.6 The Commissioned Organisation will promptly notify ACIAR of the details of any Project IP. Any notification will be treated as Confidential Information by ACIAR.

13.7 Unless otherwise expressly agreed in writing by the Parties, this Agreement does not affect the ownership of Background IP.

13.8 The Commissioned Organisation warrants to ACIAR that to its actual knowledge and belief, following all diligent and reasonable enquiries, at the date that ACIAR first consents to use, or otherwise uses, Background IP supplied by the Commissioned Organisation pursuant to this Agreement (as applicable):

(a) it is the owner of, or is otherwise entitled to use, the Background IP

(b) it is entitled to grant any licences to such Background IP made pursuant to this Agreement, and

(c) the exercise by ACIAR of its rights in such Background IP granted pursuant to this Agreement will not infringe the IP Rights of any third party.

13.9 Where the Commissioned Organisation intends to publish any article or paper of an academic, scientific or technical nature in regard to the Services or this Agreement, or to place any advertisement requesting applications from persons to perform any part of the Services, any such publication or advertisement must acknowledge the funding and other support provided by ACIAR in regard to this Agreement and must comply with ACIAR Branding Guidelines available on the ACIAR website https://www.aciar.gov.au/branding-guidelines.

13.10 The Commissioned Organisation may report details of this Agreement in non-specialist media provided:

(a) it acknowledges the funding and support provided under this Agreement by ACIAR, and

(b) if the subject of the proposed media report may be controversial, the Commissioned Organisation will, prior to submission for publication, request ACIAR's written consent.

Moral Rights

13.11 ACIAR and the Commissioned Organisation:

(a) acknowledge the existence of Moral Rights conferred on the authors of any Works which are created in carrying out this Agreement or which exist as part of the Background IP

(b) will immediately notify the other Party in writing:

(i) upon becoming aware of a possible infringement of Moral Rights of an author of any Works referred to in clause 13.11(a), and

(ii) upon becoming aware of a claim for infringement of Moral Rights being made against a Party by an author of any Works referred to in 13.11(a), and

(c) will, following notice under clause 13.11(a), meet to negotiate in good faith (involving, where possible, the author of the relevant Works) the appropriate steps to resolve the matter to the satisfaction of the Parties and the author.

14. Confidentiality of Information

14.1 Each Party will:

(a) keep Confidential Information of the other Party confidential and will not, without the other Party's prior written consent, disclose or permit the same to be disclosed to any third party

(b) use reasonable endeavours (including labels or verbal notification) to ensure that the receiving Party is aware of the confidential nature of Confidential Information at disclosure

(c) take reasonable steps to provide for the safe custody of Confidential Information of the other Party and to prevent unauthorised access to or use of such Confidential Information, and

(d) ensure that its Personnel comply with the obligations of confidentiality imposed upon it by this clause 14, including in the case of the Commissioned Organisation (if specified in the Agreement Details and where required by ACIAR thereafter), by ensuring that its Personnel to execute deeds of confidentiality in favour of ACIAR consistent with this clause 14.

14.2 The obligations on the Parties under this clause 14 will not be taken to have been breached to the extent that a Party:

(a) discloses Confidential Information of the other Party to its:

(i) Personnel, and

(ii) legal, financial or other professional advisers,

who have a need to know for the purposes of this Agreement (and only to the extent that each has a need to know), provided the disclosure is made subject to an obligation of confidentiality in accordance with clause 14.1(d), or

(b) discloses Confidential Information of the other Party to the extent required to be disclosed:

(i) by law including under court subpoena, parliamentary order, under the *Freedom for Information Act 1982* (Cth) (or equivalent legislation) or as part of discovery during legal proceedings

(ii) to any government agency, authority, department or minister, or to any parliamentary committee, or

(iii) by the rules of a stock exchange,

provided that to the extent reasonably possible, prior written notice of such required disclosure is given to the disclosing Party to enable it to seek to challenge the disclosure of its Confidential Information.

14.3 At any time upon written request, a Party must return all documents in any form which embody Confidential Information of the other Party, provided that a Party may retain one copy of such Confidential Information as necessary to meet its reasonable record-keeping requirements subject to an obligation to keep such copy confidential in accordance with this clause 14.

14.4 Each Party's obligations under this clause 14 survive expiration or earlier termination of this Agreement and continue until the Confidential Information disclosed to it lawfully becomes part of the public domain.

15. Reports, Records, Review and Evaluation

Reports

15.1 The Commissioned Organisation must provide ACIAR the Reports at the times specified in the Agreement Details, and any other reports as reasonably requested by ACIAR (such as interim final reports, project factsheets, and other ad hoc reports).

15.2 Where a self-assessment of the potential for significant environmental impacts under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) has been produced and accepted pursuant to this Agreement, the Commissioned Organisation will provide ACIAR with a report by 14 July each year on the implementation and effectiveness of the risk management procedures identified in the self-assessment.

15.3 Within 30 days of completion of any travel referred to in clause 12.1, the Commissioned Organisation will provide ACIAR a trip report including the travel itinerary and all information reasonably required by ACIAR to enable ACIAR to monitor the Project.

15.4 Each report provided under this clause 15 must be accurate, complete and detailed to enable ACIAR to confirm the true status of the Project, and (where applicable) prepared in accordance with the 'Guidelines for Annual Reports' available on the ACIAR website www.aciar.gov.au (**Guidelines**).

Access to documents

15.5 In clause 15.6, 'document' and 'Commonwealth Contract' have the same meaning as in the *Freedom of Information Act 1982* (Cth).

15.6 If:

(a) the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details

(b) this Agreement (or a subcontract of this Agreement) is a Commonwealth Contract, and

(c) the Commonwealth has received a request for access to a document created by, or in the possession of, the Commissioned Organisation (or any of its Personnel) that relates to the performance of this Agreement (and not to the entry into of this Agreement),

the Commonwealth may at any time by written notice require the Commissioned Organisation to provide the document to the Commonwealth, and the Commissioned Organisation must, at no additional cost to the Commonwealth, promptly comply with the notice.

Records

15.7 The Commissioned Organisation must, at its cost, for the period commencing on the Commencement Date and ending seven years after expiry or termination of this Agreement (**Bookkeeping Period**), keep (and ensure its Personnel keep) adequate books and records, in accordance with international accounting standards, in sufficient detail to enable the determination of how Payments have been expended, and the determination of any other amounts paid or payable under this Agreement (**Records**).

15.8 The Commissioned Organisation must, at its cost, keep (and ensure that its Approved Subcontractors keep) accurate hardcopy or digital scientific records relating to the Project – such records will include detailed, witnessed laboratory notebooks (which may be kept in digital or hardcopy format) sufficient to document any discoveries or inventions made in the course of the Project (**Scientific Records**).

Reviews

15.9 In addition to the Reviews that ACIAR may undertake as specified in the Agreement Details, ACIAR may at any time during the Term, undertake (through its Personnel or its appointed nominee(s)) to review and evaluate this Agreement and the exercise of rights and obligations relating to it (including in respect of the performance of Services). To facilitate any such review, the Commissioned Organisation will at its cost promptly provide any financial, technical or such other information (including Records and Scientific Records) as is required by ACIAR, provide ACIAR with access to Personnel participating in the Project to enable interview and general cooperation, and will at all reasonable times permit persons authorised by ACIAR to have access to the premises upon which the Services are being, or have been, performed.

15.10 ACIAR may at any time during the Bookkeeping Period, direct that the Records be examined by an independent accountant nominated by ACIAR and will permit the accountant to take copies or extracts from the Records. The Commissioned Organisation will give the accountant all assistance, access and facilities necessary to enable the accountant to verify the Records and will supply such other information as may be necessary or proper to verify how Payments have been expended.

Post Project Updates

15.11 Upon request at any time in the ten (10) years following completion of the Project, the Commissioned Organisation will use all reasonable endeavours to provide ACIAR updates in respect of the current outcomes and impact of the Project, having regard to Project objectives (**Post Project Update**). Each Post Project Update will (as all reasonable endeavours enable) include:

(a) details of Project impacts (including scientific impacts, capacity-building impacts, community impacts and environmental impacts)

(b) details of steps take to obtain the full benefit of Project outcomes

(c) where applicable, details of how Project outcomes could be better used to benefit communities, and

(d) learnings as to what future projects may be conducted to benefit communities in respect of the Project outcomes and topics related to the Project.

15.12 The Commissioned Organisation may charge ACIAR a fee for complying with clause 15.11, provided that:

(a) such fee is reasonable and commensurate with the effort involved in complying with clause 15.11, and

(b) the Commissioned Organisation has provided written notice to ACIAR of the amount of such fee (the notified amount calculated to comply with clause 15.12(a)) prior to commencing activities in compliance with clause 15.11.

Accessing Premises

15.13 In accessing the premises of the other Party (**Host**), a Party (**Visitor**) will:

(a) give reasonable written notice to the Host, such notice identifying the representatives of the Visitor to attend the Host's premises

(b) ensure that its representatives comply with all policies of the Host with respect to their attendance (including policies relating to health and safety, security, and standards of conduct) and otherwise comply with all reasonable directions, and

(c) procure that its representatives will (if required) sign a confidentiality agreement in favour of the Host to protect the confidentiality of any Confidential Information of the Host.

16. Termination and Reduction

Termination due to circumstances outside the control of the Parties

16.1 Should acts of God, fire, storm, flood, earthquake, explosion, accident, acts of a public enemy or terrorism, war, political upheaval, rebellion, insurrection, sabotage, epidemic, quarantine restrictions, industrial dispute, withdrawal of necessary support for the Project by a host nation government listed in the International Arrangements, transportation embargo or failure or delay in transportation render the completion of the Project impossible or unfeasible, either Party may terminate this Agreement upon providing the other with three months' written notice.

Termination

16.2 ACIAR may terminate or sever part of this Agreement without cause at any time by giving written notice to the Commissioned Organisation which must, on receipt, immediately cease all work and take appropriate action to mitigate any loss and prevent further costs being incurred with respect to the Services.

16.3 Without prejudice to any other rights ACIAR may have under this Agreement or at law, ACIAR may terminate or sever part of this Agreement for default by providing the Commissioned Organisation written notice if:

(a) the Commissioned Organisation breaches any term of this Agreement where that breach is not capable of remedy

(b) the Commissioned Organisation undergoes a change in Control or is subject to an Adverse Event

(c) the Commissioned Organisation or its Personnel engage in conduct that, in the reasonable opinion of ACIAR, is detrimental to the reputation of ACIAR or the Commonwealth, or

(d) if the Commissioned Organisation breaches any term of this Agreement where the breach is capable of remedy and the breach is not remedied within 14 days of receipt of notice in writing from ACIAR.

Effect of termination (or partial termination)

16.4 If this Agreement is terminated pursuant to clause 16.1, ACIAR may recover (and the Commissioned Organisation agrees to return) any Payments provided to the Commissioned Organisation that have not been expended as at the date the Commissioned Organisation was notified of termination.

16.5 Where this Agreement is terminated, wholly or in part, under clause 16.2, ACIAR must pay invoices in respect of:

(a) all reasonable amounts due in accordance with clause 16.2 for Services performed by the Commissioned Organisation in accordance with the terms of this Agreement up until the date of termination, and

(b) the equivalent of any liabilities or expenses of the Commissioned Organisation relating to the terminated Services which are substantiated, and which are properly incurred by the Commissioned Organisation, to the extent that those liabilities or expenses cannot be mitigated, but no other amount,

provided that in no event will ACIAR be required to pay any loss of prospective profits.

16.6 For the purposes of clauses 16.2 and 16.3, ACIAR may elect to sever part of this Agreement (**Partial Termination**) by notifying the Commissioned Organisation that it no longer requires the Commissioned Organisation to provide a particular Service, in which case:

(a) the Commissioned Organisation will cease to provide that Service

(b) ACIAR will no longer be obliged to provide any Payments in respect of that Service (and any Payments made available on account of the future performance of that Service will be returned to ACIAR), and

(c) this Agreement will be construed, and its provisions will be enforceable by and against the Parties, as if references to the Services the subject of that Partial Termination, and Payments made (or to be made) available in respect of those Services, were severed from the Contract.

16.7 If ACIAR notifies the Commissioned Organisation of termination of this Agreement under clause 16.3, ACIAR may, in addition to terminating this Agreement:

(a) recover any Payments provided to the Commissioned Organisation for Services or other obligations that have not been fulfilled or performed

(b) be regarded as discharged from any further obligations under this Agreement, and

(c) pursue any additional or alternative remedies provided by law.

17. Insurance

17.1 The Commissioned Organisation will, for so long as any obligations remain in connection with this Agreement, effect and maintain with reputable and substantial underwriters the following insurance:

(a) workers' compensation for an amount required by any relevant legislation

(b) in relation to Services performed in Australia, public liability insurance for an amount of not less than $20,000,000 per claim and $20,000,000 in aggregate

(c) in relation to Services performed outside Australia, adequate insurance against claims by third parties resulting from acts or omissions of the Commissioned Organisation in carrying out the Services, and

(d) adequate travel and medical insurance for any domestic and international travel undertaken on behalf of this Agreement by its Personnel.

17.2 Within 14 days of a written request from ACIAR, the Commissioned Organisation must provide ACIAR with a copy of any insurance policy (or related certificates of currency) effected in accordance with this clause 17 and of all receipts for payments of premiums.

17.3 The requirement of clause 17.1(c) will not apply in relation to work performed in a particular country if ACIAR has agreed in writing that such insurance is not available in relation to the performance of the Services in that country.

17.4 The Commissioned Organisation will ensure that any Approved Subcontractor maintains appropriate insurances.

17.5 Notwithstanding the above, the Commissioned Organisation may undertake self-insurance arrangements with ACIAR's prior written approval.

18. Indemnity

18.1 The Commissioned Organisation indemnifies ACIAR and the Personnel of ACIAR (**Those Indemnified**) from and against any loss (including legal costs and expenses on a solicitor/own client basis), or liability, incurred or suffered by any of Those Indemnified arising from any claim, suit, demand, action or proceeding by any person where such loss or liability was caused by any breach of a term or condition of this Agreement or wilful misconduct or unlawful or negligent act or omission of the Commissioned Organisation and the Personnel of the Commissioned Organisation in connection with the Services.

18.2 The Commissioned Organisation's liability to indemnify Those Indemnified under clause 18.1 will be reduced proportionally to the extent that any unlawful or negligent act or omission of Those Indemnified contributed to the loss or liability.

18.3 Neither party shall be liable to the other Party for any special, indirect or consequential loss or damages arising under or pursuant to this Agreement (including without limitation for loss of profits or an anticipated saving or benefit).

19. Compliance with laws and policies

Modern Slavery

19.1 In these additional terms 19.1 to 19.3:

(a) **Guiding Principles on Business and Human Rights** means the United Nations' Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework available at https://www.ohchr.org/documents/publications/ guidingprinciplesbusinesshr_en.pdf.

(b) **Modern Slavery** has the same meaning as it has in the *Modern Slavery Act 2018* (Cth).

19.2 The Commissioned Organisation must take reasonable steps to identify, assess and address risks of Modern Slavery practices in the operations and supply chains used in the provision of the Services, having regard to the Guiding Principles on Business and Human Rights.

19.3 If at any time the Commissioned Organisation becomes aware of Modern Slavery practices in the operations and supply chains used in the performance of this Agreement, the Commissioned Organisation must as soon as reasonably practicable take all reasonable action to address or remove these practices, including where relevant by addressing any practices of other entities in its supply chains.

Prohibited dealings

19.4 The Commissioned Organisation must ensure that it and any individuals, persons, entities or organisations involved in the Project, including its Personnel, are not:

(a) directly or indirectly engaged in preparing, planning, assisting or fostering a terrorist act

(b) listed terrorist organisations for the purposes of the *Criminal Code Act 1995* (Cth) (details of listed terrorist organisations are available at https://www.nationalsecurity.gov.au/Listedterroristorganisations/Pages/default.aspx)

(c) subject to sanctions or similar measures under the Charter of the United Nations Act 1945 (Cth) or the Autonomous Sanctions Act 2011 (Cth) (details of individuals and entities are available at: https://dfat.gov.au/international-relations/ security/sanctions/Pages/consolidated-list.aspx)

(d) listed on the 'World Bank's Listing of Ineligible Firms and Individuals' posted at https://www.worldbank.org/en/projects-operations/procurement/debarred-firms

(e) owned, controlled by, acting on behalf of, or at the direction of individuals, persons, entities or organisations referred to in clauses 19.4(a) to 19.4(d) above, or

(f) providing direct or indirect support, resources or assets (including any grant monies) to individuals, persons, entities or organisations referred to clauses 19.4(a) to 19.4(d).

19.5 Where the Commissioned Organisation becomes aware that there are reasonable grounds to suspect it or any of its Personnel has or may have contravened any part of clause 19.4, the Commissioned Organisation must:

(a) notify ACIAR and confirm that information in writing as soon as possible, which must be no later than within 24 hours

(b) immediately take all reasonable action to mitigate the risks, and

(c) take any other action required by ACIAR.

Security Requirements

19.6 The Commissioned Organisation must perform its obligations to the highest professional standards and comply with the security requirements for the protection of official information: as detailed in the Commonwealth Protective Security Policy Framework available at: https://www.protectivesecurity.gov.au/ as amended from time to time; and as advised by ACIAR from time to time during the term of this Agreement.

Public Interest Disclosure

19.7 Public officials (including service providers under a Commonwealth contract) who suspect wrongdoing within the Commonwealth public sector can raise their concerns under the *Public Interest Disclosure Act* 2013 (Cth). Prior to making a disclosure, refer to information available at: http://www.ombudsman.gov.au/about/making-a-disclosure/information-for-disclosers.

19.8 All Public Interest Disclosure matters (relating to this procurement) should be referred to:

Name/Position:	**Chief Financial Officer**
Address:	Chief Financial Officer ACIAR House GPO Box 1571, Canberra, ACT 2601
Telephone:	[redacted]

FOI Act s. 47f

Compliance with relevant legislation and policies

19.9 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must:

(a) observe the same standards and obligations that are imposed on Commonwealth personnel under the *Work Health Safety Act 2011* (Cth) or where relevant any state or territory law and regulations applicable to work health and safety

(b) comply with the obligations imposed under the *Lobbying Code of Conduct* (Cth), if applicable

(c) comply with all relevant legislation of the Commonwealth, or of any State, Territory or local authority under any agreement entered into with the Commonwealth including:

(i) the *Crimes Act 1914* (Cth)

(ii) the *Disability Discrimination Act 1992* (Cth)

(iii) the *Racial Discrimination Act 1975* (Cth)

(iv) the *Sex Discrimination Act 1984* (Cth)

(v) the *Age Discrimination Act 2004* (Cth) and the *Age Discrimination (Consequential Provisions) Act 2004* (Cth)

(d) comply with all applicable workers compensation laws, and

(e) comply with such other Commonwealth and agency policies relevant to the performance or provision of the Services and notified in writing to the Commissioned Organisation.

19.10 If the Commissioned Organisation is not identified as an 'Australian Entity' in the Agreement Details then, without limiting any other provisions of this Agreement, the Commissioned Organisation must comply with all laws and standards corresponding or equivalent to those listed in clause 19.9 in the country or territory in which the Commissioned Organisation is based or in which Services are performed (as applicable).

Child safety

19.11 If any part of the Project involves the Commissioned Organisation employing or engaging Personnel in a manner that requires the Personnel by local law to have a working with children check (or equivalent) to undertake the Project or any part of the Project, the Commissioned Organisation agrees:

(a) to comply with all local law relating to the employment or engagement of people who work or volunteer with children in relation to the Project, including mandatory reporting and working with children checks (or equivalent), and

(b) if requested, provide the Commonwealth at the Commissioned Organisation's cost, an annual statement of compliance with this clause 19.11, in such form as may be specified by the Commonwealth.

Privacy

19.12 In clauses 19.13 to 19.16, capitalised terms have the meaning provided in the *Privacy Act 1988* (Cth) (**Act**).

19.13 The Commissioned Organisation acknowledges that ACIAR will store, use and disclose Personal Information in accordance with its privacy policy located at www.aciar.gov.au/privacy-policy and the Commissioned Organisation is responsible for obtaining all necessary consents to enable ACIAR to do so in respect of Personal Information provided to ACIAR by or through the Commissioned Organisation pursuant to this Agreement.

19.14 The Commissioned Organisation must in undertaking this Agreement comply with all applicable privacy laws including, to the extent that the Australian *Privacy Act 1988* (Cth) applies to any of its activities under this Agreement by:

(a) complying with the Australian Privacy Principles and with any registered, applicable APP Code or Registered CR Code, and

(b) cooperating with any reasonable request or direction of ACIAR in relation to an inquiry, audit or other exercise of powers or functions, by the Information Commissioner under that Act.

19.15 Where the Act applies:

(a) if the Commissioned Organisation becomes aware that there are reasonable grounds to suspect that there may have been an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its performance of the Services, the Commissioned Organisation agrees to:

(i) notify ACIAR in writing as soon as possible, which must be no later than within three (3) days of becoming aware, and

(ii) unless otherwise directed by ACIAR, carry out an assessment in accordance with the requirements of the Act, and

(b) if the Commissioned Organisation is aware that there are reasonable grounds to believe there has been, or where ACIAR notifies the Commissioned Organisation that there has been, an Eligible Data Breach in relation to any Personal Information held by the Commissioned Organisation as a result of this Agreement or its provision of the Services, the Commissioned Organisation must:

(i) take all reasonable action to mitigate the risk of the Eligible Data Breach causing serious harm to any of the individuals to whom the Personal Information relates

(ii) unless otherwise directed by ACIAR, take all other action necessary to comply with the requirements of the Act, and

(iii) take any other action as reasonably directed by ACIAR.

19.16 Where privacy or data breach laws of another territory apply, the specific obligations of the Commissioned Organisation under clause 19.15 shall be modified only as necessary to ensure compliance with the privacy or data breach laws of that territory.

Fraud and Anti-Corruption

19.17 The Commissioned Organisation warrants that neither it nor its Personnel will make or cause to be made, receive or seek to receive any offer, gift or payment or benefit of any kind, which could be construed as an illegal or corrupt act, either directly or indirectly to any individual or organisation in relation to the execution of this Agreement.

19.18 Without limitation to any other clause of this Agreement, the Commissioned Organisation must comply with ACIAR's Fraud Policy Statement and guidance on reporting any allegations or concerns regarding fraud within the Project which is available at: https://www.aciar.gov.au/Standard-Contract-Conditions-and-Intellectual-Property-Policy.

19.19 On request, the Commissioned Organisation will provide for ACIAR's review and acceptance a fraud control plan that details actions the Commissioned Organisation will undertake in order to identify, report and manage instances of actual or potential fraud. The fraud control plan will specify what audit procedures and audit frequency will be applied.

19.20 If the Commissioned Organisation is identified as an 'Australian Entity' in the Agreement Details then, without limiting its obligations under this clause 19, the Commissioned Organisation must comply with the requirements of the Commonwealth Fraud Control Framework or any replacement guidelines, in force from time to time, available at http://www.ag.gov.au/Integrity/counter-fraud/fraud-australia/Documents/CommonwealthFraudControlFramework2017.DOCX

Conflict of interest

19.21 The Commissioned Organisation warrants that, to the best of its knowledge after making diligent inquiry, at the date of signing this Agreement no conflict of interest exists or is likely to arise in the performance of its obligations under this Agreement.

19.22 If, during the performance of the Services a conflict of interest arises, or appears likely to arise, the Commissioned Organisation must:

(a) notify ACIAR immediately in writing

(b) make full disclosure of all relevant information relating to the conflict, and

(c) take such steps as ACIAR requires to resolve or otherwise deal with the conflict.

20. Taxes & Invoices

Stamp Duty and other taxes

20.1 Subject to clauses 20.2 and 20.3, the Commissioned Organisation must pay all:

(a) stamp duty (including penalties and interest) assessed or payable in respect of this Agreement and the undertaking of the Project, and

(b) all taxes, duties and government charges imposed or levied in Australia or overseas in connection with the performance of this Agreement.

GST

20.2 In clause 20.3:

(a) subject to clause 20.2(b), a word or expression defined in the *A New Tax System (Goods and Services Tax Act) 1999* (Cth) (**GST Act**) has the meaning given to it in the GST Act, and

(b) where a taxable supply takes place outside Australia in a territory that imposes a goods and services tax, value added tax, or similar, then references in this clause to GST, GST

Liability, and GST Law will refer to the applicable tax, tax liability and legislation in that territory and clause 20.3 will be read and construed accordingly.

20.3 Unless otherwise specified in the Budget, amounts that ACIAR is required to pay under this Agreement are calculated on a GST-exclusive basis. Where the Commissioned Organisation becomes liable to remit any amount of GST in respect of any Supply it makes to ACIAR in accordance with this Agreement (**GST Liability**), the amount otherwise payable by ACIAR under this Agreement will be increased by the amount of the GST Liability, or any lesser amount required by law. The increased amount will be payable by ACIAR in the same manner and at the same time as other amounts payable under this Agreement; and where required, the Commissioned Organisation will provide a tax invoice that may enable ACIAR, if permitted by the GST Act, to claim a credit or refund, a notional credit refund, of GST.

21. Miscellaneous

Warranties

21.1 The Commissioned Organisation warrants that it has all necessary permissions and is entitled to undertake the Services and that it is not subject to any agreement, policy, arrangement or otherwise, which is inconsistent with or would otherwise restrict its ability to undertake the Services and vest or licence IP Rights under clause 13.

Approvals and consents

21.2 Except where this Agreement expressly states otherwise, a Party may, in its discretion, give conditionally or unconditionally or withhold any approval or consent under this Agreement.

Entire agreement

21.3 This Agreement contains the whole of the agreement between the Parties with respect to its subject matter and supersedes any and all other representations or statements by a Party whether oral or in writing and whether made prior or subsequent to the date of this Agreement.

Notices

21.4 All notices, requests, demands and other communications under this Agreement will be in writing directed to the representative specified in the Agreement Details (which may be updated by providing a notice to the other Party in accordance with this clause 21.4) and will be deemed to have been given: (i) immediately if delivered by hand, (ii) on the seventh day following postage if delivered by express post; and (iii) on the next business day in the location of the recipient's address if sent by email.

Negation of Employment, Partnership and Agency

21.5 The Commissioned Organisation will not by virtue of this Agreement be, or for any purpose be deemed to be, an officer, employee, partner or agent of ACIAR or the Commonwealth, or as having power or authority to bind or represent ACIAR or the Commonwealth, and will not represent itself, and will ensure that its Personnel do not represent themselves, as such.

Applicable Law

21.6 This Agreement will be governed by and construed in accordance with the laws of the State of Victoria. The Commissioned Organisation submits to the jurisdiction of the courts of Victoria and any court competent to hear appeals from those courts.

Waiver

21.7 A waiver by either Party in respect of any breach of a condition or provision of this Agreement must be made in writing and will not be deemed to be a waiver in respect of any continuing or subsequent breach of that provision, or breach of any other provision. The failure of either Party to enforce any of the provisions of this Agreement at any time will in no way be interpreted as a waiver of such provisions.

Authority and consents

21.8 Any and all rights, powers, authorities and discretions expressed in this Agreement or in the specifications to be conferred upon or vested in ACIAR may be exercised by any person designated for that purpose by the Commonwealth minister responsible for ACIAR.

21.9 Except as expressly provided in this Agreement, ACIAR may conditionally or unconditionally in its absolute discretion give or withhold any consent or approval under this Agreement.

Assignment

21.10 The Commissioned Organisation must not assign or attempt to assign or otherwise transfer or encumber any right or obligation arising out of this Agreement except with the written consent of ACIAR.

Variation to this Agreement

21.11 This Agreement may only be amended by a written instrument signed by the Parties.

No Merger

21.12 The rights and obligations of the Parties under this Agreement do not merge on completion of any transaction contemplated by this Agreement.

Further acts

21.13 A Party, at its own expense and within a reasonable time of being requested by the other Party to do so, must do all things and execute all documents that are reasonably necessary to give full effect to this Agreement and the transactions contemplated by it.

Severance

21.14 A term or part of a term of this Agreement that is illegal or unenforceable may be severed from this Agreement and the remaining terms or parts of the term of this Agreement will continue in force.

Costs and Expenses

21.15 Each Party will bear its own costs and expenses in relation to the negotiation, preparation, execution, delivery and completion of this Agreement and any related documentation.

Counterparts

21.16 This Agreement may be executed in counterparts. All executed counterparts constitute one document. Counterparts may be exchanged and relied on in facsimile or digital scanned form.

Survival

21.17 Without limitation to the express provisions of this Agreement or those clauses of this Agreement which are intended or capable of having effect following the expiry or termination of this Agreement, the following clauses will survive the expiry or termination of this Agreement: clauses 1 to 3, 10.4, 10.5, 13 to 15, 16.4, 16.5, 16.7,17, 18, 20, 21.3, 21.5, 21.6, 21.7, 21.10, 21.12, 21.14, 21.16 and this clause 21.17.

EXECUTED as an Agreement

Signed for and on behalf of the **Commonwealth of Australia** as represented by the **Australian Centre for International Agricultural Research ABN 34 864 955 427** by its duly authorised delegate

[redacted] ←

Signature of delegate

Prof Wendy J. Umberger

Name of delegate (print)

Chief Executive Officer

Position of delegate (print)

ON: [insert date] 10 / 09 / 2024 ←

Executed by **Charles Sturt University** by its duly authorised delegate

FOI Act s. 47

[redacted] ←

Professor Mark Evans

Name of delegate (print)

Deputy Vice-Chancellor (Research)

Position of delegate (print)

ON: [insert date] 21 / 06 / 2024 ←

A8 apply equally to the Auditor-General or a delegate of the Auditor-General, or the Privacy Commissioner or a delegate of the Privacy Commissioner, for the purpose of performing the Auditor-General's or Privacy Commissioner's statutory functions or powers

(h) the Commissioned Organisation must do all things necessary to comply with the Auditor-General's or his or her delegate's or the Privacy Commissioner's or his or her delegate's requirements, notified under additional term A8(g), provided such requirements are legally enforceable and within the power of the Auditor-General, the Privacy Commissioner, or his or her respective delegate

(i) the requirement for, and participation in, audits does not in any way reduce the Commissioned Organisation's responsibility to perform its obligations in accordance with this Agreement

(j) the Commissioned Organisation must ensure that any subcontract entered into for the purpose of this Agreement contains an equivalent clause granting the rights specified in this additional term A8

(k) nothing in this Agreement reduces, limits or restricts in any way any function, power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner. The rights of the Commonwealth under this Agreement are in addition to any other power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner, and

(l) this additional term A8 applies for the Term and for a period of seven years from the expiry or termination of this Agreement.

A9. Intellectual property

A9.1 Without limitation to additional term A3.2(a), the Commissioned Organisation and any relevant Collaborating Institution, as part of the entering into a Collaborating Institute Agreement, negotiate Intellectual Property arrangements between those parties (**IP Arrangements**) that cover matters such as:

(a) how Project IP may be used and disseminated by those parties in accordance with the terms of this Agreement including, if applicable, the CGIAR IA Principles

(b) the terms of any rights to Project IP between those parties, including securing such rights as are necessary for the Commissioned Organisation to grant ACIAR and any other parties rights to Project IP pursuant to this Agreement

(c) the terms of any licence of Background IP, including securing such rights as are necessary for the parties to undertake the Project and to grant ACIAR or any other party any rights to Project IP pursuant to this Agreement

(d) indemnity arrangements against liability arising from claims by third parties in connection with the breach of Intellectual Property Rights

(e) whether the Commissioned Organisation and any Collaborating Institution will seek to put in place any 'Limited Exclusivity Agreements' or 'Restricted Use Agreements' as defined in and in accordance with Articles 6.1 to 6.3 of the CGIAR IA Principles, and

(f) the allocation of costs relating to the application for and maintenance of the IP Rights between the Commissioned Organisation and any relevant Collaborating Institution,

provided that in no circumstances may the IP Arrangements provide for arrangements that would be inconsistent with any other term of this Agreement (including as found in the Project Document), or otherwise place the Commissioned Organisation in breach of this Agreement.

details of the duration of the proposed appointment

(c) a copy of the curriculum vitae of each of the proposed persons which details relevant employment experience and educational qualifications, and

(d) any other information relating to the proposed appointment necessary for, or directly related to, the Services.

A8. Audit and access

Without limitation to clause 15:

(a) the Commonwealth through ACIAR or a representative may conduct audits relevant to the performance of the Commissioned Organisation's obligations under this Agreement. Audits may be conducted of:

(i) the Commissioned Organisation's operational practices and procedures as they relate to this Agreement, including security procedures

(ii) the Commissioned Organisation's compliance with its confidentiality, privacy and security obligations under this Agreement

(iii) records and documentation in the possession of the Commissioned Organisation relevant to the Services or this Agreement, and

(iv) any other matters determined by the Commonwealth to be relevant to the Services or this Agreement

(b) the Commonwealth through ACIAR or a representative may, at reasonable times and on giving reasonable notice to the Commissioned Organisation:

(i) access the premises of the Commissioned Organisation to the extent relevant to the performance of this Agreement

(ii) require the provision by the Commissioned Organisation, its Personnel, of records and information in a data format and storage medium accessible by the Commonwealth by use of the Commonwealth's existing computer hardware and software

(iii) inspect and copy documentation, books and records, however stored, in the custody or under the control of the Commissioned Organisation, its Personnel, and

(iv) require assistance in respect of any inquiry into or concerning the Services or this Agreement. For these purposes an inquiry includes any administrative or statutory review, audit or inquiry (whether within or external to the Commonwealth), and any inquiry conducted by Parliament or any Parliamentary committee

(c) the Commissioned Organisation must provide access to its computer hardware and software to the extent necessary for the Commonwealth to exercise its rights under this additional term A8, and provide the Commonwealth through ACIAR or its representative with any reasonable assistance requested by the Commonwealth to use that hardware and software

(d) the parties confirm that the rights of the Commonwealth set out in Additional Terms A8(b) and A8(c) may only be exercised for the purposes established in additional term A8(a)

(e) the Commonwealth through ACIAR or a representative must use reasonable endeavours to ensure that:

(i) audits performed under clause A8, and

(ii) the exercise of the general rights granted by clause A8(b) by the Commonwealth,

do not unreasonably delay or disrupt in any material respect the Commissioned Organisation's performance of its obligations under this Agreement or its business.

(f) each Party must bear its own costs of any reviews and/or audits

(g) the rights of the Commonwealth through ACIAR or its representative under additional term

A3.6 Notwithstanding clause 11.3, the ownership of Supplies procured within a Collaborating Country will vest in the government of that Collaborating Country on completion of the Project, and the Commissioned Organisation will take whatever action is necessary to effect that transfer.

A4. Project Committee

A4.1 ACIAR may establish a Project Committee that will include a representative of each of the Parties and, where relevant and appropriate (as determined by ACIAR), any Collaborating Institutions.

A4.2 The Project Committee will advise the Parties in relation to Project matters, and may call for specialised advice on any matter related to the Project.

A5. Payments

A5.1 The Commissioned Organisation may, subject to the following qualification and without reference to ACIAR, transfer Payments payable in respect of a particular item in the Budget for the Project to another item. The amount transferred may be the lesser of 10% of the total of the particular item in the Budget or $10,000 from which the Payments are being transferred.

A5.2 Notwithstanding additional term A5.1, the Commissioned Organisation will not transfer Payments payable in respect of a particular item in the Budget payable outside Australia to another item in the Budget payable outside Australia. However, any Collaborating Institution will be able to vary its component of the Budget in the same way described in additional term A5.1. Transfer of Payments between items in excess of the amount referred to in additional term A5.1 must not be made without the prior written approval of ACIAR.

A5.3 Where the Budget for the Project provides for the payment of any Payments by the Commissioned Organisation to a Collaborating Institution, the Commissioned Organisation will pay those Payments six-monthly in advance within seven days following receipt of Payments from ACIAR. Any Payments that are unexpended by the Collaborating Institution at the expiration of the Payment Period for which they were allocated will be carried over for expenditure in the following Payment Period and the advance made for the following Payment Period by the Commissioned Organisation to the Collaborating Institution will be reduced proportionately, unless ACIAR approves otherwise in writing.

A6. Dispute Resolution

A6.1 Subject to additional term A6.4, before resorting to external dispute resolution mechanisms, the Parties will attempt to settle by negotiation any dispute in relation to this Agreement including by referring the matter to personnel who may have authority to intervene and direct some form of resolution.

A6.2 If a dispute is not settled by the Parties within 10 working days of one Party first sending to the other Party written notice that they are in dispute, the dispute may be the subject of court proceedings or may be submitted to some alternative dispute resolution mechanism as may be agreed in writing between the Parties.

A6.3 Notwithstanding the existence of a dispute, each Party will continue to perform its obligations under this Agreement.

A6.4 A Party may commence court proceedings relating to any dispute arising from this Agreement at any time where that Party seeks urgent interlocutory relief.

A7. Personnel

A7.1 The Commissioned Organisation will obtain the prior written approval of ACIAR to the appointment of any specialist or scientist Personnel not identified in the Project Document to perform the Services, which approval will not be unreasonably withheld. If ACIAR requests, the Commissioned Organisation must promptly provide any relevant information relating to such specialist or scientist including:

(a) the full names and date of birth of the proposed person(s)

(b) a statement which describes the position to be held, the position selection criteria and

Additional Terms

A1. Interpretation and further definitions

A1.1 In these Additional Terms, unless the context otherwise requires, reference to a clause is a reference to a clause of the Primary Terms and reference to an additional term is to a clause of these Additional Terms.

A2. Application

A2.1 These Additional Terms will only take effect in accordance with clause 2.

A3. Collaborating Countries and Collaborating Institutions

A3.1 As applicable, international agreements that establish the overseas operating framework for the Project including such matters as protocols, customs assistance, in-country security, indemnities and intellectual property rights will be signed by the parties to the Project, including the Parties and any applicable Collaborating Institutions.

A3.2 In undertaking the Project, the Commissioned Organisation will engage with each Collaborating Institution (if any) via an agreement:

(a) as negotiated and agreed with each Collaborating Institution, provided that in no circumstances may an agreement with a Collaborating Institution provide for arrangements that would be inconsistent with any other term of this Agreement (including as found in the Project Document), or otherwise place the Commissioned Organisation in breach of this Agreement, or

(b) substantially on the terms set out in Schedule 1 to these Additional Terms,

(**Collaborating Institution Agreement**).

A3.3 The Commissioned Organisation warrants that, as of the date of signing this Agreement, each Collaborating Institution has received a draft copy of a proposed Collaborating Institution Agreement and that the terms of a proposed Collaborating Institution Agreement have either:

(a) been agreed and executed by the Commissioned Organisation and each Collaborating Institution, or

(b) been in substance approved by each of the Commissioned Organisation and each Collaborating Institution, and

the Commissioned Organisation shall provide ACIAR with a copy of each executed Collaborating Institution Agreement as soon as practical following the later of:

(c) execution of this Agreement, or

(d) execution of the relevant Collaborating Institution Agreement.

A3.4 The Commissioned Organisation acknowledges that ACIAR may:

(a) delay the provision of any Payments until the Commissioned Organisation has provided ACIAR with copies of all applicable Collaborating Institution Agreements, and

(b) terminate this Agreement with immediate effect upon providing the Commissioned Organisation written notice if the Commissioned Organisation has not provided ACIAR with all applicable Collaborating Institution Agreements within one (1) calendar month of the date this Agreement is signed by the last Party to sign, and clause 16.7 shall apply.

A3.5 Without limitation to clause 5, in performing the Services the Commissioned Organisation will cooperate fully with any Collaborating Institution for the purpose of ensuring timely completion of the Project.

ANNEXURE B – ADDITIONAL TERMS

ANNEXURE A – PROJECT DOCUMENT

Australian Government

Australian Centre for
International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/017 v1
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organization, collaborating institution(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavors to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Project Variation

[redacted]

Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/017
Project title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Proposal stage	Full Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/09/2019
Proposed finish date	~~31/08/2022~~ 31/12/2022

Key contacts

Activity leader: Commissioned agent

Title and name	Dr Lee Baumgartner
Position	Associate Research Professor (Fisheries and River Management)
Organisation	Charles Sturt University
Phone	[redacted]
Fax	
Email	
Postal address	
Street address (if different to postal)	

Administrative contact: Commissioned agent

Title and name	Dr Jason White
Position	Director – Research Office
Organisation	Charles Sturt University
Phone	[redacted]
Fax	
Email	
Postal address	

Collaborating scientist: Australian collaborating organisation

Title and name	Karl Pomorin
Position	Managing Director
Organisation	KarlTek Pty Ltd
Phone	[redacted]
Fax	
Email	
Postal address	
Street address	

Collaborating scientist: partner country collaborating organisation

Title and name	Mr Douangkham Singhanouvong
Position	Deputy Director
Organisation	Living Aquatic Resources Research Center (Lao PDR)
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FOI Act s. 47

Contents

1 Project Summary

1.1 Background and Justification

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupts access to vital spawning, nursery and feeding habitat. The LMB fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, will be operational in 2019. Xayaburi Dam blocks the entire width of the river, presenting an impassable barrier to all fish species. Significant investment (US$300M) to provide for fish passage was incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world. Nevertheless, the facilities need to be rigorously assessed to determine if they meet the design specifications.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. The dam design includes a series of 70 different moveable gates which can be configured to alter fish pass flow in order to improve passage rates for specific species and/or specific seasonal flows. The project team will be able to, within the funding envelope on offer, adaptively alter the configuration of the fishway and determine if different settings alter passage rates for particular fish species and their life stages, and for different seasonal flow rates. This will provide XPCL with operational recommendations to optimise the performance of their facilities overall. This represents a substantial challenge and the question of whether the fish passage facilities will be effective in allowing a large proportion of fish numbers and species to pass is a question that the developer, Government of Lao PDR and scientists are all keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential to be developed in regions where poor people are dependent on natural resources. The Xayaburi facilities provide an opportunity to design and commence experiments to test the efficiency of the fish passage design, and to apply/adapt learnings to other sites.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods that will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and *in situ*. These trials will be used to install a functional tag detection system which will be used. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust approaches to calculating fish pass efficiency. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Assess upstream fish passage within the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the 30-year concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). The overall project budget, excluding the SRA commitment, is split between three cash contributors [redacted] as significant additional in-kind support over the three year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defendable, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used to improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its support or publication of results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to other sites, for example, both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities and monitoring programs. The research methods developed here may lead to a new set of standards that can be applied at other sites.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams) (Commission 2010). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB (Hortle 2007, Baumgartner et al. 2016). Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein (ICEM 2010). Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction (Amornsakchai et al. 2000). The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade (Commission 2010), there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong’s productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB (Orr et al. 2012). All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing a productive river fishery. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 95% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. This work was done by a US company and did not involve Australian expertise. XPCL has invested US$300 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America (Williams 2008), but where investment only targets salmon species. XPCL invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site. The purpose was to exchange information especially in relation to possible future

research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.2 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households (Hortle 2007). Most rural Asian citizens are actively involved in inland capture fisheries and river, and fishery health is crucial to securing food and income for local communities (Dugan et al. 2006, Millar et al. 2018). The Xayaburi Dam was expected to have a potential impact on upstream food resources; which is why a fish pass is being constructed. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It will also address an important planning need across the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development (Dugan et al. 2006). Irrigation development has negatively impacted inland fisheries (Dudgeon 2000). This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating positive outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing (Siason et al. 2010). Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has brought together an international team of private, developmental and governmental sectors to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to develop methods which will be available to quantify fisheries migration studies into the future.

2.3 Relationship to other ACIAR investments and other donor and partner-country activities

2.3.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (Australian Government AusAID 2012). By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies if the fish pass is effective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising female professionals to use the newly established research infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining robust fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome 'Agriculture, Fisheries and Water'. Hydropower development is one of the most significant water management issues in the LMB; and Xayaburi Dam, being the first site, is of particular significance and international interest. [redacted] Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due in December 2019. To maintain continuity for project staff, the large follow-on project must commence in August 2019.

2.3.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in researching the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies on all aspects of fish passage (upstream and downstream). XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.4 Research questions

2.4.1 Xayaburi fishpass overview

Specific design parameters were incorporated into the dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Fig. 1). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

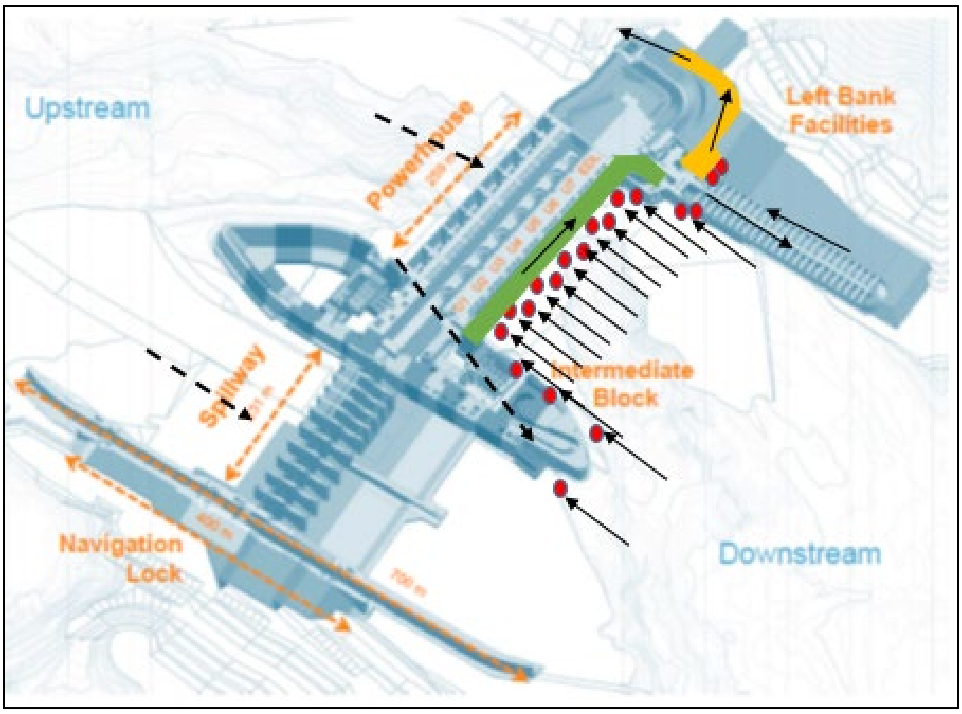


Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

2.4.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	**Potential research methods**
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	**Potential research methods**
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

2.4.3 Request from XPCL: Final selection of Research Questions

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, is beyond the scope of the available budget so the ACIAR/DFAT team is only focusing on methods to assess upstream fish passage at this stage. Consequently, the research questions posed are:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

2.4.4 Previous work on fish species selection for passage

There have been a number of fish studies done in the region of the dam as part of the environmental approval process, as well as earlier studies – in both the published and grey literature. These have generated a list of 308 potential adult species in the region, many of which are migratory.

Part of the GoL conditions of approval was that XPCL are required to provide for migratory fish to pass through the dam. To ensure the fish passage design catered to the slowest swimming species, FishTek, a British consulting company, performed a series of fish passage trials to identify the swimming abilities of key species. The swimming abilities of the slowest species formed the basis for the final design decisions for the fishway engineering. The GoL and XPCL agreed on a list of 26 potential migratory adult species (Table 2) that were the most important to monitor for effective passage. Their criteria for importance were based on a combination of food security and conservation significance.

XPCL contracted fishermen surveys to identify important species to the local fishers and communities (Team consulting, 2014). Using this study and others done in the region, we have highlighted in Table 2 (in bold) those species considered important for food security for local communities.

Thus, fish species selection in the project will be based on:

i) Those species that have been listed as important to pass through the fish passage by the GoL/XPCL, which includes species important to food security for local communities and conservation significance, and

ii) Those species that can be successfully tagged, released and monitored.

2.5 Gender focus

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong River bank in Xayaburi and Luang Prabang provinces, with seven of these requiring relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP has to enhance the quality of life for the project affected people (PAPs) and to minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Our research team is playing a very small, but important, role within XPCL's community consultation process. Our team will participate within the XPCL monitoring framework. In particular, we will engage with the XPCL consultation framework through our Lao government partners to ensure our decisions about fish species selection in relation to food security are endorsed by locals; including men and women. We also plan to include a Lao national on a project reference panel, so will report to them on our level of engagement with communities and inclusion of gender perspectives on key decisions, particularly regarding species selection.

Consideration of gender within the research team

Our research team consists of XPCL staff, Laos government (LARReC) and university staff (NUOL) and the Australian team. The XPCL monitoring team was selected by the company and staff were allocated to our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately, this has provided a gender structure among the project team which is predominantly male.

Outside the nominated project team in-country, the Australian team strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female Australian honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, but that the team is more balanced.

3 Research strategy and partnerships

3.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass, upstream, large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems.

The logical sequence for the proposed research is to:

1. Perform laboratory and *in situ* trials of three techniques (PIT detection antennas, electrofishing boat and a long-term tagging study) to optimise tag and recapture methods
2. Implement these methods at the dam site

3. Perform real-time monitoring of upstream fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual upstream fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, to report on the daily operation of the fish pass
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. Most of the current knowledge pertaining to the effectiveness of fishway designs has been for temperate species, and/or has come from laboratory-based trials (Mallen-Cooper 1992), whereas very little knowledge has been obtained via *in situ* field-based evaluations (Baumgartner et al. 2012). Indeed, only two *in situ* fishway evaluations have been published thus far in the LMB (Baumgartner et al. 2012, Baumgartner et al. 2018). At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defendable; and
c) When combined, provide an overall picture of upstream fish pass effectiveness.

4.1 Project aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities to move fish upstream.

The project team has been asked to provide advice on optimizing fish passage performance, not to set targets for triggering changes in operational procedures. We will select a subset of the 70 moveable gates within the fish passage design as reference points for fish pass performance. Each of these reference points will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. The results for various species, life stages and times of the year will be used to establish maximum achievable passage rates for each target species. These rates will be used to advise when and what operational changes should be made to the fishway to optimise the fishway's effectiveness for the target species, life stages and/or times of year.

The specific objectives are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

We note that passing fish downstream, including eggs and larvae, is also a significant challenge at the site. However, at this stage the team has only been asked to focus on upstream moving fish through the fish pass facilities. Downstream movement studies are equally important but, at this stage, are beyond the scope of the available budget and

request from XPCL. The team are very experienced with downstream movement work and can consider additions at a later stage if requested and appropriately resourced.

4.2 Research activities, methods and outputs

4.2.1 Monitoring upstream fish movement at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods (Williams 2008). Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters) (Williams 2008). In terms of fish monitoring research, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation, thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field

6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system), but have low overall ongoing running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely (Castro-Santos et al. 1996). At other dam sites world-wide, PIT data is being used to advise daily operations in relation to upstream migration rates. For instance, Bonneville Dam on the Columbia River (USA) has an elaborate set of fish passes and PIT systems (Williams 2008). The PIT systems report daily fish movement rates, both upstream and downstream, to a cloud-based database. Scientists monitor, in real time, passage rates and species arrivals. The PIT systems also report entrance efficiency and percentage passage rates based on pre-calculated algorithms. When different species arrive, or passage rates change, the flow rates through the dam gates or fishway channel are changed to maximise efficiency. These are ways in which PIT data can be used to provide real-time feedback between fish movement efficiency and dam operations.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

Integrity: This is the critical component of any system. A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

Veracity: It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system, a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events.

Reliability: This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency.

In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance (Castro-Santos et al. 1996). They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Selection of fish tracking technologies relevant to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL need to demonstrate through their research and monitoring program that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific upstream fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate fish are moving upstream.

PIT tags were determined to be a suitable technology upon which to base initial trials for upstream migration studies. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully (Castro-Santos et al. 1996, Baumgartner et al. 2010), (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in*

and *ex-situ*. Based on successes at other dam sites internationally (Castro-Santos et al. 1996, Baumgartner et al. 2010), PIT tagging has been identified as the most suitable technique. If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase (18 months): There is the actual testing (offsite) and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation.

(2) Operational Implementation (18 months): Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise the Xayaburi fishway's adjustable settings and integrate fish movement requirements into dam operation management.

4.2.6 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a "high dam" fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA) (Williams 2008). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System (PTAGIS) framework. PTAGIS is a large, spatially integrated upstream fish migration monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is 'pinged' within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement (Downing et al. 2001, Williams 2008).

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass (Barrett and Mallen-Cooper 2006). Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative

benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales) (Barrett and Mallen-Cooper 2006). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to that based on PTAGIS (See https://www.ptagis.org/). With two such systems operating successfully in cascade rivers internationally, and with a cascade proposed for the LMB, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

4.2.7 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a ‘loop’ that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency (K. Pomorin pers. comm.). PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway ‘slots’ to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions. The team have identified research questions that could be answered using a PIT system installed into the slots (of various widths) located along the length of the fish passage (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each is necessary.

Stage 2: Obtain detailed engineering drawings. The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped to identify optimal design configurations.

Stage 3: **Construct prototype antennas and set up ‘in the dry’.** KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions; Figure 2). The antennas, as indicated in the options diagrams over page, will be constructed. The efficiency tests will be performed scientifically. Antennas will be tested for a range of width’s and length’s and two tag sizes will be assessed (23 mm tag and 12mm tag). The 12 mm tag is preferable as it is much smaller and produces a lower “tag burden” on fish. However, it has a smaller read-range

than the 23mm tag. Determining if 12 mm tags will perform efficiently with large antennas is essential. The approach will be to construct and establish each antenna, take five tag readings (each of a 12 mm and 23 mm tag) and record the read distances (in cm). These readings will be plotted to provide an efficiency map for each antenna morphology. This approach is considered world-standard for antenna efficiency tests.

Figure 2. Slots where antennas are proposed to be installed and possible configurations.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the *ex situ* test in stage four in terms of percent number of tagged fish detected (See Table 3 for list of fish passage criteria to be assessed), we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these *in situ* tests will then advise the locations where fixed antennas should be located.

Additionally, and based on *ex situ* testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway. Here we will initially focus on the entrance and exit locations of the fishway. A ‘bank’ of antennas will be fitted to the entrance slots; a second ‘bank’ will be fitted to the exit slots.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

4.2.8 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable

because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others) (Thorstad et al. 2013). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

Research activities

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 300 migratory species at the Xayaburi site and at least 26 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Two previous fish studies have been conducted at the site. The first, by “Team Consulting”, and the second by “FishTek”. These studies firstly, quantified the species present on site and, secondly, determined the swimming ability of these species to inform fishway design. These data, along with information from the community consultations as to which species are important food sources, was used to generate a shortlist of potential priority species for fish passage. (Table 2). The fish pass infrastructure was designed specifically to accommodate these species. What is unknown is whether these species are optimal candidates for PIT tagging. It is proposed, to test the efficacy of PIT tagging for each species under laboratory conditions.

Stage 2: Construct a fish hatchery facility to house the wild caught fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction is due for completion in June 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial ACIAR-funded work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish (Grieve et al. 2018a). So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days (Grieve et al. 2018a). However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the batch of tagged fish to inform on fishway operation.

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

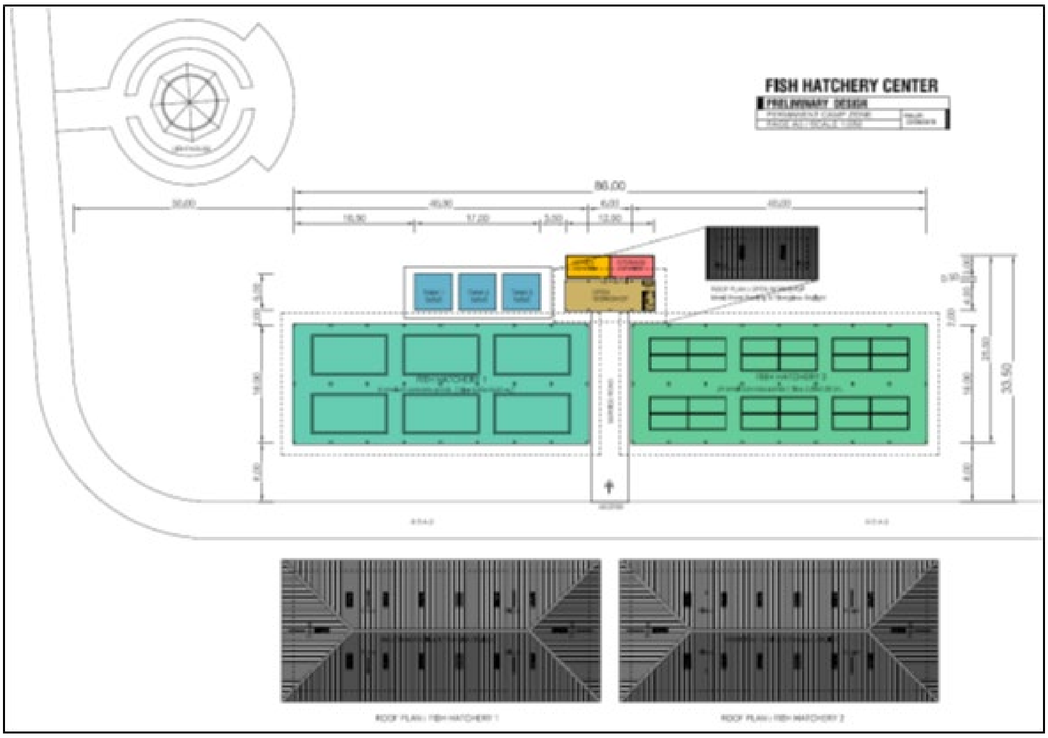
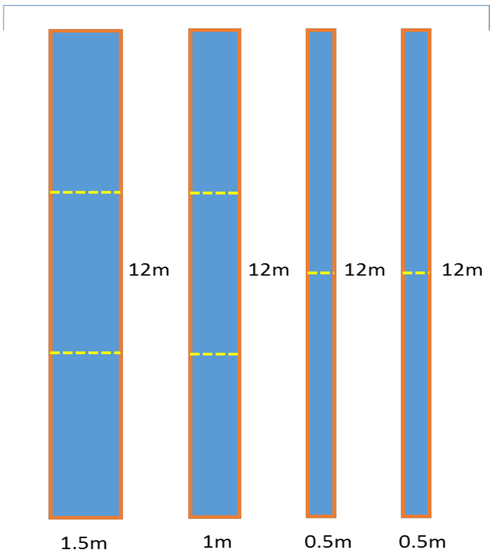


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	**Diagram**
Maximum predicted number of antennas for each width of fish slot in the fish passage: three antennas for the wider slots (1.5 and 1m), and two for the two narrower slots (0.5 m). antenna fitted into the 12m high fish slots. Number of slots to be fitted = 8.	

4.2.9 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. However, gill netting is a harsh technique that can cause stress and, in extreme cases, impact survival. Tagging a fish that has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish (Sigourney et al. 2005). It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL has provided all funds to purchase the vessel and will allocate contractors to fit out the vessel. This was on the basis that CSU can guide operation and train Lao government, University and XPCL staff in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish (Bohlin et al. 1989). It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival (Burkhardt and Gutreuter 1995). It is widely used in Australia, and Charles Sturt University will run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river; therefore, combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. There are two commonly applied approaches to electrofishing; the "grunt method" and the "power transfer" method.

For the "grunt" method, the boat is started and the voltage settings gradually raised until the generator is significantly working to input electricity into the water. It is the most commonly applied approach in Australia.

For the "power transfer method", the electrofisher settings are optimised to the water conductivity. "Power transfer theory" predicts that electrofishing will be optimised when the conductivity of the fish matches that of the water. As such, voltage and amperage settings can be optimised depending on the water conductivity in order to match, as closely as possible, the target species.

For this research component, we will compare the "grunt" and "power transfer" fishing methods. We will need to firstly determine the "conductivity" of the target species. This is achieved by using a multimeter to measure the conductivity of target fish. Then we will

manipulate the voltage settings of the electrofishing unit (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong. For each electrofishing “shot” all species will be collected, measured and weighed. Statistical analyses will be performed to determine if any differences exist between the two methods.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into the Mekong River Commission Design Guidelines for Mainstem Dams.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

Table 2. List of migratory adult species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Green indicates the upstream migration season and yellow the downstream migration season. Imp column indicates the primary importance of the species whether for food, conservation or income.

Species	Imp	Local name	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Cyclocheilichthys enoplos	F	Pa Joke												
Cyclocheilichthys repasson	F	Pa Joke-sai												
Henicorhynchus lobatus	F	Pa Sroi												
Labeo chrysophekadion	F, I	Pa Pia												
Hemibagrus nemurus	F, C, I	Pa Kod												
Mekongina erythospila	F	Pa Sa-ee												
Sikukia gudgeri	F	Pa Mang												
Chitala sp.	F, I	Pa Tong												
Pangasius macronema	F, C, I	Pa Yorn												
Hemisilurus mekongensis	F, C, I	Pa Dangdaeng												
Phalacronotus apogon	F, I	Pa Sa-ngua												
Bagarius suchus	F, I	Pa Khae												
Paralaubuca typus	F	Pa Teab												
Tenulosa thibaudeaui	F	Pa Mak-pang												
Pangasianodon hypophthalmus	F, C, I	Pa Sway												
Cyprinus carpio carpio	F, I	Pa Nai												
Yasuhikotia modesta	C	Pa Kiaw-Gai												
Macrochirichthys macrochirus	F	Pa Fak-pa												
Pristolepis fasciata	F, C	Pa Chang-yeab												
Pangasius bocourti	F, C, I	Pa Phor												
Pangasius conchophilus	F, C, I	Pa Mong												
Pangasius larnaudii	F, C, I	Pa Thay-po												
Phalacronnotus bleekeri	F, C, I	Pa Sa-ngua												
Wallago attu	F, C, I	Pa Kaow												
Hemibagrus filamentus	F, C, I	Pa Kod-rueng												
Pangasianodon gigas	C	Pa Buek												

4.2.10 Research component 4: Measuring upstream fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study the project team were to use PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations which are all being applied to the work at Xayaburi. So the team are starting from a strong knowledge and experience base.

For application at Xayaburi there is a defined chronological sequence that needs to be completed in order to arrive at this research component. For example, the antennas must be installed, then it will be possible to use the PIT system to determine the overall efficiency of the fish pass. The tag validation trials must have been completed, and we must be able to collect sufficient sample sizes of fish. Some of this is seasonal and some will vary annually. So the proposed species list will need to be revised on an opportunistic basis.

Once all stages are completed, and if the PIT tag system reveals that the fish pass is demonstrated to be sub-optimal (for one or more species), then the dam constructors have incorporated a series of 70 different moveable gates which can be configured to alter fish pass flow in order to determine if improved passage has been achieved. So the project team will be able to adaptively alter the configuration of the fishway and determine if different settings alter passage rates.

It is important to emphasise here that optimal passage rates are difficult to set at this fish pass facility. Our approach will be to record the current rates, seek to understand where design points could be improved and manipulate the adjustable gates to optimise passage rates. So our aim is to achieve a change in percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation (using methods developed in research component 2). Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will shed tags, there will be a need to re-tag fish in every year to maintain a sufficient sized pool of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating at maximum efficiency.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	~~Conclude~~ Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	Covid has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos Assumes that remote training will be effective To minimise risk, training will continue under the instruction of Dr Wayne Robinson (whilst he is based in Laos)	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on Covid-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during Covid travel restrictions	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.7	Project steering committee meeting (May need to be delayed depending on Covid-19)	Hold team meeting on site	Nov 2020 Or pushed into early 2021 if travel restrictions continue	All milestones are met	Project progress is on track

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	~~Aug 2022~~ Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are four main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission and community beneficiaries.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway for upstream migrants.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.

The Mekong River Commission (MRC) is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the "Mainstem Dam Hydropower Guidance" document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a "Joint Environmental Monitoring Initiative" (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. There is some overlap between the JEM initiative and the proposed research plan. Where overlap exists, then is an opportunity to ensure that so that results can inform the environmental monitoring requirements and standards for future dams. We will also be the first to have trialled many of these technologies on the Mekong. So there is significant interest from the JEM team, where there is obvious mutual interests, to integrate their training of local staff with the technologies being implemented on site. Of prime importance is that the process of fish selection for testing considers the food security needs of impacted communities. The interests of community beneficiaries will be considered by inclusion of a civil society representative on the Advisory Panel.

Project extension and communication

Project extension and communication will be promoted to the extent agreed by project partners, and by the terms negotiated through the reference panel. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam

and it is important research results are presented in a defendable manner. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect these items and is unwilling for the technical details of its product to enter the public domain during the research phase. XPCL also have commercial-in-confidence considerations. With these issues in mind, the project team has entered into a confidentiality arrangement where no public project messaging will be made without the approval of all parties. Thus, extension and outreach will need to be carefully managed throughout project implementation.

4.4.2 Capacity building

Partner countries
Fish passage technology and implementation, as pertaining to hydropower dams, will provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL has a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from our research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Covid has created significant disruptions to international travel. The disruption has restricted access to the Xayaburi site and created additional administrative requirements to obtain permission to gain access. A reduced ability to visit site will place an increasing reliance on remote learning. The team as had discussions with Darren Grigg, a videographer from Grigg media, to develop a series of instructional videos. These will be developed and passed onto Lao-based staff as reference items. These will be important over the short (during Covid restrictions) and long term (if new staff enter the project team).

Australian team
Australian researchers will benefit from involvement in the project. The tropical rivers of South East Asia offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes than they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with future hydropower development activities.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, there is potential to link with the Mekong River Commission's JEM initiative and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Action Plans', which take the activities and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These annual plans are devised before each New Year, and assessed at the end. These Action Plans then inform Progress Reports.

Medium-term cycles

The yearly reports and a forum, will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year, and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program

- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai (XPCL employed) scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) Factors influencing PIT antenna efficiency at high dam fishways
  (b) Tag retention and mortality in key Lower Mekong Basin species
  (c) Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers
  (d) Optimising electrofishing for deployment in the Lower Mekong Basin
- A project final report
- Abstracts published in conference proceedings

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.6 Intellectual property and other regulatory compliance

See Section 7. Appendix A.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site, and the overall fish pass performance has implications at a site, national and international level. Site based impacts relate to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and the development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam’s day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we plan to influence the design and construction of other dams into the future (Figure 5).

Importantly, our team focusing on upstream migration only will limit the extend of applicability to other dams. It is important to note that, if the majority of fish are migrating upstream to recolonize habitat, or to spawn, it follows that these fish may need to move downstream at a later date to complete important life history stages. Focusing on upstream migration, at least initially, effectively mitigates a series of risks because our team is only focusing on one aspect initially. Thus, the political pressure to provide answers to <u>all</u> migration questions is significantly reduced by this focused scope.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The "gold standard" Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs.

Long term (strategic):

1) PIT tagging incorporated into the Mekong River Commission Design Guidelines for Mainstem Dams
2) PIT tag systems installed at other mainstem dam sites
3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key South East Asian economies on a common issue.

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across South East Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

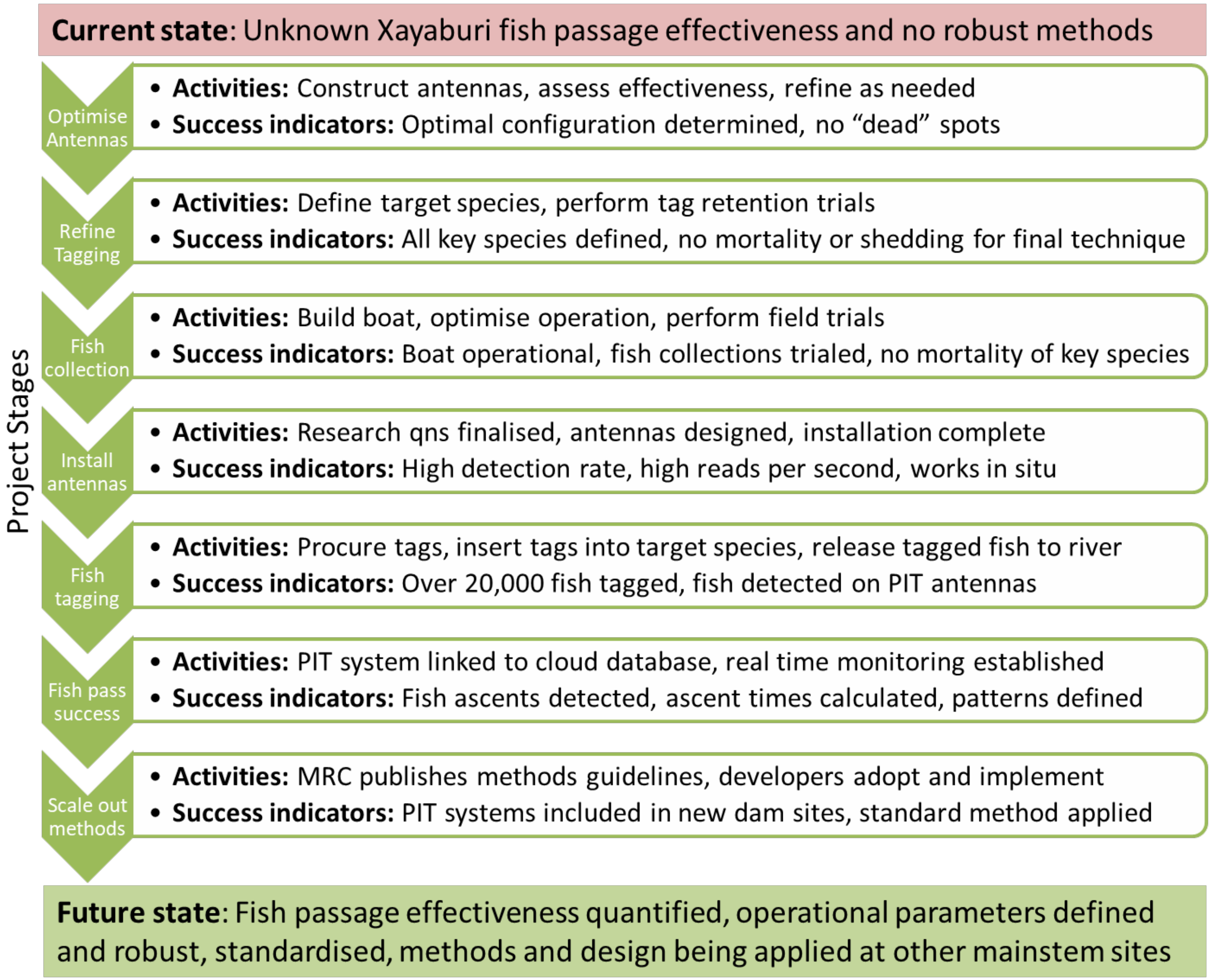


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of ‘unknowns’ to a future state of “knowns” being applied to future projects.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the LMB and globally. It is important to note that the methods being developed will be applied in the LMB for the first time. Further, the implementation is occurring at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground, but we recognise that there are many assumptions and challenges that may lead to compromised data and outputs. To mitigate this risk, we have consulted with a biostatistician experienced in the Australian hydroelectric research field to advise on how to ensure statistically robust methods in the event of each possible failure point.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring upstream movement using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility for their research and monitoring program, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. <u>PIT tagging</u>: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. <u>Electrofishing:</u> A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating masters students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have conditional approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is imported from outside over the short term and built through a steady stream of learned graduates over the longer term.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hands-on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.4 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by participating in MRC dam guidance discussions and development where appropriate. An important platform for these discussions will be through the reference panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4 Community impacts

The science justifying fish passage implementation is sound (Williams 2008, Baumgartner et al. 2016). Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems. The research impact of this project is within the footprint of the Xayaburi Dam

site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner that can influence these outcomes, particularly through the Advisory Panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards (Commission 2010). The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction cost is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $300M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year (Nam et al. 2015). Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to meet the performance specifications set by the GoL, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region, while recognising the immense technical challenges we face in realising these results.

5.4.2 Social impacts

It is expected that effective fishway construction on mainstem dams will ultimately maintain fisheries productivity, although many technical and operational challenges must be overcome before this is verified through the project. The local benefits to communities from this research are maintained food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls in decision-making (Siason et al. 2010, Baumgartner et al. 2016)

Local communities will directly benefit through unchanged access to fish for food and income if the Xayaburi facilities are demonstrated to work. Nonetheless, if the Xayaburi facilities are demonstrated to not work effectively, this research will be critical to informing XPCL's business decisions about which aspects of the fish pass to target for maximising improvements to triple bottom line outcomes.

Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed and operated, any fish that move upstream through the dam will become accessible to the upstream villages, thus creating an equitable access to the resource. However, there are likely to be considerable negative social impacts as there are numerous unknowns about the design and function of the fish passage infrastructure. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative social impact, considering the reliance of the capture fishery of the LMB for food security and income (Nam et al. 2015). Apart from those adverse effects due to dam construction and forced relocation, is the likely overall reduction, to some extent, in fish passage compared to pre-dam conditions, leading to a reduced abundance and range of fish species accessible to fishers. The project is likely to indirectly improve social benefits by minimising this negative impact - through advice to XPCL on operational management to optimizing fish passage at the Xayaburi Dam, and more broadly to the GoL on standardised tools and protocols for fish tagging and monitoring, and improvements in fish passage design for future hydropower development.

Therefore, demonstrating fish passage functionality through robust research is very important for XPCL to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The Xayaburi fish pass facilities were constructed to ensure fish are able to pass the dam. The overall aim is to demonstrate, through sound operation and integration into dam operations, fish pass effectiveness. The overall aim is to ensure fish communities upstream of the dam do not decline. The flow on effects to livelihoods and nutrition are being measured through the XPCL community program.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the region can be measured by the ability to influence Mekong River Commission mainstem dam guidelines, ensuring new dams include functional fish passes, as well as adopt standard monitoring methods.

6 Project management

6.1 Management aspects

6.1.1 Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be

responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work. A recommendation from these consultations was to establish a Project Reference Panel consisting of the major stakeholders that would be regularly briefed and consulted regarding project progress and outcomes.

Under the contract terms of the first phase of research (the SRA), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated the panel meet on an annual basis, at the dam site.

The Project Reference Panel will have advisory status, and consist of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited plus representation of Lao nationals (Figure 2).

They will conduct their business in confidence which will be defined by a terms of reference will be established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly-funded data must be openly available according to ACIAR’s contractual requirements, and also that that some IP will be required to remain commercial-in-confidence.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. We need to respect that our research team are invited ‘guests’ on the project site. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support.

The data sharing and publication arrangements therefore need to be carefully considered and discussed and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

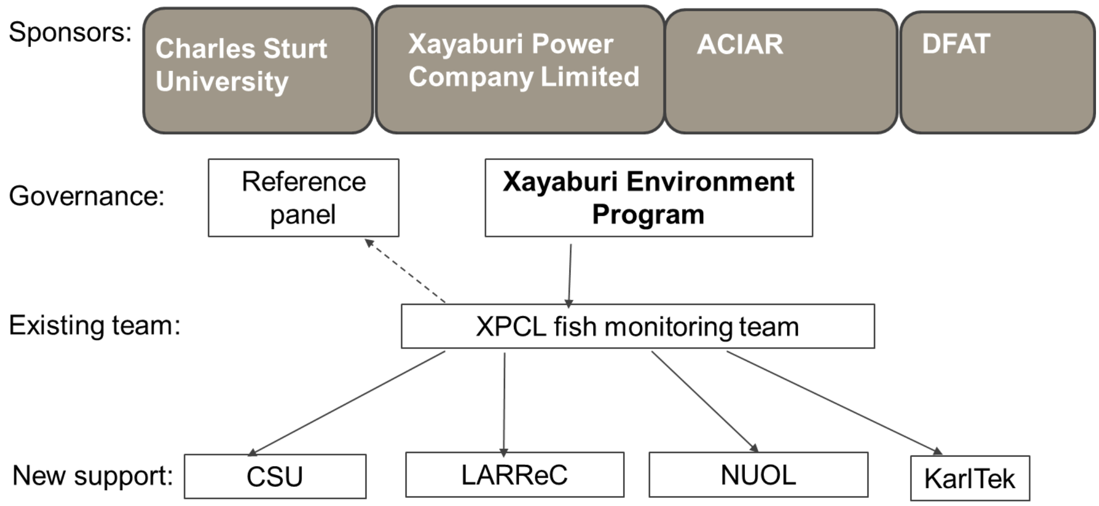


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will integrate within existing governance arrangements.

6.1.2 Mid and final project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR "mid-project review" (after 18 months) and "end of project review" processes.

6.1.4 Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables
- Development of instructional videos and manuals as reference items

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role on-ground in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Douangkham Singhanouvong (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Coordinator and Government rep	[redacted]
Douangkham Singhanouvong	M	Living Aquatic Resources Research Centre	Deputy Director	Coordinator and Government rep	[redacted]
Thonglom Phommavong	M	National University of Laos	Research Associate	Collaborating scientists	[redacted]
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	[redacted]
Phousone Vorsane	M	National University of Laos	Research Associate	Field technical support	[redacted]
Saleumphone Chantavong	M	Living Aquatic Resources Research Centre	Research Associate	Field technical support	[redacted]
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	[redacted]
Michael Raeder	M	Xayaburi Power	Owner Representative	Owner representative	[redacted]
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Collaborating Scientist~~	[redacted]
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	[redacted]
John Dore	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	[redacted]
Casual Staff	TBA	Charles Sturt University	TBA	Assistance with fieldwork or other project requirements	[redacted]

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Wayne Robinson	M	Charles Sturt University	Research Fellow	Field and biometric support	
Lauren Withers	F	Australian Volunteers	Volunteer	Project support	
Garry Thorncraft	M	National University of Laos	Research Associate	Collaborating Scientist	
Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental Monitoring	Project support	
Jarrod McPherson	M	Charles Sturt University	Research assistant	Field support and coordination	
Nathan Ning	M	Charles Sturt University	Scientist	Manuscript preparation and writing	
Chris Barlow	M	IP Matters	Director	High level support and writing	
Darren Grigg	M	Grigg Media	Videographer	To produce a series of instructional videos on PIT tagging and fish husbandry	

6.3 Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
~~Jürgen Geist~~	~~M~~	~~Technical University of Munich~~	~~Chair of Aquatic Systems and Director of FITHydro initiative~~	~~Reference panel member~~	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member	
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Reference panel member~~	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required.

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

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6.4 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	
Jarrod McPherson Charles Sturt University	
Thanasak Poomchaivej Xayaburi Power Company	
Dr Michael Raeder Xayaburi Power Company Limited	
Garry Thorncraft National University of Laos	

Name	[redacted]
Dr Oudom Phonekhampheng National University of Laos	[redacted]
Douangkham Sinhanouvong Living Aquatic Resources Research Centre	[redacted]
Karl Pomorin KarlTek Pty Ltd	[redacted]
Dr Nathan Ning Charles Sturt University	[redacted]
Dr Chris Barlow Fish Matters IP	[redacted]
Lauren Withers (and others) Australian Volunteer	[redacted]

Name	[redacted]
Phousone Vorsane (NUOL) and Saleumphone Chantavong (LARReC)	
Thonglom Phommavong (NUOL) Khampheng Homsombath (LARReC)	
Wayne Robinson (CSU)	
Darren Grigg (Grigg Media)	

6.5 Summary details of proposed reference panel participants

Name	[redacted]
Jody Swirepik (chair) Australian Government	
Dr Elizabeth Pope Snowy Hydro	

Name	[redacted]
~~Prof Jürgen Geist~~ ~~Technical University of Munich~~	[redacted]
Dr Daniel Deng PNNL	[redacted]
Dr Michael Raeder XPCL	[redacted]
Lao citizen representative TBA	[redacted]
Dr Ann Fleming ACIAR	[redacted]
Dominique Vigie DFAT	[redacted]

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6.6 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including

Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR. CSU has extensive experience with PIT system data analysis and installations throughout Australia and has extensively collaborated with researchers and the Australian government on the installation of fish monitoring systems since 2001. There are no other universities in Australia with such extensive experience and networks for fishway monitoring.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (HDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

7 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

7.1 Administrative details

[redacted]

7.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

[redacted]

If “yes” to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	Details of plant or animal germplasm exchange

Proprietary materials, techniques and information

[redacted]

“Data” means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

7.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If "yes", for each applicable country provide brief details.

[redacted]

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Australian Government
Australian Centre for International Agricultural Research

Attachment A

Standard Conditions for Project Agreements

between the

Commonwealth of Australia

represented by the

Australian Centre for International Agricultural Research

and the

Commissioned Organisation

as at January 2020

Table of Contents

Standard Conditions for Project Agreements

between the

Commonwealth of Australia represented by the Australian Centre for International Agricultural Research ("ACIAR")

and the

Commissioned Organisation

ACIAR is an Australian Government agency that operates as part of Australia's Aid Program within the portfolio of Foreign Affairs and Trade. It contributes to the aid program objectives of advancing Australia's national interest through facilitating research to underpin poverty reduction and sustainable development.

ACIAR has developed the Standard Conditions which are the foundation of agreements for the research partnerships it facilitates. These Standard Conditions must be read in conjunction with the Letter of Agreement and the Project Document (which together form the Project Agreement).

THE PARTIES AGREE AS FOLLOWS:

Whereas:

ACIAR has requested certain research services to be carried out and the Commissioned Organisation has agreed to provide the Services in order to complete the Project on the terms of the Project Agreement.

1. Interpretation

1.1 **Definitions**. Unless a contrary intention appears, in these Standard Conditions the following definitions apply:

"ACIAR project management system" means the collaborative project site that lets the Project Leader, and other members of the Commissioned Organisation, share documentation and respond to tasks allocated by ACIAR;

"Acquittal" means the provision of an accurate report on funded activities, providing a breakdown of what the funds have been spent on and assurance that they have been spent on the intended purpose and in accordance with the terms of the Project Agreement.

"Act" means the Australian Centre for International Agricultural Research Act 1982 (Cth);

"Annual Report" means the annual report on the Project to be delivered to ACIAR;

"Background IP" means Intellectual Property that is:

(a) in existence prior to the date of the Project Agreement; or

(b) is brought into existence independently of this Project,

and which is used in, or is otherwise required for the use of, the Project IP;

"*Budget*" means the financial document as part of the Project Document that details the high level application and distribution of funds within the Project.

"*CEO"* means the Chief Executive Officer of ACIAR;

"*Collaborating Country*" means the country with which ACIAR has entered into an International Agreement;

"*Collaborating Institution*" means the organisation or institution in the Collaborating Country which is nominated by the government of the Collaborating Country to undertake any aspects of the Project which are to be conducted outside Australia in collaboration with the Commissioned Organisation;

"*Commissioned Organisation*" means the person named as the Commissioned Organisation in the Letter of Agreement who by executing and returning the duplicate to ACIAR has undertaken to provide the Services in accordance with the Project Agreement;

"*Commonwealth*" means the Commonwealth of Australia;

"Confidential Information" means information that is by its nature confidential and:

(a) is designated by a party as confidential; or

(b) the other party knows or ought to know is confidential;

but does not include information which:

(c) is or becomes public knowledge other than by:

  (i) breach of the Project Agreement; or

  (ii) any other unlawful means;

(d) is in the possession of a party without restriction in relation to disclosure before the date of receipt from the other party;

(e) has been independently developed or acquired by the other party;

(f) is contained in any clause, provision or Item of, or Schedule or Attachment to, the Project Agreement;

(g) by law is required to be disclosed including under court subpoena, parliamentary order, under the *Freedom for Information Act 1982* (Cth) or as part of discovery during legal proceedings; or

(h) is required to be disclosed to any government agency, authority, department or Minister, or to any parliamentary committee,i referred to in paragraphs (c) to (h) above is on the other party;

"Correctly Rendered Invoice" means an invoice that:

(a) Is correctly addressed and calculated in accordance with the Project Agreement;

(b) Relates only to Goods and/or Services that have been accepted by ACIAR in accordance with the Project Agreement;

(c) Includes the Purchase Order number, the name and phone number of the ACIAR Contract Manager;

(d) Is for an amount, together with all previously Correctly Rendered Invoices, do not exceed the Project Agreement price; and

(e) Is a valid taxinvoice in accordance with the GST Act.

"Expended Funds" means the sum of all incurred expenditure and paid expenditure;

"Final Acquittal" means the financial Acquittal at the end of a Project of all amounts not acquitted in previous financial Acquittals;

"Final Report" means the final report on the Project which must be delivered to ACIAR;

"*Financial Year*" means the period from 1 July to 30 June of the following year;

"*Fraud*" means dishonestly obtaining a benefit from the Commonwealth or causing a loss to the Commonwealth by deception or other means';

"*General Interest Charge Rate* " means the general interest charge rate determined under section 8AAD of the *Tax Administration Act 1953* on the day payment is due, expressed as a decimal rate per day;

"Intellectual Property" means all intellectual property rights, whether or not such rights are registered or capable of being registered, including the following:

(a) patents and inventions, plant varieties, copyright, rights in circuit layouts, designs, trade marks (including goodwill in those marks), trade secrets and knowhow, and domain names;

(b) any application or right to apply for registration of any of the rights referred to in paragraph (a); and

(c) all rights of a similar nature to any of the rights in paragraphs (a) and (b) which may subsist in Australia or elsewhere;

'International Agreements' means a Memorandum of Understanding, Memorandum of Subsidiary Agreement or Deed of Agreement with a Collaborating Institution;

"*Letter of Agreement*" means the letter forwarded by ACIAR to the Commissioned Organisation offering to enter into an agreement with the Commissioned Organisation to perform the Services on the terms set out in the Project Agreement;

"*Letter of Interim Agreement*" means a Letter of Agreement forwarded by ACIAR to the Commissioned Organisation where the Project Agreement is conditional on the International Agreements being signed and creates an interim agreement where a payment can be made but ACIAR is under no further obligation to make further payments until the International Agreement is signed. Consequently if the International Agreement is not signed within 3 months of the date the Letter of Interim Agreement is signed by both parties, then no further payments will be made and the Project Agreement terminates.

"*Material*" means any subject matter including documents, equipment, software, goods, information or data stored by any means;

"*Memorandum of Understanding*" means the memorandum of understanding or similar arrangement entered into between ACIAR and the government of the Collaborating Country in regard to the Project;

"*Minister*" means the Commonwealth Government Minister responsible for ACIAR;

"*Moral Rights*" means the right of attribution of authorship, the right not to have authorship falsely attributed and the right of integrity of authorship granted to authors under the *Copyright Act 1968* (Cth).

"*month*" means a calendar month;

"Net Monies Received" means all monies received by the Commissioned Organisation net of any expenses that are properly paid on an arms-length basis by the Commissioned Organisation in exploiting the Project IP;

"*Parties*" means ACIAR and the Commissioned Organisation;

"*Payment Period*" means the periods: 1 January to 30 June; or 1 July to 31 December. The Payment Period may be reduced in length if the start or end date of the Project Agreement falls within the period;

"*Project*" means the project described in the Project Document and referred to in the Letter of Agreement;

"*Project Agreement*" means the Letter of Agreement between ACIAR and the Commissioned Organisation, these Standard Conditions and the Project Document;

"*Project Document*" means the document including Budget, which was provided to ACIAR by the Commissioned Organisation in relation to the Project, which has been approved by the CEO. The active version of the Project Document (including Budget) is that which appears as the last ACIAR approved document on the ACIAR project management system;

"*Project IP*" means Intellectual Property that is brought into existence by or on behalf of the Commissioned Organisation or the Collaborating Institution as a result of performing the Services under the Project Agreement.

"*Services*" means the tasks to be performed by the Commissioned Organisation as set out in the Project Agreement;

"*Specified Personnel*" means professional, technical, support and administrative staff who have been nominated in the Project Document by the Commissioned Organisation to perform all or part of the Services;

"*Standard Conditions*" means the terms set out in this 'Standard Conditions for Project Agreements' document from clauses 1 to 35;

"Unexpended Funds" means all funds remaining after deducting funds expended in accordance with the Project Agreement, including the Project Document and the Budget;

"Withholding Payment" means the amount withheld by ACIAR from the final payment for the Services pending receipt of a satisfactory Final Report.

"Works" means the copyright material licensed to ACIAR under clause 12.2 and clause 12.11.

1.2 **Interpretation**. Unless a contrary intention appears, in these Standard Conditions:

(a) words imputing a gender include any other gender;

(b) the singular includes the plural and vice versa;

(c) another grammatical form of a defined word or expression has a corresponding meaning;

(d) a reference to a statute or other law includes regulations and other instruments under it and consolidations, amendments, re-enactments or replacements of any of them;

(e) a reference to a document includes the document as novated, altered, supplemented or replaced from time to time;

(f) a reference to a person includes the person's permitted successors, substitutes (including persons taking by novation) and assigns;

(g) a reference to a person includes a natural person, partnership, body corporate, association, governmental or local authority or agency or other entity;

(h) "including", "includes", "such as" and "in particular" do not limit the generality of the words which precede them or to which they refer;

(i) any agreement, representation, warranty or indemnity by two or more parties (including where two or more persons are included in the same defined term) binds them jointly and severally;

(j) any agreement, representation, warranty or indemnity in favour of two or more parties (including where two or more persons are included in the same defined term) is for the benefit of them jointly and severally;

(k) a rule of construction does not apply to the disadvantage of a party because the party was responsible for the preparation of these Standard Conditions or the Letter of Agreement;

(l) paragraph headings are inserted for convenient reference only and have no effect in limiting or extending the language of provisions to which they refer;

(m) all references to dollars are to Australian dollars; and

(n) a reference to a “clause” is a reference to a clause in these Standard Conditions and a reference to “Schedule” is a reference to a Schedule (if any) to these Standard Conditions.

2. Services

2.1 The Commissioned Organisation shall perform the Services within the period for performing the Services specified in the Letter of Agreement and the Project Document and in accordance with the Project Agreement.

2.2 When performing the Services, the Commissioned Organisation shall cooperate fully with the Collaborating Institution for the purpose of ensuring timely completion of the Project.

2.3 The Parties acknowledge and agree that from time to time there may be events which delay the Commissioned Organisation's ability to perform its obligations under the Project Agreement which are beyond the reasonable control of the Commissioned Organisation. The Parties agree to deal with such unavoidable delays as follows:

(a) the Commissioned Organisation shall:

(i) notify ACIAR in writing as soon as it becomes aware of any event which it believes will delay its ability to perform its obligations under the Project Agreement and which it believes are beyond its reasonable control; and

(ii) specify all the facts and circumstances which have caused the Commissioned Organisation to form the view that there will be a delay, and the delay is unavoidable and is beyond the reasonable control of the Commissioned Organisation;

(b) where there is likely to be a delay in performance of the Commissioned Organisation obligations, ACIAR shall not exercise its rights and remedies for default under clause 20.6 of these Standard Conditions or under common law:

(i) before considering all the facts and circumstances relating to the delay; and

(ii) if it accepts that the delay has been caused by an act, omission or event beyond the reasonable control of the Commissioned Organisation, or was not reasonably foreseeable at the time the Project Agreement was executed;

(c) if ACIAR accepts that the delay was unavoidable, the Parties shall use their best endeavours to resolve the causes of the delay, including but not limited to, adjusting the Project Document and any relevant timeframes; and

(d) if the causes of the delay cannot be resolved within 3 months, ACIAR may terminate the Project Agreement in accordance with clause 20.

3. Subcontracting

3.1 The Commissioned Organisation shall not, without the prior written approval of ACIAR, subcontract the performance of any part of the Services that, or engage a subcontractor who, was not expressly specified in the initial CEO approved Project Document. Where ACIAR approves subcontracting, either as part of the initial CEO approved Project Document or as a result of a subsequent request by the Commissioned Organisation to vary the Project, the Commissioned Organisation shall comply with any terms imposed by ACIAR. Any failure by a Commissioned Organisation or its subcontractor to comply will entitle ACIAR to terminate the Project Agreement in accordance with clause 20.

3.2 The Commissioned Organisation shall be fully responsible for the performance of the Services notwithstanding that the Commissioned Organisation has subcontracted the performance of any part of those Services.

3.3 Where requested, the Commissioned Organisation shall provide a copy of any such subcontract to ACIAR within 7 days of its execution.

3.4 The Commissioned Organisation agrees that ACIAR may publicly disclose the names, Australian Business Numbers and addresses of the subcontractors approved under the Project Agreement and their role in fulfilling the Project Agreement.

3.5 The Commissioned Organisation must ensure that any subcontract entered into for the purpose of the Project Agreement contains an equivalent provision to clause 3.4 permitting ACIAR to disclose the information specified in that clause.

4. Term of Project Agreement

4.1 The Project Agreement commences on the date specified in the Letter of Agreement. Any Services performed by the Commissioned Organisation prior to the date of commencement of the Project Agreement may be treated as Services under the Project Agreement if so specified by ACIAR in the Letter of Interim Agreement.

4.2 A Project Agreement may be extended where ACIAR determines that sufficient reason exists to do this and the Parties so agree in writing.

5. Payment

5.1 The total amount of funds payable by ACIAR to the Commissioned Organisation for the Services is the “financial limitation” specified in the Letter of Agreement.

5.2 In performing the Services the Commissioned Organisation shall not incur expenditure in any period in excess of the funds payable for that period in accordance with clause 5.4 without the prior written approval of ACIAR.

5.3 Unless otherwise agreed by the Parties in writing, ACIAR shall in no way be liable for any additional costs incurred for services performed by the Commissioned Organisation outside the scope of the Services.

5.4 Subject to clause 5.1, in consideration of the performance of the Services by the Commissioned Organisation, ACIAR agrees, subject to appropriation being made by the Parliament of the Commonwealth, to pay from the Australian Centre for International Agricultural Research Official Departmental Account to the Commissioned Organisation:

(a) the funds specified in the Budget of the Project Document in the ‘Payment Schedule’ tab; and

(b) any other costs or funds as may from time to time be agreed in writing between the Parties.

5.5 ACIAR shall pay the Commissioned Organisation during the term of the Project Agreement the funds referred to in clause 5.4 in accordance with the Budget for the Project set out in the Project Document as follows:

(a) each payment shall only be made following ACIAR’s receipt of:

(i) a satisfactory written report as detailed in clause 5.10 in relation to the Payment Period; and

(ii) where required by clause 19.1, a satisfactory Annual Report.

(b) any funds that are unexpended by the Commissioned Organisation at the expiration of the Payment Period for which they were allocated shall be carried over for expenditure in the following Payment Period and the advance made for the following six month period by ACIAR to the Commissioned Organisation shall be reduced accordingly, unless ACIAR approves otherwise in writing.

5.6 Notwithstanding clause 5.5, ACIAR shall withhold from the Commissioned Organisation the Australian component of the final payment (that is the amount specified in the ‘Payment Schedule’ tab of the Budget in the Project Document) a Withholding Payment as follows:

(a) the sum of $10,000 where the Financial Limitation is less than or equal to $400,000; or

(b) the sum of $20,000 where the Financial Limitation is greater than $400,000;

pending receipt of a satisfactory Final Report as detailed in clause 19.2. The Withholding Payment shall be made to the Commissioned Organisation within thirty

(30) days of ACIAR's acceptance of the Final Report. Within thirty (30) days of receipt of the Withholding Payment, the Commissioned Organisation must provide a Final Acquittal for the Project including all unexpended funds.

5.7 The Commissioned Organisation may, subject to the following qualification and without reference to ACIAR, transfer funds payable in respect of a particular item in the Budget for the Project to another item. The amount transferred may be 10% or $10,000 of the total of the particular item in the Budget from which the funds are being transferred, whichever is the lesser. Transfers involving larger amounts must not be made without ACIAR's prior written approval.

5.8 Notwithstanding clause 5.7, the Commissioned Organisation shall not transfer funds payable in respect of a particular item in the Budget payable outside Australia to another item in the Budget payable outside Australia. However, the Collaborating Institution shall be able to vary its component of the Budget in the same way described in clause 5.7. Transfer of funds between items in excess of the amount referred to in clause 5.7 shall not be made without the prior written approval of ACIAR.

5.9 Where the Budget for the Project set out in the Project Document provides for the payment of any funds by the Commissioned Organisation to a Collaborating Institution, the Commissioned Organisation shall pay those funds six-monthly in advance within seven days after receipt of payment from ACIAR under clause 5.5 during the term of the Project Agreement. Any funds that are unexpended by the Collaborating Institution at the expiration of the Payment Period for which they were allocated shall be carried over for expenditure in the following Payment Period and the advance made for the following Payment Period by the Commissioned Organisation to the Collaborating Institution shall be reduced proportionately, unless ACIAR approves otherwise in writing.

5.10 No later than 30 days after the expiration of each Payment Period for which the funds were allocated ("acquittal period"), the Commissioned Organisation shall provide to ACIAR a written acquittal that includes the following details:

(a) the unacquitted amount from the prior period (if any), the amount received from ACIAR for the acquittal period and the amounts expended in the acquittal period;

(b) an explanation detailing the reasons for the delay in spending funds must be provided where unexpended funds exceed 20% of available funds;

(c) sign-off by the Project Leader; and

(d) certification by an officer duly authorised by the Commissioned Organisation that the amounts, reported under clause 5.10(a) above, are correct and accurately reflect expenditure which has been incurred against each item for the purposes of the Project.

5.11 The report to be provided under clause 5.10 must be in the form set out in the ACIAR project management system.

5.12 The Commissioned Organisation acknowledges it is solely responsible for payment of, and accounting to ACIAR for, all expenses incurred in performing the Services.

5.13 **Taxes**

The Commissioned Organisation must pay all:

(a) stamp duty (including penalties and interest) assessed or payable in respect of the Project Agreement and the undertaking of the Project; and

(b) subject to clause 7, all taxes, duties and government charges imposed or levied in Australia or overseas in connection with the performance of the Project Agreement.

6. Interest on Late Payments

6.1 Where ACIAR and the Commissioned Organisation both have the capability to deliver and receive e Invoices through the Pan-European Public Procurement On-Line (PEPPOL) framework and have agreed to use electronic invoicing (e-Invoicing), ACIAR will pay the amount of a Correctly Rendered Invoice to the Commissioned Organisation within five (5) calendar days after receiving it, or if this day is not a business day, on the next business day.

6.2 In all other circumstances, ACIAR will pay the amount of a Correctly Rendered Invoice to the Commissioned Organisation within twenty (20) calendar days after receiving it, or if this day is not a business day, on the next business day.

6.3 If the total initial value of the Contract (excluding any options, extensions, renewals or other mechanisms that may be executed over the life of the contract) is less than A$1 million (GST inclusive) and ACIAR fails to make a payment to the Commissioned Organisation by the business day it is due, ACIAR will pay the unpaid amount plus interest on the unpaid amount, provided the amount of interest payable under this clause exceeds A$100.

6.4 Interest payable under this clause will be simple interest calculated in respect of each calendar day from the day after the amount was due and payable, up to and including the day that ACIAR effects payment, calculated using the General Interest Charge Rate available on the Australian Taxation Office website as it applies on the day the amount was due and payable expressed as a daily rate.

7. Goods and Services Tax

7.1 Amounts that ACIAR is required to pay under the Project Agreement are calculated on a GST-exclusive basis. Where the Commissioned Organisation becomes liable to remit any amount of GST in respect of any Supply it makes to ACIAR in accordance with the Project Agreement ("GST liability"), the amount otherwise payable by ACIAR under the Project Agreement will be increased by the amount of the GST liability, or any lesser amount required by law. The increased amount will be payable by ACIAR in the same manner and at the same time as other amounts payable under the Project Agreement.

7.2 Where required, the Commissioned Organisation shall provide a tax invoice that may enable ACIAR, if permitted by the *A New Tax System (Goods and Services Tax Act) 1999* (Cth) (the "GST Act"), to claim a credit or refund, a notional credit or refund, of GST.

7.3 In clause 7, a word or expression defined in the GST Act has the meaning given to it in that Act.

8. Negation of Employment, Partnership and Agency

8.1 The Commissioned Organisation shall not by virtue of the Project Agreement be or for any purpose be deemed to be an officer, employee, partner or agent of the Commonwealth or ACIAR, or as having power or authority to bind or represent the Commonwealth or ACIAR, and shall not represent itself, and shall ensure that its officers, employees, agents and subcontractors do not represent themselves, as such.

9. Personnel

9.1 The Commissioned Organisation shall provide adequate and competent personnel to perform the Services and shall ensure that they undertake the Services in accordance with the terms of the Project Agreement.

9.2 Subject to clause 9.6 the Commissioned Organisation shall ensure that the Specified Personnel undertake work in respect of the Services in accordance with the terms of the Project Agreement. Where Specified Personnel are unable to undertake work in respect of the Services, the Commissioned Organisation shall notify ACIAR immediately. The Commissioned Organisation shall, if so requested by ACIAR, provide replacement personnel acceptable to ACIAR at no additional charge and at the earliest opportunity.

9.3 Personnel of the Commissioned Organisation (including Specified Personnel, employees, agents and subcontractors) who are undertaking Services in the Collaborating Country and who are not citizens of that country shall in no way become involved in the political affairs of the Collaborating Country. If, in the opinion of ACIAR such personnel have become involved in the political affairs of the Collaborating Country, ACIAR may require the Commissioned Organisation, at its own cost, to promptly remove the personnel involved from work in respect of the Services and for their replacement with personnel of equal competence approved in writing by ACIAR prior to their appointment.

9.4 ACIAR may, on reasonable grounds, give notice requiring the Commissioned Organisation to remove personnel (including Specified Personnel, employees, agents and subcontractors) from work in respect of the Services. The Commissioned Organisation shall at its own cost, promptly arrange for the removal of such personnel from work in respect of the Services and their replacement with personnel acceptable to ACIAR. If the Commissioned Organisation is unable to provide acceptable replacement personnel under this clause 9.4, clause 9.2 or clause 9.3, ACIAR may terminate the Project Agreement in accordance with clause 20.

9.5 The Commissioned Organisation is responsible for arranging and paying for travel for, and payment of salaries and allowances to, its personnel including Specified Personnel and subcontractors from the Budget provided for in the Project Document.

9.6 Where not specified in the initial CEO approved Project Document, the Commissioned Organisation shall obtain the prior written approval of ACIAR to the appointment of the Specified Personnel or any specialist or scientist to perform the Services, which approval shall not be unreasonably withheld. If ACIAR requests, the Commissioned Organisation must promptly provide any relevant information including:

(a) the full names and date of birth of the proposed person(s);

(b) a statement which describes the position to be held, the position selection criteria and details of the duration of the proposed appointment;

(c) a copy of the curriculum vitae of each of the proposed persons which details relevant employment experience and educational qualifications; and

(d) any other information relating to the proposed appointment necessary for or directly related to the Services.

10. Travel

10.1 The Commissioned Organisation shall provide prior written notice to ACIAR detailing all visits scheduled to a Collaborating Country by its personnel, including Specified Personnel and subcontractors. Details of any dependants accompanying the personnel shall also be provided in the notice. The written notice is to be provided as a Travel Advice Note available on the ACIAR website (http://aciar.gov.au/travel).

10.2 In the event it is advised that officials from the Collaborating Country involved in the Project intend to visit Australia, the Commissioned Organisation shall use its best endeavours to ensure that as much notice as possible is provided to the Australian Embassy, the Australian High Commission or the Australian Consulate, as appropriate, in the Collaborating Country so that it may commence visa and other formalities.

10.3 The Commissioned Organisation shall provide promptly to ACIAR a copy of any such notices to the Australian Embassy, the Australian High Commission or the Australian Consulate.

10.4 At the completion of the travel referred to in clause 10.1, the Commissioned Organisation shall provide to ACIAR within thirty days of travel, a trip report that shall include the travel itinerary and information relevant to ACIAR's monitoring of the Project.

10.5 From time to time Australians are advised for security and safety reasons not to travel to certain countries or areas within countries. The Commissioned Organisation is responsible for the security and safety of any personnel it engages for the Project and should either make its own enquiries or check the Department of Foreign Affairs and Trade (DFAT) Travel Advices before Project personnel travel. Neither ACIAR nor its officers, employees or subcontractors accept any responsibility or liability for any injury, loss, damage or expense incurred by personnel of the Commissioned Organisation and/or its subcontractors, in any circumstances and in particular, who travel in areas where security or safety risks exist or who travel against the advice of DFAT in these matters.

11. Project Equipment and Supplies

11.1 The Commissioned Organisation shall arrange, from the funds payable by ACIAR to the Commissioned Organisation for the Services, the procurement and delivery of all equipment and supplies that are specified in the Project Document.

11.2 The Commissioned Organisation shall exercise administrative control of and maintain and keep equipment and supplies referred to in clause 11.1 in good repair.

11.3 The Parties agree that the ownership of equipment and supplies that are procured for the Project for the performance of the Services in Australia shall vest in the Commissioned Organisation from the date of purchase.

11.4 The Parties agree that the ownership of equipment and supplies procured by the Commissioned Organisation for the purposes of the Project in the Collaborating Country shall vest in the government of the Collaborating Country at the completion of the project.

11.5 Unless otherwise agreed in writing, the Commissioned Organisation shall effect with reputable and substantial underwriters and maintain insurance against all loss or damage to the Project equipment referred to in clause 11.1 until the Services are completed.

11.6 Notwithstanding clause 11.5, the Commissioned Organisation may undertake self-insurance arrangements with ACIAR's prior written approval.

12. Intellectual Property

12.1 ACIAR and the Commissioned Organisation shall have regard to the provisions of and fulfil all relevant obligations under international arrangements to which Australia is a signatory relating to intellectual property and biological resources including:

- the International Treaty on Plant Genetic Resources;
- the FAO trustee arrangements with international agricultural research centres;
- the Convention on Biological Diversity;
- the Agreement on Trade Related Aspects of Intellectual Property rights;
- and the provisions of the International Union for the Protection of New Varieties of Plant.

Transfer and exchange of germplasm between the Commissioned Organisation and the Collaborating Institution shall be subject to Materials Transfer and Acquisition Agreements and in accordance with the Convention on Biological Diversity. This clause 12.1 shall be interpreted such that the relevant obligation is that which was in effect at the time of the action in question.

12.2 Unless otherwise expressly agreed in writing by the Parties, the Project Agreement does not affect the ownership of Background IP. The Commissioned Organisation grants to ACIAR or shall secure the grant of a permanent, irrevocable, royalty free, world-wide, non-exclusive licence (including a right to sublicense its rights to third parties) to use, reproduce, modify, publish, adapt and communicate to the public Background IP in conjunction with Project IP. Where ACIAR proposes to sub-license its rights under this clause 12.2, ACIAR will ensure that any sub-licence will be on the same or substantially the same terms as the licence ACIAR has from the Commissioned Organisation.

12.3 The Commissioned Organisation warrants that to its actual knowledge and belief, following all diligent and reasonable enquiries, at the date of the Project Agreement or the date on which Background IP is first used in the Project (whichever is applicable to the circumstances):

(a) it is the owner of, or is otherwise entitled to use, the Background IP;

(b) it is entitled to grant the licences under clauses 12.2 and 12.11; and

(c) the exercise by ACIAR of its rights under clauses 12.2 and 12.11 will not infringe any Intellectual Property rights of any third party.

12.4 The Commissioned Organisation shall indemnify, and keep indemnified ACIAR, its officers, employees and agents, from and against any and all liability, loss, damage, cost (including the cost of any settlement and legal costs and expenses on a solicitor/client basis), compensation or expense incurred by them arising out of any action, claim, suit, dispute, or proceeding brought by any third party in connection with the breach of the warranties set out in clause 12.3.

12.5 For the purposes of this clause 12, "infringe" and "infringement" means unauthorised acts which would, but for the operation of section 183 of the Copyright Act 1968 (Cth), constitute an infringement.

12.6 The warranties and indemnities contained in this clause 12 shall survive the expiration or termination of the Project Agreement.

12.7 The Commissioned Organisation shall notify ACIAR of the details of any Intellectual Property created as a result of the performance of the Services. Any notification shall be treated as Confidential Information by ACIAR.

12.8 The Parties agree that Project IP shall:

(a) in Australia, vest in the Commissioned Organisation; and

(b) in the Collaborating Country, vest in the Collaborating Institution or an authority designated by the government of the Collaborating Country.

12.9 The Commissioned Organisation and the Collaborating Institution shall, prior to the commencement of the Services, enter into an agreement covering, without limitation, the following:

(a) the ownership of Project IP in countries other than Australia and the Collaborating Country;

(b) the terms of any licence of Project IP between the Parties, including securing such rights as are necessary for the Commissioned Organisation to grant the licence to ACIAR under clause 12.11;

(c) the terms of any licence of Background IP, including securing such rights as are necessary for the Commissioned Organisation to grant the licence to ACIAR under clause 12.2; and

(d) the allocation of costs relating to the application for and maintenance of the Intellectual Property rights between the Commissioned Organisation and the Collaborating Institution.

12.10 The Commissioned Organisation agrees that the arrangements referred to in clause 10.9 shall be made taking into account the following factors:

(a) the intellectual contributions of the Commissioned Organisation and the Collaborating Institution;

(b) the financial contributions of the Commissioned Organisation and the Collaborating Institution;

(c) the contribution of pre-existing Intellectual Property, materials, research effort and preparatory work of the Commissioned Organisation and the Collaborating Institution;

(d) the facilities provided by the Commissioned Organisation and the Collaborating Institution; and

(e) such other relevant considerations as the Commissioned Organisation and the Collaborating Institution may mutually determine.

12.11 Where ownership of the Project IP vests in the Commissioned Organisation, the Commissioned Organisation grants to ACIAR a permanent, irrevocable, royalty free, world-wide, non-exclusive licence (including a right to sublicense its rights to third parties) to use, reproduce, modify, publish, adapt and communicate to the public that IP. Where ACIAR proposes to sublicense its rights under this clause 12.11, ACIAR will ensure that any sublicence will be on the same or substantially the same terms as the licence ACIAR has from the Commissioned Organisation.

12.12 The Commissioned Organisation agrees that it will not sub-license or assign Project IP without first obtaining ACIAR's prior written consent. Despite this, a Commissioned Organisation may sub-license Project IP on a non-exclusive basis to subcontractors specified in the initial CEO approved Project Document without first seeking ACIAR's approval.

12.13 Where ownership of Project IP vests in the Commissioned Organisation, the Commissioned Organisation agrees that it shall pay to ACIAR within 30 days of the expiration of 30 June and 31 December each year 25%, or such percentage as is otherwise agreed, of Net Monies Received by the Commissioned Organisation in the previous six months by way of licence fees, sale price or royalties in relation to such Intellectual Property, and this obligation of the Commissioned Organisation shall continue for a period of twenty (20) years from the commencement of the Project Agreement.

12.14 The Commissioned Organisation shall maintain proper books of account which evidence receipt of any licence fees, sale price or royalties payable to it in respect of Project IP and any expenses properly paid in relation thereto and ACIAR shall be granted access to those records at any time upon request. This obligation shall continue for a period of twenty (20) years from the commencement of the Project Agreement.

12.15 Where the Commissioned Organisation intends to publish any article or paper of an academic, scientific or technical nature in regard to the Services or the Project, or to place any advertisement requesting applications from persons to perform any part of the Services, any such publication or advertisement must acknowledge the funding and other support provided by ACIAR in regard to the Project.

12.16 The Commissioned Organisation may report details of the Project in the non-specialist media provided:

(a) it acknowledges the funding and support provided to the Project by ACIAR; and

(b) in the event that the subject of the proposed media report is or may be potentially controversial, the Commissioned Organisation shall, prior to submitting any information for publication, request ACIAR's written consent.

13. Moral Rights

13.1 ACIAR and the Commissioned Organisation:

(a) acknowledge the collaborative nature of the Project and the mutual benefit derived by the Parties from the Project;

(b) acknowledge the existence of Moral Rights conferred on the authors of any Works which are created in carrying out the Project or which exist as part of the Background IP;

(c) will immediately notify the other Party in writing:

(i) upon becoming aware of a possible infringement of Moral Rights of an author of any Works referred to in clause 13.1(b); or

(ii) upon becoming aware of a claim for infringement of Moral Rights being made against a Party by an author of any Works referred to in clause 13.1(b);

(d) will, following notice under clause 13.1(c), meet to negotiate in good faith (involving, where possible, the author of the relevant Works) the appropriate steps to resolve the matter to the satisfaction of the Parties and the author.

14. Disclosure of Information

14.1 The Commissioned Organisation shall not, without prior written approval of ACIAR, disclose to any person other than ACIAR, any Confidential Information of ACIAR.

14.2 ACIAR shall not, without prior written approval of the Commissioned Organisation, disclose to any person other than the Commissioned Organisation, any Confidential Information of the Commissioned Organisation. In giving written approval, the Commissioned Organisation may impose such terms and conditions as it thinks fit.

14.3 Either Party may at any time require the other Party to give and arrange for its employees, officers, agents and subcontractors to give written undertakings relating to the non-disclosure of its Confidential Information. The other Party shall promptly arrange for all such undertakings to be given.

14.4 The obligations under this clause shall not be taken to have been breached where the information referred to is legally required to be disclosed.

15. Privacy

15.1 The Commissioned Organisation, to the extent that it deals with Personal Information, when and for the purpose of, the Project – is a 'contracted service provider' within the meaning of the *Privacy Act 1988* (Cth), and in accordance with that Act must:

(a) comply with the Australian Privacy Principles ('APP') and with any registered, applicable APP Code or Registered CR Code, and

(b) cooperate with any reasonable request or direction of ACIAR in relation to an inquiry, audit or other exercise of powers or functions, by the Information Commissioner under that Act.

16. Coordinator

16.1 The person designated in the Project Document as the Project Leader, or any person agreed in writing by the Parties to replace that person, shall be responsible for coordinating all the Services to be provided by the Commissioned Organisation and this person shall liaise with ACIAR regularly in regard to the progress of the Project.

17. Project Committee

17.1 ACIAR may establish a Project Committee that shall include a representative of each of the Parties and, where appropriate, the Collaborating Institution.

17.2 The Project Committee shall advise the Parties in relation to Project matters, and may call for specialised advice on any matter related to the Project.

18. Review and Evaluation

18.1 ACIAR may at any time undertake to review and evaluate the Project.

18.2 ACIAR may within three years of the completion of the Project undertake a review to assess the adoption and uptake of the Project results.

18.3 To facilitate any review under clauses 18.1 and 18.2, the Commissioned Organisation shall promptly provide any financial, technical or such other information as is required by ACIAR and shall at all reasonable times permit persons authorised by ACIAR to have access to the premises upon which the Services are being or have been performed.

19. Report

19.1 The Commissioned Organisation shall provide ACIAR with Annual Reports by 14 July each year until the final year. If the project has been active for more than five months on 14 July an Annual Report is required to be submitted. Annual reports must be prepared in accordance with the Guidelines that are current at the time of preparation of the report and which are available through the ACIAR project management system. The Annual Report for the final year (or part year) of the Project should be subsumed into the Final Report.

19.2 Upon the completion of the Project in accordance with the Project Agreement, the Commissioned Organisation shall provide ACIAR with a Final Report. Final Reports must be prepared in accordance with the Guidelines that are current at the time of preparation of the Report and which are available through the ACIAR project management system. The Final Report is due within 60 days of the completion of the Project.

19.3 Where requested, the Commissioned Organisation shall provide ACIAR additional reports prepared in accordance with the Guidelines available through the ACIAR project management system. Such additional reports may include an Interim Final Report, Project Factsheets and/or other *ad hoc* reports.

19.4 Where, during the development, approval and life of a Project a Self Assessment of the potential for significant environmental impacts under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been accepted, the Commissioned Organisation shall provide ACIAR with a Report by 14 July each year on the implementation and effectiveness of the risk management procedures identified in the Self Assessment.

20. Termination

20.1 In the event of acts of God, fire, storm, flood, earthquake, explosion, accident, acts of a public enemy or terrorism, war, rebellion, insurrection, sabotage, epidemic, quarantine restrictions, industrial dispute, transportation embargo or failure or delay in transportation that render the performance of the Services impracticable or impossible either Party may, upon providing a minimum of three (3) calendar months written notice to the other, terminate the Project Agreement.

20.2 In addition to clause 20.1, ACIAR may at any time by written notice, terminate the Project Agreement, or reduce it in scope. If the Project Agreement is terminated under clause 20.1 or 20.2, ACIAR shall be liable only for:

(a) payments under the payment provisions of the Project Agreement for Services rendered before the effective date of termination; and

(b) subject to clauses 20.3, 20.4 and 20.5 any reasonable costs incurred by the Commissioned Organisation and directly attributable to the termination or partial termination of the Project Agreement.

20.3 Upon receipt of a notice of termination the Commissioned Organisation shall:

(a) stop work as specified in the notice;

(b) take all available steps to minimise loss resulting from that termination and protect the Material; and

(c) continue work on any part of the Services not affected by the notice.

20.4 In the event of a reduction in scope, ACIAR's liability to provide funds under the Project Agreement shall, in the absence of agreement to the contrary, abate proportionately to the reduction in the Services.

20.5 ACIAR shall not be liable to pay compensation in an amount that would, in addition to any amounts paid or due, or becoming due, to the Commissioned Organisation under the Project Agreement, together exceed the funds set out in the Project Agreement. The Commissioned Organisation shall not be entitled to compensation for loss of prospective profits.

20.6 If the Commissioned Organisation fails to fulfil or is in breach of any of its material obligations under the Project Agreement and does not rectify the omission or breach after receiving fourteen (14) days' notice in writing from ACIAR to do so, ACIAR may terminate the Project Agreement by giving written notice to the Commissioned Organisation of the termination which is effective immediately.

21. Insurance

21.1 The Commissioned Organisation shall, for so long as any obligations remain in connection with the Project Agreement, effect and maintain with reputable and substantial underwriters the following insurance:

(a) workers' compensation for an amount required by any relevant legislation;

(b) in relation to Services performed in Australia, public liability insurance for an amount of not less than $10,000,000 per claim and $10,000,000 in aggregate;

(c) in relation to work performed outside Australia, adequate insurance against claims by third parties resulting from negligent acts performed by the Commissioned Organisation in carrying out the Services; and

(d) adequate travel and medical insurance for any domestic and international travel undertaken on behalf of the Project by its personnel including Specified Personnel.

21.2 Within 14 days of a written request from ACIAR, the Commissioned Organisation must provide ACIAR with a copy of any insurance policy (or related Certificates of Currency) effected in accordance with this requirement and of all receipts for payments of premiums.

21.3 The requirement of clause 21.1(c) does not apply in relation to work performed in a particular country if ACIAR agrees in writing that such insurance is not available in relation to the performance of the Services in that country.

21.4 Notwithstanding the clause 19.1(c), the Commissioned Organisation may undertake self-insurance arrangements with ACIAR’s prior written approval.

21.5 ACIAR undertakes no responsibility in respect of loss or damage to Project equipment or supplies or in respect of any life, accident, travel or any other insurance coverage that may be necessary or desirable for the personnel or subcontractors of the Commissioned Organisation or for the dependants of any such persons as may travel for the purposes of the Services.

22. Indemnity

22.1 The Commissioned Organisation shall indemnify ACIAR, its officers, employees and agents from and against any loss (including legal costs and expenses on a solicitor/own client basis), or liability, incurred or suffered by any of those indemnified arising from any claim, suit, demand, action or proceeding by any person where such loss or liability was caused by any wilful misconduct or unlawful or negligent act or omission of the Commissioned Organisation, its officers, employees, agents or subcontractors in connection with the Services.

22.2 The Commissioned Organisation’s liability to indemnify ACIAR under clause 22.1 shall be reduced proportionally to the extent that any unlawful or negligent act or omission of ACIAR or its officers, employees, agents or sub-licencees contributed to the loss or liability.

23. Waiver

23.1 A waiver by either Party in respect of any breach of a condition or provision of the Project Agreement shall not be deemed to be a waiver in respect of any continuing or subsequent breach of that provision, or breach of any other provision. The failure of either Party to enforce any of the provisions of the Project Agreement at any time shall in no way be interpreted as a waiver of such provisions.

24. Compliance with laws and policies

24.1 General

Without limiting specific provisions of the Project Agreement, the Commissioned Organisation must:

(a) observe the same standards and obligations that are imposed on Commonwealth personnel under the *Work Health Safety Act 2011* (Cth) or where relevant any state or territory law and regulations applicable to work health and safety;

(b) comply with the obligations imposed under the *Lobbying Code of Conduct* (Cth), if applicable;

(c) comply with all relevant legislation of the Commonwealth, or of any State, Territory or local authority under any agreement entered into with the Commonwealth including:

(i) the *Crimes Act 1914* (Cth);

(ii) the *Disability Discrimination Act 1992* (Cth);

(iii) the *Racial Discrimination Act 1975* (Cth);

(iv) the *Sex Discrimination Act 1984* (Cth);

(v) the *Age Discrimination Act 2004* (Cth) and the *Age Discrimination*

(Consequential Provisions) Act 2004 (Cth);

(vi) any obligations it has under the *Work Health Safety Act* 2011 (Cth) or equivalent state or territory law and regulations;

(d) comply with all applicable workers compensation laws; and

(e) comply with such other Commonwealth and agency policies relevant to the performance or provision of the Services and notified in writing to the Commissioned Organisation.

24.2 The Commissioned Organisation must ensure that it and any individuals, persons, entities or organisations involved in delivering Goods and or Services under this Contract, including its officers, employees, agents and subcontractors, are not:

(a) directly or indirectly engaged in preparing, planning, assisting or fostering a terrorist act;

(b) listed terrorist organisations for the purposes of the *Criminal Code Act 1995* (Cth) (details of listed terrorist organisations are available at https://www.nationalsecurity.gov.au/Listedterroristorganisations/Pages/default.aspx);

(c) subject to sanctions or similar measures under the *Charter of the United Nations Act 1945* (Cth) or the *Autonomous Sanctions Act 2011* (Cth) (details of individuals and entities are available at: https://dfat.gov.au/international-relations/security/sanctions/Pages/consolidated-list.aspx);

(d) listed on the 'World Bank's Listing of Ineligible Firms and Individuals' posted at: https://www.ag.gov.au/Integrity/counter-fraud/fraud-australia/Pages/fraud-frameworks-legislation-policies.aspx ;

(e) owned, controlled by, acting on behalf of, or at the direction of individuals, persons, entities or organisations referred to in clauses 24.2(a) to 24.2(d) above; or

(f) providing direct or indirect support, resources or assets (including any grant monies) to individuals, persons, entities or organisations referred to in clauses 24.2(a) to (e) above.

24.3 Where the Commissioned Organisation becomes aware that there are reasonable grounds to suspect it or any of its officers, employees, agents and subcontractors has or may have contravened any part of clause 24.2, the Commissioned Organisation must:

(a) notify ACIAR and confirm that information in writing as soon as possible, which must be no later than within 24 hours;

(b) immediately take all reasonable action to mitigate the risks; and

(c) take any other action required by ACIAR.

24.4 The Commissioned Organisation must ensure that any subcontract entered into by the Commissioned Organisation must ensure that any subcontract entered into by the Commissioned Organisation for the purposes of fulfilling its obligations under this Contract imposes on the Subcontractor the same obligations that the Commissioned Organisation has under this clause, including this requirement to impose obligations on any further subcontractor.

25. Child safety

25.1 If any part of the Project involves the Commissioned Organisation employing or engaging a person (whether as an officer, employee, contractor, or volunteer) that is required by State or Territory law to have a working with children check to undertake the Project or any part of the Project, the Commissioned Organisation agrees:

(a) to comply with all State, Territory or Commonwealth law relating to the employment or engagement of people who work or volunteer with children in relation to the Award, including mandatory reporting and working with children checks however described; and

(b) if requested, provide the Commonwealth at the Commissioned Organisation's cost, an annual statement of compliance with this clause, in such form as may be specified by the Commonwealth.

25.2 When Child Safety obligations may be relevant to a Subcontract, the Commissioned Organisation must ensure that any subcontract entered into by the Supplier for the purposes of fulfilling the Commissioned Organisation's obligations under the contract imposes on the Subcontractor the same obligations regarding Child Safety that the Commissioned Organisation has under the Contract. Each subcontract must also require the same obligations (where relevant) to be included by the Subcontractor in any secondary subcontracts.

26. Workplace Gender Equality

26.1 This clause 26 applies only to the extent that the Commissioned Organisation is a 'Relevant Employer' for the purposes of the *Workplace Gender Equality Act 2012* (Cth) (the WGE Act).

26.2 The Commissioned Organisation must comply with all of its obligations under the WGE Act.

26.3 If the Commissioned Organisation becomes non-compliant with the WGE Act during the term of the Project Agreement, the Commissioned Organisation must notify ACIAR.

26.4 If the term of the Project Agreement exceeds 18 months, the Commissioned Organisation must provide a current letter of compliance with the WGE Act within 18 months from the Commencement Date of any Project Agreement, and following this annually to ACIAR.

26.5 Compliance with the WGE Act does not relieve the Commissioned Organisation from its responsibilities to comply with its other obligations under the Project Agreement.

27. Fraud Control

27.1 Without derogating from its obligations in the Project Agreement, the Commissioned Organisation must comply with the requirements of the Commonwealth Fraud Control Framework or any replacement guidelines, in force from time to time, available at http://www.ag.gov.au/Integrity/counter-fraud/fraud-australia/Documents/CommonwealthFraudControlFramework2017.DOCX

27.2 ACIAR's Fraud Policy Statement and guidance on reporting any allegations or concerns regarding fraud within the Project is available at https://www.aciar.gov.au/Standard-Contract-Conditions-and-Intellectual-Property-Policy

27.3 On request, the Commissioned Organisation will provide for ACIAR's review and acceptance a Fraud Control Plan that details actions the Commissioned Organisation will undertake in order to identify, report and manage instances by its personnel and/or third party members including subcontractors of any Fraud and any suspected Fraud incident. The Control Plan will specify what audit procedures and audit frequency will be applied.

28. Conflict of interest

28.1 **Warranty that there is no conflict of interest**

The Commissioned Organisation warrants that, to the best of its knowledge after making diligent inquiry, at the date of signing the Project Agreement no conflict of interest exists or is likely to arise in the performance of its obligations under the Project Agreement.

28.2 **Notification of a conflict of interest**

If, during the performance of the Services a conflict of interest arises, or appears likely to arise, the Commissioned Organisation must:

(a) notify ACIAR immediately in writing;

(b) make full disclosure of all relevant information relating to the conflict; and

(c) take such steps as ACIAR requires to resolve or otherwise deal with the conflict.

29. Applicable Law

29.1 The Project Agreement shall be governed by and construed in accordance with the laws of the Australian Capital Territory. The Commissioned Organisation submits to the jurisdiction of the courts of that Territory and any court competent to hear appeals from those courts.

29.2 The Commissioned Organisation shall ensure that in carrying out the Services it complies with the laws from time to time in force in the Australian State or Territory or in the country in which the Services, or any part thereof, are to be carried out.

30. Authority and consents

30.1 Any and all rights, powers, authorities and discretions expressed in the Project Agreement or in the specifications to be conferred upon or vested in ACIAR may be exercised by any person designated for that purpose by the Minister.

30.2 Except as expressly provided in the Project Agreement, ACIAR may conditionally or unconditionally in its absolute discretion give or withhold any consent or approval under the Project Agreement, ACIAR will not unreasonably withhold consent.

31. Cooperation

31.1 ACIAR shall provide necessary representation with appropriate officials of the Government of the Collaborating Country to assist in securing cooperation reasonably required for the successful completion of the Project.

32. Variation to the Project Agreement

32.1 The Project Document including Budget is the latest ACIAR approved version within the ACIAR projects management system.

32.2 ACIAR or the Commissioned Organisation may make minor variations to the Project Document within the ACIAR project management system. Minor variations include changes to the scope of activities and to Collaborating Institution personnel.

32.3 Significant variations to the Project Agreement shall be made by means of a Letter of Variation signed for and on behalf of the Parties to the Project Agreement. A significant variation would include changes in objectives, or changes to the 'Payment Schedule' of the Budget.

33. Dispute Resolution

33.1 Subject to clause 33.4, before resorting to external dispute resolution mechanisms the Parties shall attempt to settle by negotiation any dispute in relation to the Project Agreement including by referring the matter to personnel who may have authority to intervene and direct some form of resolution.

33.2 If a dispute is not settled by the Parties within 10 working days of one Party first sending to the other Party written notice that they are in dispute, the dispute may be the subject of court proceedings, or may be submitted to some alternative dispute resolution mechanism as may be agreed in writing between the Parties.

33.3 Notwithstanding the existence of a dispute, each Party shall continue to perform its obligations under the Project Agreement.

33.4 A Party may commence court proceedings relating to any dispute arising under the Project Agreement at any time where that Party seeks urgent interlocutory relief.

34. Books and records

34.1 Commissioned Organisation to keep books and records

The Commissioned Organisation must:

(a) keep and require its subcontractors to keep adequate books and records, in accordance with Accounting Standards, in sufficient detail to enable the amounts payable by the Commonwealth under the Project Agreement to be determined; and

(b) retain and require its subcontractors to retain for a period of seven years after the expiry or termination of the Project Agreement all books and records relating to the Services.

34.2 **Costs**

The Commissioned Organisation must bear its own costs of complying with this clause 34.

34.3 **Survival**

This clause 34 applies for the Term of Project Agreement and for a period of seven years from the expiry or termination of the Project Agreement.

35. Audit and access

35.1 **Right to conduct audits**

The Commonwealth through ACIAR or a representative may conduct audits relevant to the performance of the Commissioned Organisation's obligations under the Project Agreement. Audits may be conducted of:

(a) the Commissioned Organisation's operational practices and procedures as they relate to the Project Agreement, including security procedures;

(b) the Commissioned Organisation's compliance with its confidentiality, privacy and security obligations under the Project Agreement;

(c) Material (including books and records) in the possession of the Commissioned Organisation relevant to the Services or the Project Agreement; and

(d) any other matters determined by the Commonwealth to be relevant to the Services or the Project Agreement.

35.2 **Access by the Commonwealth**

(a) The Commonwealth through ACIAR or a representative may, at reasonable times and on giving reasonable notice to the Commissioned Organisation:

(i) access the premises of the Commissioned Organisation to the extent relevant to the performance of the Project Agreement;

(ii) require the provision by the Commissioned Organisation, its employees, agents or subcontractors, of records and information in a data format and storage medium accessible by the Commonwealth by use of the Commonwealth's existing computer hardware and software;

(iii) inspect and copy documentation, books and records, however stored, in the custody or under the control of the Commissioned Organisation, its employees, agents or subcontractors; and

(iv) require assistance in respect of any inquiry into or concerning the Services or the Project Agreement. For these purposes an inquiry includes any administrative or statutory review, audit or inquiry (whether within or external to the Commonwealth), and any inquiry conducted by Parliament or any Parliamentary committee.

(b) The Commissioned Organisation must provide access to its computer hardware and software to the extent necessary for the Commonwealth to exercise its rights under this clause 33, and provide the Commonwealth through ACIAR or its representative with any reasonable assistance requested by the Commonwealth to use that hardware and software.

35.3 **Conduct of audit and access**

The Commonwealth through ACIAR or a representative must use reasonable endeavours to ensure that:

(a) audits performed under clause 33.1; and

(b) the exercise of the general rights granted by clause 33.2 by the Commonwealth,

do not unreasonably delay or disrupt in any material respect the Commissioned Organisation's performance of its obligations under the Project Agreement or its business.

35.4 **Costs**

Unless otherwise agreed in writing, each party must bear its own costs of any reviews and/or audits.

35.5 **Auditor-General and Privacy Commissioner**

The rights of the Commonwealth through ACIAR or its representative under clause 33.2(a)(i) to 33.2(a)(iii) apply equally to the Auditor-General or a delegate of the Auditor-General, or the Privacy Commissioner or a delegate of the Privacy Commissioner, for the purpose of performing the Auditor-General's or Privacy Commissioner's statutory functions or powers.

35.6 **Commissioned Organisation to comply with Auditor-General's requirements**

The Commissioned Organisation must do all things necessary to comply with the Auditor-General's or his or her delegate's or the Privacy Commissioner's or his or her delegate's requirements, notified under clause 33.2, provided such requirements are legally enforceable and within the power of the Auditor-General, the Privacy Commissioner, or his or her respective delegate.

35.7 **No reduction in responsibility**

The requirement for, and participation in, audits does not in any way reduce the Commissioned Organisation's responsibility to perform its obligations in accordance with the Project Agreement.

35.8 **Subcontractor requirements**

The Commissioned Organisation must ensure that any subcontract entered into for the purpose of the Project Agreement contains an equivalent clause granting the rights specified in this clause 35.

35.9 **No restriction**

Nothing in the Project Agreement reduces, limits or restricts in any way any function, power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner. The rights of the Commonwealth under the Project Agreement are in addition to any other power, right or entitlement of the Auditor-General or a delegate of the Auditor-General or the Privacy Commissioner or a delegate of the Privacy Commissioner.

35.10 **Survival**

This clause 33 applies for the Term of the Project Agreement and for a period of seven years from the expiry or termination of the Project Agreement.

36. Access to documents

36.1 **Definitions**

In this clause, 'document' and 'Commonwealth contract' have the same meaning as in the *Freedom of Information Act 1982* (Cth).

36.2 **Application of this clause**

This clause 36 only applies where the Project Agreement or a subcontract is a Commonwealth contract.

36.3 **Obligations**

The Commissioned Organisation agrees that where the Commonwealth has received a request for access to a document created by, or in the possession of, the Commissioned Organisation (or any subcontractor) that relates to the performance of the Project Agreement (and not to the entry into the Project Agreement), the Commonwealth may at any time by written notice require the Commissioned Organisation to provide the document to the Commonwealth, and the Commissioned Organisation must, at no additional cost to the Commonwealth, promptly comply with the notice.

36.4 **Subcontractor requirements**

The Commissioned Organisation must include in any subcontract relating to the performance of the Project Agreement provisions that will enable the Commissioned Organisation to comply with its obligations under clause 34.

37. Survival

In addition to any clauses individually expressed to survive, the following clauses survive the expiry or termination of the Project Agreement:

(a) Clause 7 (GST);

(b) Clause 12 (Intellectual Property Rights);

(c) Clause 13 (Moral Rights);

(d) Clause 14 (Disclosure of Information);

(e) Clause 15 (Privacy);

(f) Clause 21 (Insurance);

(g) Clause 22 (Indemnity);

(h) Clause 29 (Applicable Law); and

(i) Clause 33 (Dispute Resolution).

Change Register

ACIAR has developed Standard Conditions which which are a key part of Project Agreements, helping to facilitate research partnerships.

Recent changes to the Standard Conditions are identified below. This information is provided to assist Commissioned Organisations keep up to date with changes to the Standard Conditions. This Change Register will be updated as further substantive changes are made.

Inclusion of a definition of *"Works"* in clause 1, Interpretation	Jan 05
Replacement of clause 11 Moral Rights with a complete new clause relating to moral rights	Jan 05
Clause 20.1: Deletion of the words "and hold harmless"	March 07
ACIAR Act amendment as a result of governance changes. ACIAR now enters into this agreement on behalf of the Commonwealth of Australia. Subsequent changes to the agreement.	July 07
Removal of guidelines and proformas for the preparation of annual and final reports. Inclusion of a reference to web based guidelines and proformas.	July 07
Included reference to clause 10.2 in definition of *"Works"* in clause 1	July 07
Deleted reference to "exploit" in clause 1.	
Inclusion of subclause 7.2 relating to the conduct of personnel engaged in the Services and related definitions.	July 07
Clause 10.3: Included wording to Commissioned Organisation warranty on use of background IP	July 07
Clauses 10.2 and 10.11: Deleted "exploit" and included wording on sub-licencing by ACIAR	July 07
Clause 20.2: Included words "unlawful or negligent"	July 07
Clause 10.1: Amended reference to International *Treaty*	July 07
Clause 13.4: Wording change from "which arises directly or indirectly" to "arising"	July 07
Clause 20.1: Included words "wilful misconduct"	July 07
Clause 20.2: Included words "and sub-licencees"	July 07
Revised Clause 5.14 GST	July 07
Revised Clause 8 Travel	January 13
Revised Clause 17.1. Timeframe before first Annual Report now more than 5 months	June 2013
Inclusion of Clause 17.3. EPBC Act reporting (if required)	December 2013
Inclusion of Definition to Clause 1.1. Fraud	February 2014
Inclusion of Clause 22. Compliance with laws and policies	February 2014
Inclusion of Clause 23 Workplace Gender Equality	February 2014
Inclusion of Clause 24 Fraud Control	February 2014
Inclusion of Clause 25 Conflict of Interest	February 2014
Clause 5.10 Revision of acquital requirements	May 2014

Clause 13 Protection of Personal Information deleted and replaced with Clause 13 Privacy	May 2014
Change register – ACIAR Acquital revised	May 2014
Layout Change	February 2015
Clauses 7.4 & 7.5 - Expand definition of Commissioned Organisation Personnel to include Specified Personnel, employees, agents and subcontractors)	February 2015
Clause 3 –Subcontracting expanded with new clauses 3.4 and 3.5	February 2015
Addition of Clause 5.14 – Taxes	February 2015
Clause 5.13 deleted and replaced with Clause 31- Books and records, Clause 32 – Audit and Access and Clause 33 – Access to documents	February 2015
Clause 19.1(c) –amended	February 2015
Addition of Clause 34 - Survival	February 2015
Definition amended for Project Agreement Letter to Letter of Agreement	July 2015
Definition amended for Letter of Intent to Letter of Interim Agreement	July 2015
Definition amended for Collaborating Country, Commissioned Organisation, Project and Project Agreement	July 2015
Added new definition International Agreement	July 2015
Clause 1.1 Interpretation; amend definition for "Letter of Interim Agreement"	August 2015
Amend Clause 24 Fraud Control	January 2016
Changes to support ACIAR project management system	September 2017
Amend clause 24 Compliance with laws and policies	January 2020
Addition of new clause 6 - Interest on Late Payments and Definitions	January 2020

IP Assessment

Administrative details	
Project ID	FIS/2023/133
Project title	Optimising fish passage at hydropower sites in the Mekong
Name of person providing this Assessment	
Tick if person providing the Assessment is NOT the Project Leader	[ ]
Date of assessment	

Plant or animal germplasm exchange

Does the project involve:	Yes	Country	[redacted]
provision of germplasm by Australia to a partner country?	[ ]		
provision of germplasm from a partner country to Australia?	[ ]		
provision of germplasm from or to an IARC or another organisation and a project participant?	[ ]		
use of germplasm from a third party	[ ]		
material subject to plant breeders/variety rights in Australia or another country?	[ ]		

Proprietary materials, techniques and information

Does the project involve provision (from one party to another) of:	Yes	Country	[redacted]
research materials or reagents (e.g. enzymes, molecular markers, promoters)?	[ ]		
proprietary techniques or procedures?	[x]	Australia	

			[redacted]
data	[ ]		
proprietary computer software?	[x]	Australia	

Other agreements

Is any aspect of the project work subject to, or dependent upon:	Yes	Country	[redacted]
other materials-transfer agreements entered into by any project participant?	[ ]		
confidentiality agreements entered into by any project participant?	[x]	Australia Lao PDR	

Foreground IP (IP that is expected to be developed during the project)

Foreground, background and third party Intellectual Property	Yes	Country	[redacted]
Is it expected that there will be Foreground IP?	[x]	Lao PDR Australia	

			[redacted]

<u>Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)</u>

Background IP	Yes	Country	[redacted]
Is it there Background IP?	[x]	Lao PDR Australia	[redacted]

			[redacted]
If “yes”, are there any restrictions on the project's ability to use the Background IP?	[x]	Australia Lao PDR	
would there be any restriction on ACIAR or the overseas collaborator claiming their rights to IP for the project based on the Background IP (refer ACIAR Standard Conditions)?	[x]	Lao PDR Australia	

			[redacted]

<u>Third Party IP (IP that is owned by or licensed from other parties)</u>

Third party IP	Yes	Country	[redacted]
Is there any relevant Third Party IP that is essential to the project?	[x]	Australia	
If “yes”, would there be any restriction on ACIAR claiming its rights to IP for the project (refer ACIAR Standard Conditions)?	[ ]		

<u>Other contracts, licences or legal arrangements</u>

Other contracts, licenses or legal	Yes	Country	
Are there any other contracts, licences or other legal arrangements that relate to the project?	[x]	Australia	

[redacted]

FOI Act s. 47

Australian Government

Australian Centre for International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/016
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organisation, collaborating institution(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavours to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/016
Project title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Proposal stage	Preliminary Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/08/2018
Proposed finish date	30/06/2019

Key contacts

Project Leader: Commissioned organisation

Title and name	Lee Baumgartner
Position at organisation	[Project Leader Position]Associate Research Professor
Organisation	Charles Sturt University

Administrative Contact: Australian commissioned organisation / commissioned IARC

Title and name	[Administrative Contact]
Position at organisation	[Administrative Contact Position]
Organisation at organisation	[Administrative Contact Organisation]

Key Project Members: Project Coordinator

Title and name	[Project Coordinator]
Position at organisation	[Project Coordinator Position]
Organisation	[Project Coordinator Organisation]

Key Project Members: Collaborating Scientist

Title and name	Dominique Vigie
Position at organisation	[Collaborating Scientist Position]
Organisation	Department of Foreign Affairs and Trade

Key Project Members: Collaborating Scientist

Title and name	Dominique Vigie
Position at organisation	[Collaborating Scientist Position]
Organisation	Department of Foreign Affairs and Trade

Contents

1 Project summary

1.1 Background and justification

Productive fisheries in the Lower Mekong Basin will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The dams have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupt access to vital spawning, nursery and feeding habitat. The Mekong region fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, is under construction and will be completed in late 2018. Xayaburi Dam blocks the entire width of the river with a dam wall more than 30 m high, presenting an impassable barrier to all fish species. Construction of Xayaburi Dam started in 2012 and is now approximately 90% complete. It will cost approximately US$3 billion and the first turbines are due to be operational in 2019. Significant investment (US$380M) in mitigation works to provide for fish passage were incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. This represents a substantial challenge and the question of whether the fish passage facilities will be effective is a question that the developer, Government of Lao PDR and scientists are keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential.

From a development perspective, energy generation is needed and will continue to be developed in regions where poor people are dependent on natural resources. The interaction of hydropower development and the maintenance of the ecosystem benefits of rivers has a tragic history worldwide. Yet, the Xayaburi facilities provide an opportunity to determine if better approaches can be demonstrated and adapted/applied to other sites. What is now certain is that Xayaburi Dam will be completed, so the present opportunity is to design and commence experiments that can help learn as much as is possible from it.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods which will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and in-situ. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aim and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust methods. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). [redacted] with significant additional in-kind support proposed over the four year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defensible, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the Lower Mekong Basin. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its agreement for publication of all results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities. The performance of the Xayaburi fish pass facilities are therefore of paramount importance to advise broader construction activities in the region. Monitoring technology developed at Xayaburi can be directly applied elsewhere and has transboundary relevance. The project team subsequently aim to connect with other developers, and bodies such as the Mekong River Commission, to ensure findings are communicated and used to inform future development decisions.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB. Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein.

Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction. The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade, there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong's productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB. All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing what is currently one of the most productive river fisheries in the world. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 70% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. XPCL has invested US$380 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America, but where investment only targets salmon species. XPCL recently invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site in May 2017. The purpose was to exchange information especially in relation to possible future research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.1.1 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural Asian citizens are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities. The Xayaburi project has been criticised for its potential impact on upstream food resources. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It is at the cutting edge of science and natural resource management in the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. Irrigation development has negatively impacted inland fisheries. This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating the expected win-win outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has, internationally, brought private, developmental and governmental sectors together to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to quantify fisheries benefits.

2.2 Relationship to other ACIAR investments and other donor and partner-country activities

2.2.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development. The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region. By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies. This will facilitate a more positive outcome from an economic and environmental perspective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising professionals to use the newly established infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining hard fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome ‘Agriculture, Fisheries and Water’. Hydropower development is one of the most significant water management issues in the Lower Mekong Basin; and Xayaburi Dam, being the first site, is of particular significance and international interest.

This project has been initially established as a four-year initiative with cash funding provided by DFAT ($1M); XPCL ($911,000), ACIAR ($400,000) and CSU ($150,000). Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 1/2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due December 2019. To maintain continuity for project staff, it is anticipated that the large follow-on project commence from August 2019.

2.2.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing during construction, and then when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies. XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.3 Research questions

2.3.1 Xayaburi fishpass overview

Specific design parameters were used to provide passage for fish at the dam site. For upstream migration, a complex fishway system was devised (Fig. 1). To successfully pass upstream:

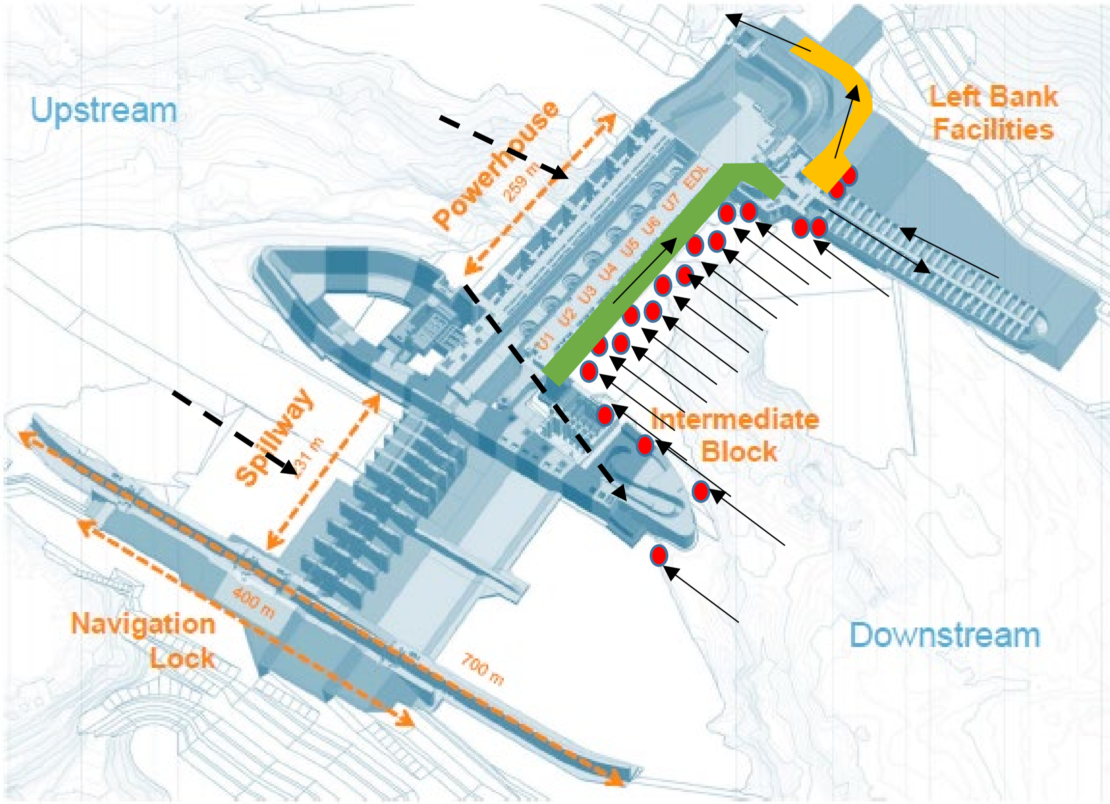
(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research program needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.



2.3.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

NB: The questions relating to downstream passage can only be answered once the site is operational.

It is essential that the research data informing the reporting is high quality and accurate. The purpose of this proposal is to develop and implement methods required to accurately answer the questions; then apply it to a site-scale assessment program. Without methods validation, the veracity of any generated data would be called into question.

2.3.3 Gender focus

It has been long recognised that empowering rural women and girls is an essential part of the solution to some of today's most serious global challenges: food security, poverty reduction and sustainable development. The five domains that most affect women's empowerment in agriculture are: production, resources, income, leadership and time. In Lao PDR, households and communities are largely stratified by gender. Therefore, systems that surround natural capital, ecosystems and biodiversity inevitably confront gender-based norms, assumptions and differences — especially in terms of resource access, usage, and control. Thus, both women and men have defined roles in fisheries value chains.

The Xayaburi project was established over 8 years ago and our research team is playing a very small, but important, role in the $US3B construction project. Many of the recruitment policies and hierarchical structures are already in place. The XPCL monitoring team was selected by the company and staff were allocated to assist our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately this has provided a gender structure (among the project team) which is predominantly male.

Outside the nominated project team, we strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, that the team is more balanced.

The overall aim of the Xayaburi Dam fish passing facilities, to achieve transparency for migrating fish in order to maintain fisheries and livelihoods, will benefit both men and women. The monitoring project is much larger than the tagging study and there are a host of metrics that XPCL are actively monitoring (fishermen catches, sediment transport, water level changes, flow data, bathymetry). This broader XPCL monitoring program is female-led and has a survey structure which is gender inclusive. Field teams comprise both male and female interviewers, and together these survey for male and female fishers and community members. But whilst these processes are outside our sphere of influence, we need to remain cogniscent of the fact that the project is seeking to preserve a resource that benefits an entire community. Access to the resource is non-discriminatory. If the project achieves its aim of passing fish then all communities, irrespective of gender, will benefit.

3 Research strategy and partnerships

3.1.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems. So there is a solid basis for the fish passage design.

The logical sequence for the proposed research is to:

1. Perform laboratory and in-situ trials of three techniques (PIT detection antennas, electrofishing boat and a long term tagging study) to optimise methods

2. Implement these methods at the dam site
3. Perform real-time monitoring of fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, if needed, the daily operation of the fish pass facilities
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

An adaptive management strategy is proposed. Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defensible; and
c) When combined, provide an overall picture of fishway effectiveness.

4.1 Project aim and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust methods. The specific objectives are:

The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

4.2 Research activities, methods and outputs

4.2.1 Monitoring fish at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods. Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters). In terms of fish, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's but have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. In recent years, the development of passive integrated transponder (PIT) technology has provided new opportunities to monitor fish migrations. A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are suitable for fish greater than 60 mm
5. Are relatively inexpensive relative to the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system) but have low overall running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FIshNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

Integrity: This is the critical component of any system. If a tag is missed, for any reason, it can cost research projects thousands of dollars. If a team spends time in the field, catching the animal, tagging it, releasing it and setting up a PIT system to detect it – it is important that the system is robust. If a tagged fish passes by an antenna but is not recorded due to some abnormality, it results in a loss of valuable data and potentially making a false assumption (fish did not pass). A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

Veracity: It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. Any data that are erroneous must be detected and rejected. This should incorporate both automatic and manual systems. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events. It is extremely important that when an animal is tagged, all data is recorded correctly.

Reliability: This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency. In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process. All of these factors are important to have faith in the data being generated.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance. They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Relevance to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement, which has been formed with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL subsequently need to demonstrate that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate no net impacts on fish.

The overall aim of this project is to implement a research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the Lower Mekong Basin. PIT tags were determined to be a suitable technology upon which to base initial trials. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully, (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species. Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in* and *ex-situ*. Based on successes at other dam sites internationally, PIT tagging has been identified as the most suitable technique.

If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase: There is the actual testing and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation. The validation phase will take approximately 18 months.

(2) Operational Implementation: Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise fishway settings and integrate fish movements into overall dam operation.

4.2.1 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a “high dam” fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System) PTAGIS framework. PTAGIS is a large, spatially integrated fish monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is ‘pinged’ within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement.

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass. Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to PTAGIS.

With two such systems operating successfully internationally, and with a cascade proposed for the Lower Mekong Basin, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

Thus, there are several distinct research phases, which need to be somewhat completed in chronological order, for site-based impacts to be scaled to other sites. The research strategy targets site-based impacts initially, but will scale to other sites as components are finalised and validated.

4.2.2 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a ‘loop’ that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency. PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway ‘slots’ to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions

The team have identified research questions that could be answered using a PIT system (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each location is paramount to success.

Stage 2: Obtain detailed engineering drawings

The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped should optimal design configurations be identified.

Stage 3: Construct prototype antennas and set up ‘in the dry’. KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions). The antennas, as indicated in the options diagrams over page, will be constructed. This approach is considered world-standard for antenna efficiency tests.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the ex-situ test in stage four, we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these in-situ tests will then advise the locations where fixed antennas should be located.

Additionally, and based on ex-situ testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

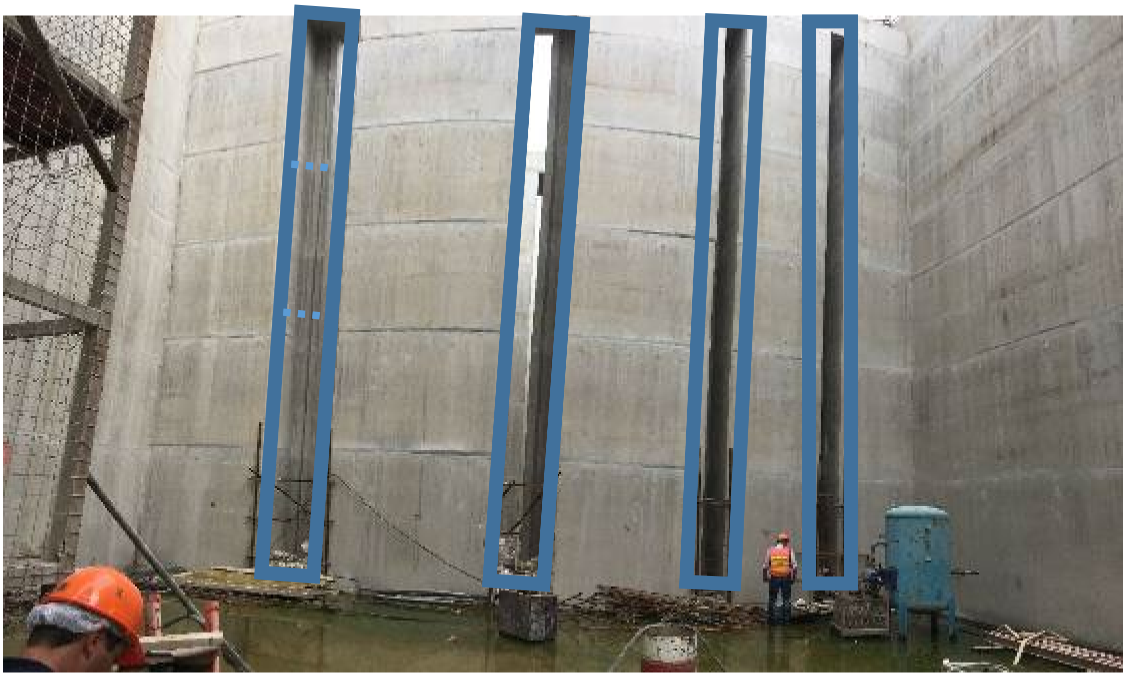


Figure 2. Slots where antennas are proposed to be installed and possible configurations.

4.2.3 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

Research activities

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 200 migratory species at the Xayaburi site and at least 20 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Work with XPCL staff and Lao government to identify target species, size classes and life history stages. This would require a rapid workshopping phase. It would likely include all species that were included in the fishway assessment studies (swimming ability) along with other species of key economic and conservation significance at the site. Ideally, the technique would be refined on the top 20 species.

Stage 2: Construct a fish hatchery facility to house the fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction will commence in 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve *et al*, 2018). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish. So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days. However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the fish batch of tagged fish to inform on fishway operation

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

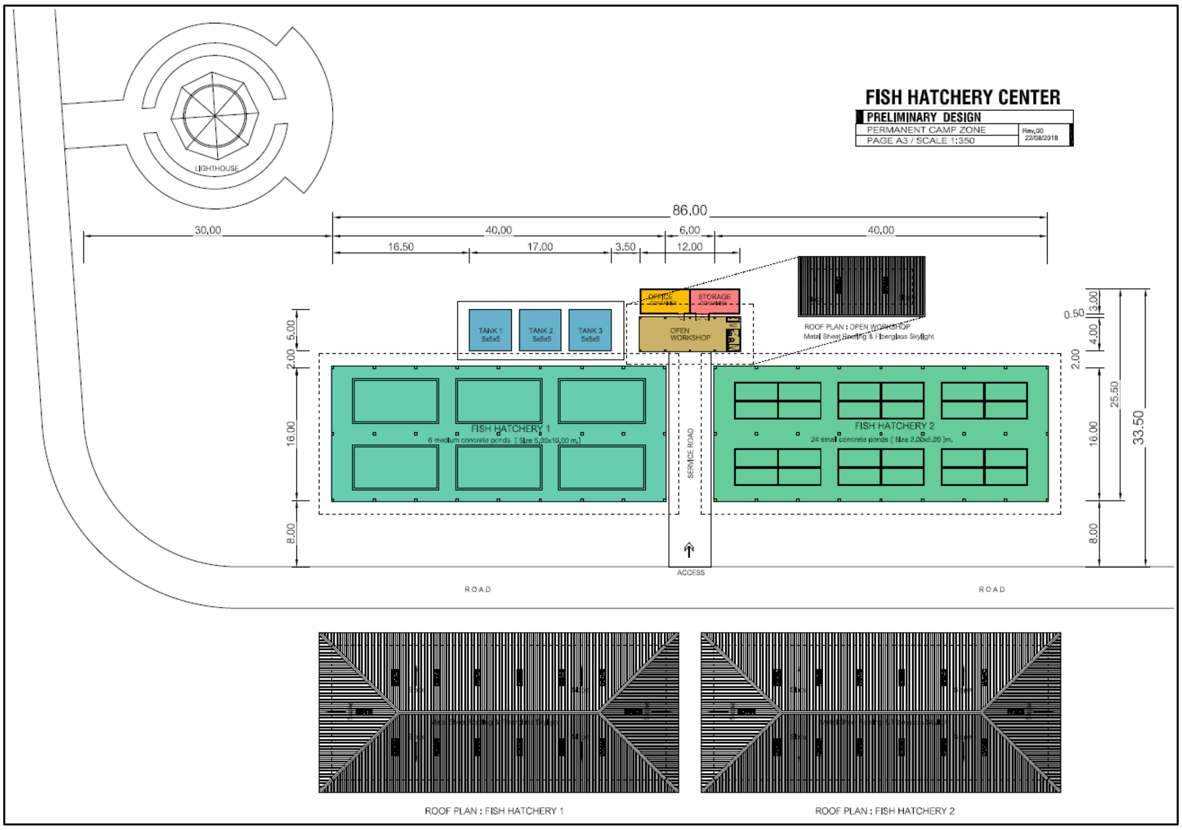
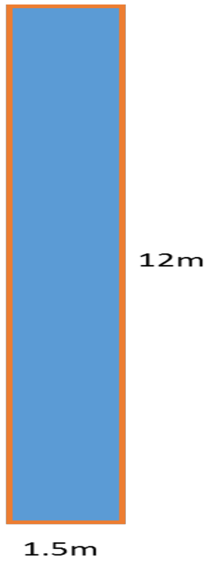
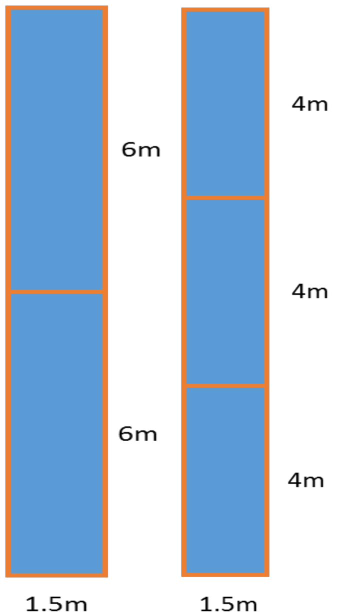
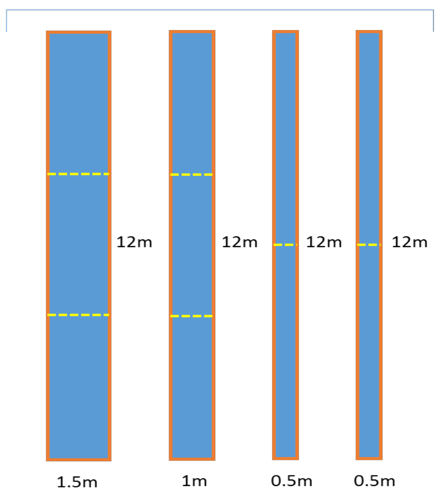


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	Diagram	Comment
12 m x 1.5 m		Large “slot” antenna. Unknown if tags will perform optimally at this width. Never before tested under such dimensions when operating from a single control unit. The target is 99% read efficiency of 12 mm tags with no “dead spot” in the middle region. Fastest read speed; but these dimensions stretch the limits of PIT technology
12 m x 1.5 m (alternatives)		Two alternative configurations. These will need to be assessed to cover individual slots should a single large design provide sub-optimal results. The target is 99% read efficiency of 12 mm tags with no “dead spot” in the middle region of any of the tag locations.
Maximum predicted number of antennas		The diagram on the left represents the maximum number of antennas for each baffle = 10.

4.2.4 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. But this is a harsh technique which can cause stress and, in extreme cases, impact survival. Tagging a fish which has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish. It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL will provide all funds to purchase the vessel assuming that CSU can guide construction and train Lao government, University and XPCL in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish. It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival. It is widely used in Australia, and Charles Sturt University staff can advise on specifications and can run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river. So combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. For this component, we will need to manipulate the voltage settings (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into regional guidelines documents.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Table 2. List of migratory species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Greed indicates the upstream migration season and yellow the downstream migration season.

species	local name	month											
		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Cyclocheilichthys enoplos	Pa Joke												
Cyclocheilichthys repasson	Pa Joke-sai												
Henicorhynchus lobatus	Pa Sroi												
Labeo chrysophekadion	Pa Pia												
Hemibagrus nemurus	Pa Kod												
Mekongina erythospila	Pa Sa-ee												
Sikukia gudgeri	Pa Mang												
Chitala sp.	Pa Tong												
Pangasius macronema	Pa Yorn												
Hemisilurus mekongensis	Pa Dangdaeng												
Phalacronotus apogon	Pa Sa-ngua												
Bagarius suchus	Pa Khae												
Paralaubuca typus	Pa Teab												
Tenulosa thibaudeaui	Pa Mak-pang												
Pangasianodon hypophthalmus	Pa Sway												
Cyprinus carpio carpio	Pa Nai												
Yasuhikotia modesta	Pa Kiaw-Gai												
Macrochirichthys macrochirus	Pa Fak-pa												
Pristolepis fasciata	Pa Chang-yeab												
Pangasius bocourti	Pa Phor												
Pangasius conchophilus	Pa Mong												
Pangasius larnaudii	Pa Thay-po												
Phalacronnotus bleekeri	Pa Sa-ngua												
Wallago attu	Pa Kaow												
Hemibagrus filamentus	Pa Kod-rueng												
Pangasianodon gigas	Pa Buek												

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

4.2.5 Research component 4: Measuring fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. The steps need to be taken in chronological sequence prior to implementing the fish pass monitoring program.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing real-time data uploads. A series of Xayaburi specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the entrance antennas).

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. Mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with to flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team are aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (assume commencement after SRA concludes in August 2019)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged	Commencement	Salaries and travel secured for Australian partners Existing SRA MOU's transfer to full project	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	XPCL staff to Australia Can align with another trip for Indonesian scientists	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	Conclude tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update MRC	Continue to meet with MRC to work on dam guidelines document	Annually, twice	MRC are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in MRC guidelines Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	July 2020	All milestones are met	Project progress is on track
1.6	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing

Year 2 (Aug 2020 – Jul 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting and project steering committee meeting	Annual reporting to GoA Hold annual workshop on site in Lao PDR or at XPCL HQ in Bangkok	July 2021	All milestones are met	Project progress is on track
2.2	Attend AFS Columbus, Ohio	Conference presentations Conference papers	Aug 2020	Funding is available to attend	All project staff present the work in an international forum The project team results are introduced into the public arena
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update MRC	Continue to meet with MRC to work on dam guidelines document	Annually, twice	MRC are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in MRC guidelines Commence dialogue with other developers in terms of applying outputs to their site

Year 3 (Aug 2021 – July 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other hydropower developers and MRC	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.5	Regular reporting to industry and regulators commences	First formal report to regulators and industry completed	Jul 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated
3.6	Final reporting	Final report to DFAT/ACIAR completed	Jul 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are three main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities and it has been suggested, by the Mekong River Commission, that these facilities must have equal, or better, functionality than those at Xayaburi.

The Mekong River Commission is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “mainstem dam hydropower guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin. The latest draft of this document is considering the considerable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. Thus, the research program is an integral part of influencing that document. Our project team subsequently includes Prof. Martin Mallen-Cooper, who is on the MRC guidance document development panel. We aim to not only influence and shape the final contents of the document but to also ensure that standard research methods are included. Thus, our aim is to ensure that the research work scoped and implemented at Xayaburi Dam becomes the minimum standard implemented at other dam sites. Hence there is a strong need to ensure our methods have been rigorously defined, are scalable and defensible.

Project extension

Project extension will be limited and controlled. There are two commercial entities which wish to limit broader messaging into the public arena. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam. There is a community of lobbyists who will not change their opinion regardless of the level of investment in mitigation. Making broad statements through an outreach program will mobilise this lobby and distract the team from project objectives. Xayaburi are also bidding for a second dam project on the Mekong and releasing too much information into the public domain could have commercial implications. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect and is unwilling for the technical details of its product to enter the public domain during the research phase. With these issues in mind, the project team has entered into a confidentiality arrangement where no project messaging will be made public without the explicit approval of all parties. Thus, extension and outreach is likely to be limited, at least initially, whilst the research methods are developed and refined.

4.4.2 Capacity building

Partner countries

Fish passage technology and implementation, as pertaining to hydropower dams will be provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL have a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Australian capacity
Australian researchers will benefit from involvement in the project. The tropical rivers offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes that they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with broader hydropower development activities into the future.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, it is essential to link with the Mekong River Commission and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Quarterly Action Plans', which take the activities in three month blocks and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These Quarterly Action Plans are devised before each new quarter, and assessed at the end of each quarter during the 'co-ordination' meetings with the partners and the coordination team. These Action Plans then become Quarterly Progress Reports. The quarterly progress reports form the basis for the bi-annual Technical Progress Report, which forms a reflective process of the last 6 months for each activity. In addition to reviewing the result progress, the coordination meetings will also allow to strengthen the linkages between the different result areas and partners.

Medium-term cycles

The quarterly reports culminate in yearly reports and a 'Learn and Adapt' forum, in line with overall yearly project reporting. In the dry season of each year a 'Learn and Adapt' forum is held in each country for the respective countries, where a review from each partner country of the previous year's achievements, challenges and learnings is presented, and plans adapted for the next country specific workplans.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored against to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam fish pass effectiveness is quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. Guidelines developed (ii; vi; v) No. New mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through access to increased food and other resources if the Xayaburi facilities are demonstrated to work. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- International recognition for project team scientists at a major regional conference
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) *Factors influencing PIT antenna efficiency at high dam fishways*
  (b) *Tag retention and mortality in key Lower Mekong Basin species*
  (c) *Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers*
  (d) *Optimising electrofishing for deployment in the Lower Mekong Basin*
- A project final report
- Presentations given at the Fish Passage 2018 conference (Albury, Australia, 2018)
- Abstracts published in conference proceedings

4.6 Intellectual property and other regulatory compliance

This will be completed at full proposal stage. There are several issues which will need to be considered.

Firstly, the fish pass design itself is considered commercial-in-confidence by Xayaburi Power Company Limited. XPCL are happy to disclose details to team members and research partners. However, distribution outside the team requires approval from the managing director. XPCL have invested significant capital into the fish pass design and are bidding for other mainstem dams. Thus, there are confidentiality considerations to be respected (See Appendix 1; XPCL-CSU MOU).

Secondly, the PIT system itself, and the associated database, is a proprietary product which has been designed and patented by Australian company KarlTek Pty Ltd. The company is obviously happy for the system to be promoted. However, the components and assembly are protected by patent and cannot be publically disclosed without written approval from KarlTek Pty Ltd.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site and overall fish pass performance has implications at a site, national and international level. Site based-impacts related to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we hope to influence the design and construction of other dams into the future (Figure 5). A key aspect of this project is including team members who are presently involved in the development of the Mekong River Commission mainstem dam guidelines.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The “gold standard” Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs

Long term (strategic):

1) PIT tagging incorporated into Mekong River Commission dam guidelines
2) PIT tag systems installed at other mainstem dam sites

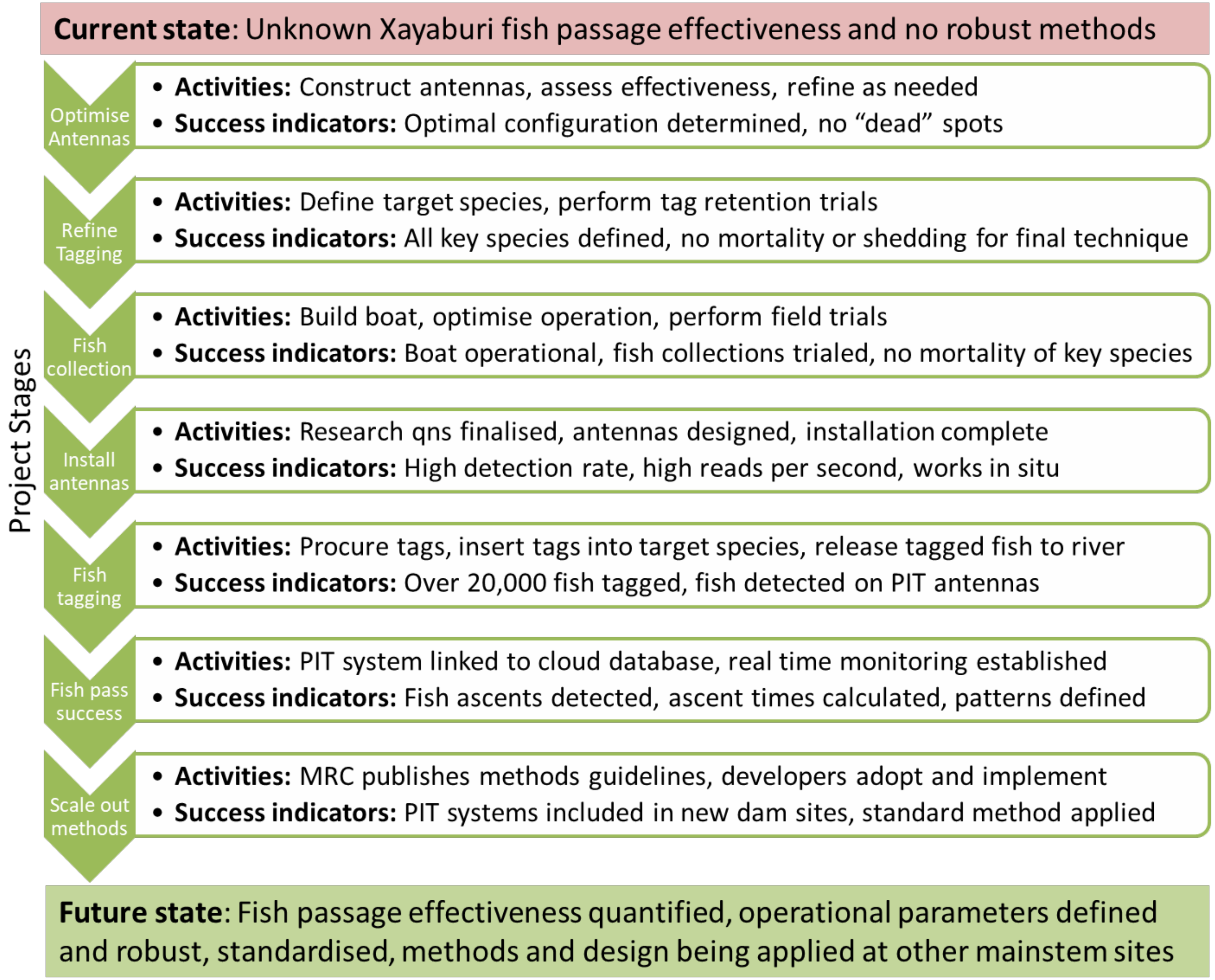


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key SE Asian economies on a common issue (via the MRC).

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across SE Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the Lower Mekong Basin and globally. It is important to note that the methods being developed will be applied in the Lower Mekong Basin for the first time. Further, they are being implemented at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. But, FishTek has since completed nominated project task pertaining to fishway design. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility to the research and monitoring, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. PIT tagging: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data

mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. Electrofishing: A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating master students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates. Our approach to deal with institutional capacity deficits will occur on two levels.

The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hand's on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.1 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by regularly inviting other developers to site and participating in MRC dam guidance discussions and development.

5.4 Community impacts

The science justifying fish passage implementation is sound. Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems.

The research impact of this project is within the footprint of the Xayaburi Dam site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity to set the bar for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner which can influence these outcomes.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards. The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction costs is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $380M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year. Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to work, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region.

5.4.2 Social impacts

The construction of a privately-managed asset can be a driver for local cohesion and cooperation. It is expected that fishway construction will ultimately increase fisheries production, which generates substantial interest. The local benefits are increased food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls.

In areas where fish passage has already been considered, there are several major social benefits which flow:

Team cohesion: Our team is united in their desire to see the project succeed, and this is evident when local staff are keen to work on the fishway project. The project team will replicate successes at low-head site in Lao PDR and actively employ local staff to assist with fieldwork, attend project workshops, coordinate community co-management meetings and disseminate information about the project widely within the community. This includes seeking and supporting active participation from women as well as men.

Improved community knowledge of floodplain fisheries: Capture fisheries ecology and productivity are difficult concepts to understand for people without university-based education. Many local fishers have a rudimentary understanding of fisheries, based largely on fish they encounter frequently. Previous ACIAR funding has determined that up to 85 per cent of citizens engaged in fishing activities had not completed secondary school (**FIS/2009/041)**. Thus, the XPCL community program is important for demonstrating the benefits of fish passage to the broader community.

Improved community co-management frameworks: Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed, and operated, it is expected that the fish will move upstream and become more accessible to the other villages (thus creating a more equitable access to the resource).

Therefore, demonstrating fish passage success through robust research is very important for Xayaburi Power Company to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The most likely environmental outcome will be to ensure fisheries at the Xayaburi Dam site do not decline. The overall aim is to demonstrate, through sound operation and integration into dam operations, that the dam will not lead to adverse environmental impacts. Fishway construction can lead to measurable rehabilitation outcomes within 12 months of construction. Measurable differences for short-lived species are expected within 12 months (Category 1), and for longer lived species, these differences are expected within 5 years (Category 2). The flow on effects to livelihoods and nutrition will be measurable and experience from Lao PDR suggests that these timeframes are realistic.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the target countries can be measured by the ability to influence MRC guidelines, ensuring new dams includefunctional fish passes, as well as developing standard methods which will be applied at other sites.

6 Project management

6.1 Management aspects

6.1.1 Project governance

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other developer through its governance team.

The plurality of partners and significant interest across governments and agencies require the establishment of a multi-agency governance structure (Figure 2). Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work.

An outcome was to establish a project reference panel who would be regularly briefed on project progress and outcomes. The panel would contain representatives from Charles Sturt University, Department of Foreign Affairs and Trade, Xayaburi Power Company Limited, Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines.

There was general agreement and commitment to publication of project outputs but a communication plan will be in place to protect and background intellectual property and to ensure transparency and consistency of any outward communication activities. These will largely be established in the form of a memorandum of understanding between Xayaburi Power Company and Charles Sturt University (Appendix 1). The MOU will extend to partners sub-contracted by Charles Sturt University.

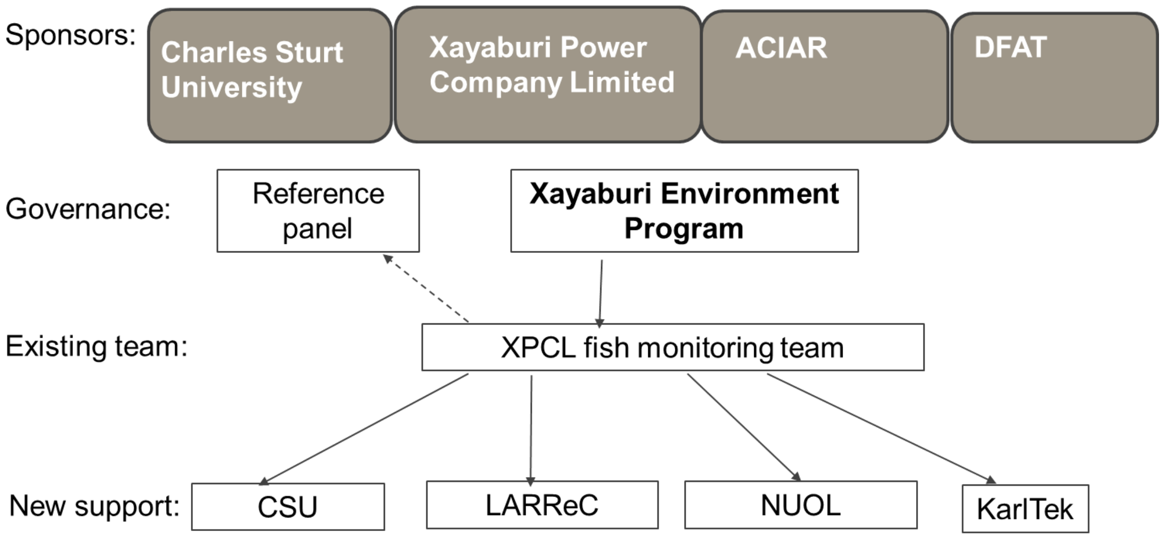


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will ingrate within existing governance arrangements. Importantly, the team will support existing monitoring efforts at the dam and augment the substantial research already underway.

6.1.2 Internal project communication and management approaches and plans

The team have been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated “leader” who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Madame Khampheng Homsombath (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Role in project	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Collaborating Scientist	Collaborating Scientist	
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	Collaborating Scientist	
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	Collaborating Scientist	
Michael Raeder	M	Xayaburi Power	Owner Representative	Collaborating Scientist	Collaborating Scientist	
Dominique Vigie	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	Collaborating Scientist	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	Project Leader	
Lauren Withers	F	Australian Volunteers	Volunteer	Research Assistant	Project support	

FOI Act s. 47

6.3 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	[redacted]
Jarrod McPherson Charles Sturt University	[redacted]
Thanasak Phomisajiev Xayaburi Power Company	[redacted]
Dr Michael Raeder Xayaburi Power Company Limited	[redacted]
Garry Thorncraft National University of Laos	[redacted]

Name	[redacted]
Dr Oudom Phonekhampheng National University of Laos	[redacted]
Khampheng Homsombath Living Aquatic Resources Research Centre	[redacted]
Karl Pomorin KarlTek Pty Ltd	[redacted]
Dr Nathan Ning Charles Sturt University	[redacted]
Dr Chris Barlow Fish Matters IP	[redacted]
Lauren Withers (and others) Australian Volunteer	[redacted]

FOI Act s. 47

6.4 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 50 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (FDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Fishway Consulting Services: Fishway Consulting Services (FCS) is one of the most respected Australian businesses in the field of water management. The organisation develops technical solutions that mitigate ecological impacts of human development in aquatic ecosystems and natural resource management. FCS collaborates closely with engineers, managers and diverse interest groups, to resolve fundamental issues over conflicting issues arising from resource development schemes that are not only site-based but integrate ecological objectives over different spatial scales.

7 Appendix 1: Supporting documentation

MOU between XPCL and CSU

Charles Sturt University

Memorandum of Understanding – Research Cooperation

Charles Sturt University

and

Xayaburi Power Company Limited

2017 Version: 1.0

Reference: LA17/9

Schedule 1 - Memorandum of Understanding Details

This Memorandum is made up of this Schedule and the Agreed Principles.

Item 1	Parties	**Charles Sturt University** (ABN 83 878 708 551) being a university incorporated in New South Wales under the *Charles Sturt University Act* 1989 and having its registered office at The Grange, Panorama Avenue, Bathurst, NSW 2795 (***CSU***) **Xayaburi Power Company Limited of** 215 Lane Xang Avenue Vientiane Lao PDR (***Cooperating Institution***)
Item 2	Commencement Date	1/01/2018
Item 3	CSU Coordinating Officer	**Name:** **Ashlea Dobson** **Position:** Partnership Officer **Division:** Office of Global Engagement and Partnerships **Organisation:** Charles Sturt University **Address:** [redacted] **Telephone:** **Email:**
Item 4	Cooperating Institution Coordinating Officer	**Name:** **Dr. Michael Raeder** **Position:** Owner Representative **Division:** N/A **Organisation:** Xayaburi Power Plc. **Address:** [redacted] **Telephone:** **Email:**

Execution

The signatories hereby personally warrant that they have express and sufficient legal authority to execute this Memorandum (which includes the **attached** Schedule and Agreed Principles) on behalf of the party on whose behaf they have signed.

Signature for CSU

SIGNED for **CHARLES STURT UNIVERSITY** in the presence of	)))	[redacted] Signature
[redacted] Signature of witness		Pro-Vice Chancellor, Global Engagement (Research & Partnerships)
Joss Ninness Name of witness (print)		Professor Heather Cavanagh
Assistant Position		15 December 2017 Date signed

Signature for Cooperating Institution

SIGNED for **XAYABURI POWER COMPANY LIMITED** in the presence of	)))	[redacted] Signature
[redacted] Signature of witness		Thanawat Trivisvavet Name (print)
Michael Raeder Name of witness (print)		Managing Director Position (print)
Owner Representative Position		13 June 2018 Date signed

Letter of support from the Lao Ministry of Energy and Mines

LAO PEOPLE'S DEMOCRATIC REPUBLIC
PEACE INDEPENDENCE DEMOCRACY UNITY AND PROSPERITY

MINISTRY OF ENERGY AND MINES
CABINET OFFICE

1098
No……………
Vientiane, 27 APR 20

To: Mr Thanawak Trivisvavet
Managing Director Xayaburi Power Company
[redacted]

Subject: Research Collaboration at Xayaburi Dam

We understand that a collaboration on fish research at Xayaburi Dam is proposed between Charles Sturt University (Australia) and Xayaburi Power Company Limited which will involve support from National University of Laos and also the National Agriculture and Forestry Research Institute.

The Ministry of Energy and Mines incorporating the Department of Energy, Policy and Planning have reviewed all of the proposed project documentation, consulted with the Ministry for Agriculture and Forestry, and sought endorsement from the Ministry for Planning and Investment.

Based on these consultations I am pleased to provide my endorsement for this collaboration to proceed. My ministry and staff will follow the collaboration with interest and expect that it will generate information that will benefit hydropower development in Lao PDR now and into the future.

- Enclosed here is subsidiary arrangement between the government of Australia and the government of the Lao people's democratic republic relating to assessing fisheries mitigation measures at Xayabury dam in Lao PDR

I wish the research team every success in its endeavours for this important work.

Yours Sincerely,

[redacted]

Dr Daovong PHONEKEO
Head of Cabinet
Ministry of Energy and Mines

Letter from the Lao Ministry of Planning and Investment endorsing National University of Laos and Living Aquatic Resources Research Centre involvement

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ແຈ້ງການ

ຮຽນ: ທ່ານ ລັດຖະມົນຕີ ກະຊວງພະລັງງານ ແລະບໍ່ແຮ່

ເລື່ອງ: ອະນຸມັດຮັບເອົາໂຄງການຕິດຕັ້ງອຸປະກອນການເກັບກຳຂໍ້ມູນການຂຶ້ນ-ລ່ອງຂອງປາຢູ່ເຂື່ອນໄຊຍະບູລີ (Assessing Fisheries Mitigation Measures at Xayaburi Dam in Lao PDR) ໂດຍໄດ້ຮັບການຊ່ວຍເຫຼືອລ້າຈາກປະເທດອົດສະຕຣາລີ

- ອີງຕາມ ດຳລັດຂອງທ່ານນາຍົກລັດຖະມົນຕີ, ສະບັບເລກທີ 75/ນຍ, ລົງວັນທີ 20 ມີນາ 2009 ວ່າດ້ວຍການຄຸ້ມຄອງ ແລະນຳໃຊ້ທຶນການຊ່ວຍເຫຼືອທາງການເພື່ອການພັດທະນາ;
- ອີງຕາມ ໜັງສືສະເໜີຂອງກະຊວງພະລັງງານ ແລະບໍ່ແຮ່ ສະບັບເລກທີ 0262/ພບ, ລົງວັນທີ 14 ກຸມພາ 2018.
- ອີງຕາມ ການຄົ້ນຄ້ວາ ແລະສະເໜີຂອງກົມຮ່ວມມືສາກົນ, ກະຊວງແຜນການ ແລະການລົງທຶນ ສະບັບເລກທີ 047 /ກຜທ.ຣມສ-ອປອ.05 ລົງວັນທີ 22 ກຸມພາ 2018

ກະຊວງແຜນການ ແລະການລົງທຶນ ຂໍຖືເປັນກຽດແຈ້ງມາຍັງທ່ານຊາບວ່າ: ກະຊວງແຜນການ ແລະການລົງທຶນ "ເຫັນດີ" ອະນຸມັດຮັບເອົາໂຄງການຕິດຕັ້ງອຸປະກອນການເກັບກຳຂໍ້ມູນການຂຶ້ນ-ລ່ອງຂອງປາຢູ່ເຂື່ອນໄຊຍະບູລີ (Assessing Fisheries Mitigation Measures at Xayaburi Dam in Lao PDR) ໂດຍໄດ້ຮັບການຊ່ວຍເຫຼືອລ້າຈາກປະເທດອົດສະຕຣາລີ, ໃນມູນຄ່າ 2,591,551 ໂດລາອົດສະຕຣາລີ, ເລີ່ມແຕ່ເດືອນມັງກອນ 2018 - ເດືອນມັງກອນ 2021 (ກຳນົດ 04 ປີ).

ກະຊວງແຜນການ ແລະການລົງທຶນ ສະເໜີໃຫ້ພາກສ່ວນທີ່ກ່ຽວຂ້ອງນຳໄປຈັດຕັ້ງປະຕິບັດແລ້ວລາຍງານຜົນສຳເລັດຂອງໂຄງການ ຫຼື ກິດຈະກຳຕ່າງໆໃຫ້ກົມຮ່ວມມືສາກົນ, ກະຊວງແຜນການ ແລະການລົງທຶນ ຊາບທຸກໆ 06 ເດືອນ ເພື່ອສາມາດຕິດຕາມວຽກໄດ້.

ດັ່ງນັ້ນ, ຈິ່ງຂໍຖືເປັນກຽດແຈ້ງມາຍັງທ່ານເພື່ອຊາບ ແລະຈັດຕັ້ງປະຕິບັດຕາມລະບຽບການດ້ວຍ.

ດ້ວຍຄວາມນັບຖື,

ລັດຖະມົນຕີ

[redacted]

ບ່ອນນຳສົ່ງ:

1.	ຫ້ອງວ່າການສຳນັກງານນາຍົກລັດຖະມົນຕີ	01 ສະບັບ
2.	ກະຊວງການຕ່າງປະເທດ	01 ສະບັບ
3.	ກະຊວງການເງິນ	01 ສະບັບ
4.	ກະຊວງກະສິກຳ ແລະປ່າໄມ້	01 ສະບັບ
5.	ເກັບຮັກສາໄວ້	02 ສະບັບ

Letter of support from the Lao Head of Mission (Australian Ambassador) providing DFAT support for the initiative

AMBASSADOR

AUSTRALIAN EMBASSY
VIENTIANE

H.E. Dr Phouangparisak Pravongviengkham
Vice Minister
Ministry of Agriculture and Forestry
Lao PDR

Re: Request to co-chair a meeting on the Xayaburi Dam's Fish Passage Facilities Study

Your Excellency,

To fulfil requirements under the Concession Agreement between the Government of Laos and Xayaburi Power Company Limited (XPCL) on fish migration through the Xayaburi Hydropower Dam, XPCL reached out, in June 2017, to the Australian Centre for International Agricultural Research (ACIAR) and Charles Sturt University (CSU) to assist in the independent monitoring and evaluation of effective fish passage at the site.

In response to this request, the Government of Australia (represented by ACIAR and the Department of Foreign Affairs and Trade) in collaboration with CSU, the Lao Ministry of Agriculture and Forestry (MAF), the National University of Laos (NUoL) and XPCL are in the process of finalizing a joint research project called "Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR." Please find attached a project brief for your reference.

Technical consultations are scheduled to take place with relevant officials at MAF, NUOL, Ministry of Natural Resources and Environment, and Ministry of Energy and Mines on 7 November.

In order to further discuss the project, I would like to request your Excellency to join me in co-chairing an inter-ministerial meeting on 8 November 2017 at 9:00-11:00 AM. The purpose of the meeting is to present and discuss the proposed research initiative and seek views from relevant ministries and stakeholders on ways to proceed with the project. The meeting will be held at Setha Palace Hotel.

I would be grateful if you could please confirm your availability with Mr Ounheuan Saiyasith on [redacted] or [redacted]

[redacted]

[redacted]

Definitions

Research outputs: These are the result of activities of the project. Examples include new varieties, methods and practices.

Research outcomes: Research outcomes are defined as the use made of the outputs by the stakeholders *directly involved with the research project*. This involves practice change and changes in knowledge, attitudes, skills and aspirations within the research project. Examples include productivity increases resulting from the adoption of new varieties or practices by farmers participating in the project at pilot sites, or strengthened capacity of project partners.

Development outcomes: Development outcomes are the use made of the research outputs *beyond the sphere of the research project*. An example is an increase in crop yields by farmers as a result of the adoption and promotion of a new crop variety (the research output) by the extension services.

Research impacts: Research impacts are social, economic, environment and community impacts of the stakeholders *directly involved with the research project.* Examples include increased household income as a consequence of adopting new farming practices developed by the project at pilot sites, or strengthened capacity of project partners that is used for other, non-project activites.

Development impacts: Development impacts are social, economic, environment and community impacts that occur *beyond the sphere of the research project*. These are large-scale, usually longer-term impacts to which the research project contributes. An example is increased income and improved livelihood of smallholder farmers in a country. The research project may have contributed to this impact by developing new crop varieties that were adopted and promoted widely by next-users such as the extension services.

Gender: Gender refers to the socially constructed roles and responsibilities of women, men, girls and boys, including the relationships, roles and expectations of each in different socio-cultural contexts. For more information see *ACIAR Gender Guidelines for Project Proposals*

Impact pathways: Impact pathways describe how research results are intended to contribute to the overall goal of the project (e.g. improving food security and livelihoods of smallholder farmers in a country). This is also referred to as the ‘theory of change’.

Next-users: Next-users are clients of the research project who will use and promote the research outputs to end-users. Examples of next-users are institutions such as extension services, non-government organisations (NGOs), policymakers and businesses. Research outputs will only be useful and contribute to development impacts if they are taken up and promoted by next-users. Some individuals of these institutions are likely to be involved in the actual research project (e.g. as part of participatory research at pilot sites).

End-users: End-users are the beneficiaries of the Reseach & Development process. For example, these may be resource-poor smallholder farmers in a province or state who have adopted new farming practices that were developed by the research project and extended by next-users. The research project will not be directly involved with these end-users, except with a subsample who may be involved in research activities such as surveys or participatory research at pilot sites.

Australian Government

Australian Centre for International Agricultural Research

Project Proposal

ACIAR Program(s) area	FIS
Project Title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/016
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

Privacy statement

ACIAR, as an Australian Government agency, is required to comply with the thirteen Australian Privacy Principles set out in Schedule 1 of the *Privacy Act 1988*.

The personal information provided in this project proposal is stored in electronic format by ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals and the names, contact details and curricula vitae (CVs) of all project members included in this proposal may be shared with external project reviewers as part of the project development cycle. It also forms part of the contract documentation exchanged with the Commissioned Organisation, collaborating institution(s) and partner-country government(s).

The names and contact details of Project Leaders may be listed with project details on the ACIAR website, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail-outs of ACIAR corporate publications.

ACIAR endeavours to keep this information as up-to-date as possible, with the assistance of the individuals whose details are recorded.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/016
Project title	Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR
Proposal stage	Preliminary Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/08/2018
Proposed finish date	30/06/2019

Key contacts

Project Leader: Commissioned organisation

Title and name	Lee Baumgartner
Position at organisation	[Project Leader Position]Associate Research Professor
Organisation	Charles Sturt University

Administrative Contact: Australian commissioned organisation / commissioned IARC

Title and name	[Administrative Contact]
Position at organisation	[Administrative Contact Position]
Organisation at organisation	[Administrative Contact Organisation]

Key Project Members: Project Coordinator

Title and name	[Project Coordinator]
Position at organisation	[Project Coordinator Position]
Organisation	[Project Coordinator Organisation]

Key Project Members: Collaborating Scientist

Title and name	Dominique Vigie
Position at organisation	[Collaborating Scientist Position]
Organisation	Department of Foreign Affairs and Trade

Key Project Members: Collaborating Scientist

Title and name	Dominique Vigie
Position at organisation	[Collaborating Scientist Position]
Organisation	Department of Foreign Affairs and Trade

Contents

1 Project summary

1.1 Background and justification

Productive fisheries in the Lower Mekong Basin will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia. The dams have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupt access to vital spawning, nursery and feeding habitat. The Mekong region fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, is under construction and will be completed in late 2018. Xayaburi Dam blocks the entire width of the river with a dam wall more than 30 m high, presenting an impassable barrier to all fish species. Construction of Xayaburi Dam started in 2012 and is now approximately 90% complete. It will cost approximately US$3 billion and the first turbines are due to be operational in 2019. Significant investment (US$380M) in mitigation works to provide for fish passage were incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. This represents a substantial challenge and the question of whether the fish passage facilities will be effective is a question that the developer, Government of Lao PDR and scientists are keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential.

From a development perspective, energy generation is needed and will continue to be developed in regions where poor people are dependent on natural resources. The interaction of hydropower development and the maintenance of the ecosystem benefits of rivers has a tragic history worldwide. Yet, the Xayaburi facilities provide an opportunity to determine if better approaches can be demonstrated and adapted/applied to other sites. What is now certain is that Xayaburi Dam will be completed, so the present opportunity is to design and commence experiments that can help learn as much as is possible from it.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods which will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and in-situ. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aim and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust methods. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). [redacted] with significant additional in-kind support proposed over the four year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defensible, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the Lower Mekong Basin. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its agreement for publication of all results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities. The performance of the Xayaburi fish pass facilities are therefore of paramount importance to advise broader construction activities in the region. Monitoring technology developed at Xayaburi can be directly applied elsewhere and has transboundary relevance. The project team subsequently aim to connect with other developers, and bodies such as the Mekong River Commission, to ensure findings are communicated and used to inform future development decisions.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB. Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein.

Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction. The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade, there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong's productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB. All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing what is currently one of the most productive river fisheries in the world. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 70% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. XPCL has invested US$380 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America, but where investment only targets salmon species. XPCL recently invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site in May 2017. The purpose was to exchange information especially in relation to possible future research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.1.1 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households. Most rural Asian citizens are actively involved in inland capture fisheries and river and fishery health is crucial to securing food and income for local communities. The Xayaburi project has been criticised for its potential impact on upstream food resources. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It is at the cutting edge of science and natural resource management in the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development. Irrigation development has negatively impacted inland fisheries. This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating the expected win-win outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing. Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has, internationally, brought private, developmental and governmental sectors together to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to quantify fisheries benefits.

2.2 Relationship to other ACIAR investments and other donor and partner-country activities

2.2.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development. The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region. By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies. This will facilitate a more positive outcome from an economic and environmental perspective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising professionals to use the newly established infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining hard fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome ‘Agriculture, Fisheries and Water’. Hydropower development is one of the most significant water management issues in the Lower Mekong Basin; and Xayaburi Dam, being the first site, is of particular significance and international interest.

This project has been initially established as a four-year initiative with cash funding provided by DFAT ($1M); XPCL ($911,000), ACIAR ($400,000) and CSU ($150,000). Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 1/2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due December 2019. To maintain continuity for project staff, it is anticipated that the large follow-on project commence from August 2019.

2.2.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing during construction, and then when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies. XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.3 Research questions

2.3.1 Xayaburi fishpass overview

Specific design parameters were used to provide passage for fish at the dam site. For upstream migration, a complex fishway system was devised (Fig. 1). To successfully pass upstream:

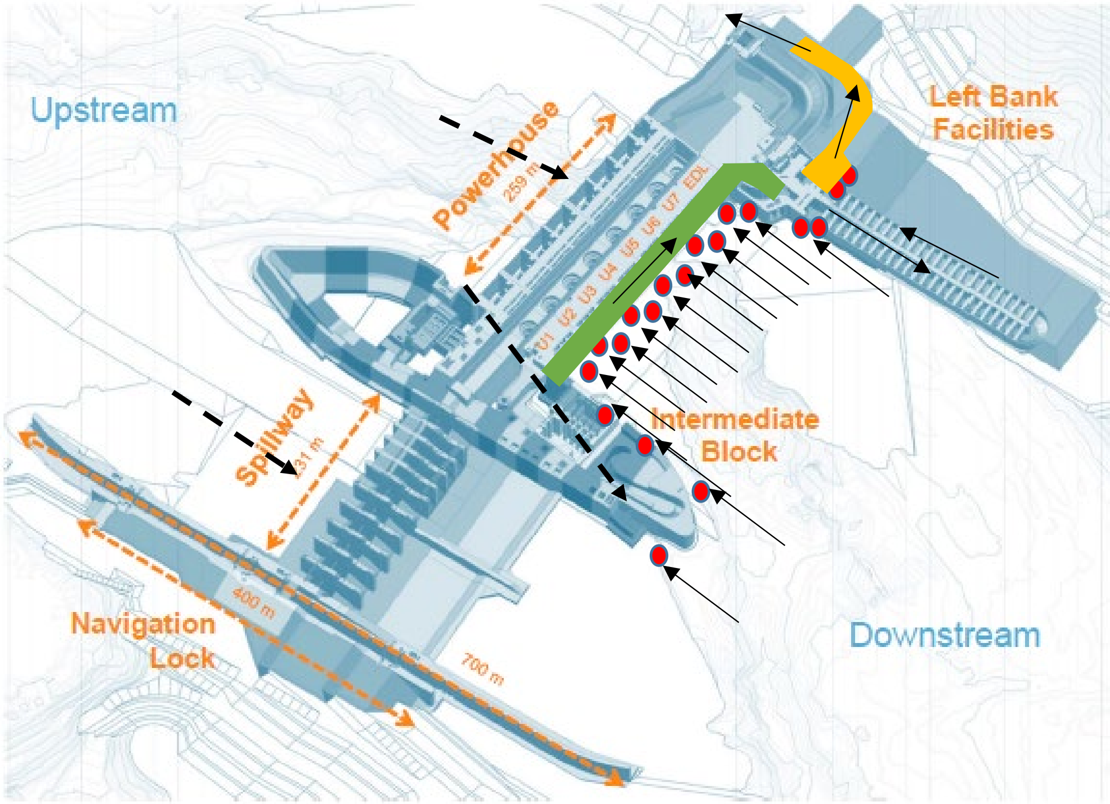
(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research program needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.



2.3.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

NB: The questions relating to downstream passage can only be answered once the site is operational.

It is essential that the research data informing the reporting is high quality and accurate. The purpose of this proposal is to develop and implement methods required to accurately answer the questions; then apply it to a site-scale assessment program. Without methods validation, the veracity of any generated data would be called into question.

2.3.3 Gender focus

It has been long recognised that empowering rural women and girls is an essential part of the solution to some of today's most serious global challenges: food security, poverty reduction and sustainable development. The five domains that most affect women's empowerment in agriculture are: production, resources, income, leadership and time. In Lao PDR, households and communities are largely stratified by gender. Therefore, systems that surround natural capital, ecosystems and biodiversity inevitably confront gender-based norms, assumptions and differences — especially in terms of resource access, usage, and control. Thus, both women and men have defined roles in fisheries value chains.

The Xayaburi project was established over 8 years ago and our research team is playing a very small, but important, role in the $US3B construction project. Many of the recruitment policies and hierarchical structures are already in place. The XPCL monitoring team was selected by the company and staff were allocated to assist our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately this has provided a gender structure (among the project team) which is predominantly male.

Outside the nominated project team, we strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, that the team is more balanced.

The overall aim of the Xayaburi Dam fish passing facilities, to achieve transparency for migrating fish in order to maintain fisheries and livelihoods, will benefit both men and women. The monitoring project is much larger than the tagging study and there are a host of metrics that XPCL are actively monitoring (fishermen catches, sediment transport, water level changes, flow data, bathymetry). This broader XPCL monitoring program is female-led and has a survey structure which is gender inclusive. Field teams comprise both male and female interviewers, and together these survey for male and female fishers and community members. But whilst these processes are outside our sphere of influence, we need to remain cogniscent of the fact that the project is seeking to preserve a resource that benefits an entire community. Access to the resource is non-discriminatory. If the project achieves its aim of passing fish then all communities, irrespective of gender, will benefit.

3 Research strategy and partnerships

3.1.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems. So there is a solid basis for the fish passage design.

The logical sequence for the proposed research is to:

1. Perform laboratory and in-situ trials of three techniques (PIT detection antennas, electrofishing boat and a long term tagging study) to optimise methods

2. Implement these methods at the dam site
3. Perform real-time monitoring of fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, if needed, the daily operation of the fish pass facilities
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

An adaptive management strategy is proposed. Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defensible; and
c) When combined, provide an overall picture of fishway effectiveness.

4.1 Project aim and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust methods. The specific objectives are:

The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

4.2 Research activities, methods and outputs

4.2.1 Monitoring fish at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods. Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters). In terms of fish, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's but have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. In recent years, the development of passive integrated transponder (PIT) technology has provided new opportunities to monitor fish migrations. A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are suitable for fish greater than 60 mm
5. Are relatively inexpensive relative to the cost of sending a research team into the field
6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system) but have low overall running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FIshNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

Integrity: This is the critical component of any system. If a tag is missed, for any reason, it can cost research projects thousands of dollars. If a team spends time in the field, catching the animal, tagging it, releasing it and setting up a PIT system to detect it – it is important that the system is robust. If a tagged fish passes by an antenna but is not recorded due to some abnormality, it results in a loss of valuable data and potentially making a false assumption (fish did not pass). A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

Veracity: It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. Any data that are erroneous must be detected and rejected. This should incorporate both automatic and manual systems. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events. It is extremely important that when an animal is tagged, all data is recorded correctly.

Reliability: This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency. In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process. All of these factors are important to have faith in the data being generated.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance. They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Relevance to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement, which has been formed with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL subsequently need to demonstrate that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate no net impacts on fish.

The overall aim of this project is to implement a research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the Lower Mekong Basin. PIT tags were determined to be a suitable technology upon which to base initial trials. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully, (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species. Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in* and *ex-situ*. Based on successes at other dam sites internationally, PIT tagging has been identified as the most suitable technique.

If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase: There is the actual testing and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation. The validation phase will take approximately 18 months.

(2) Operational Implementation: Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise fishway settings and integrate fish movements into overall dam operation.

4.2.1 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a “high dam” fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System) PTAGIS framework. PTAGIS is a large, spatially integrated fish monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is ‘pinged’ within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement.

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass. Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to PTAGIS.

With two such systems operating successfully internationally, and with a cascade proposed for the Lower Mekong Basin, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

Thus, there are several distinct research phases, which need to be somewhat completed in chronological order, for site-based impacts to be scaled to other sites. The research strategy targets site-based impacts initially, but will scale to other sites as components are finalised and validated.

4.2.2 Research component 1: Optimising antenna design

<u>Rationale</u>

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a ‘loop’ that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency. PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway ‘slots’ to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

<u>Research activities</u>

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions

The team have identified research questions that could be answered using a PIT system (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each location is paramount to success.

Stage 2: Obtain detailed engineering drawings

The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped should optimal design configurations be identified.

Stage 3: Construct prototype antennas and set up ‘in the dry’. KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions). The antennas, as indicated in the options diagrams over page, will be constructed. This approach is considered world-standard for antenna efficiency tests.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the ex-situ test in stage four, we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these in-situ tests will then advise the locations where fixed antennas should be located.

Additionally, and based on ex-situ testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

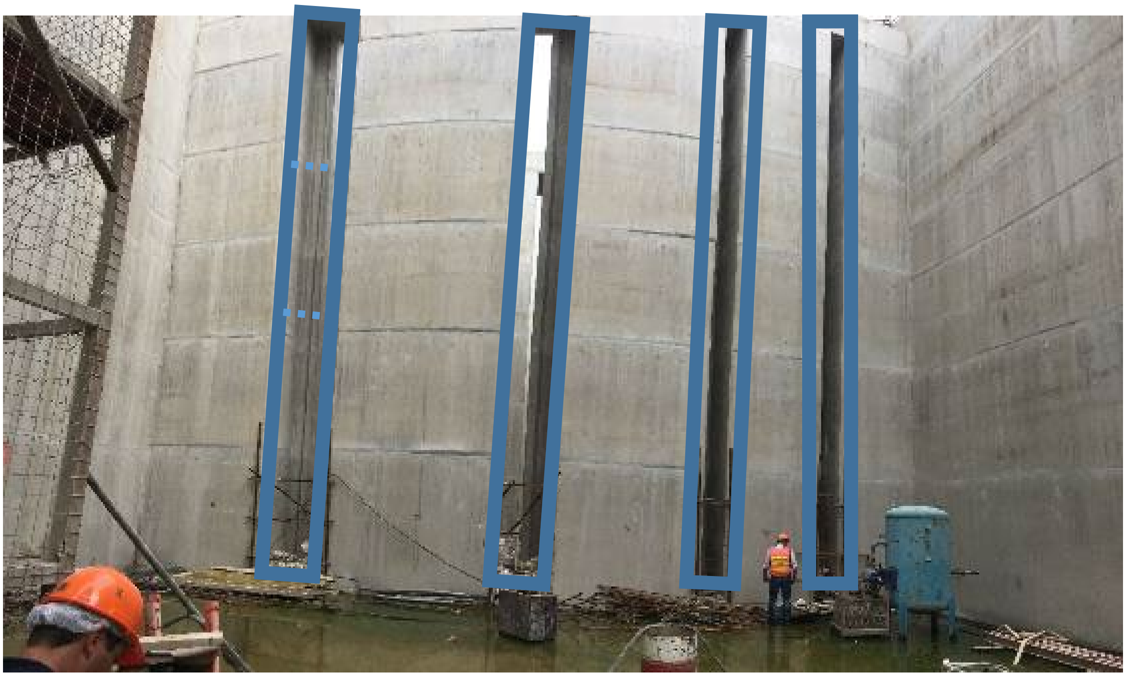


Figure 2. Slots where antennas are proposed to be installed and possible configurations.

4.2.3 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

Research activities

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 200 migratory species at the Xayaburi site and at least 20 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Work with XPCL staff and Lao government to identify target species, size classes and life history stages. This would require a rapid workshopping phase. It would likely include all species that were included in the fishway assessment studies (swimming ability) along with other species of key economic and conservation significance at the site. Ideally, the technique would be refined on the top 20 species.

Stage 2: Construct a fish hatchery facility to house the fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction will commence in 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve *et al*, 2018). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish. So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days. However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the fish batch of tagged fish to inform on fishway operation

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

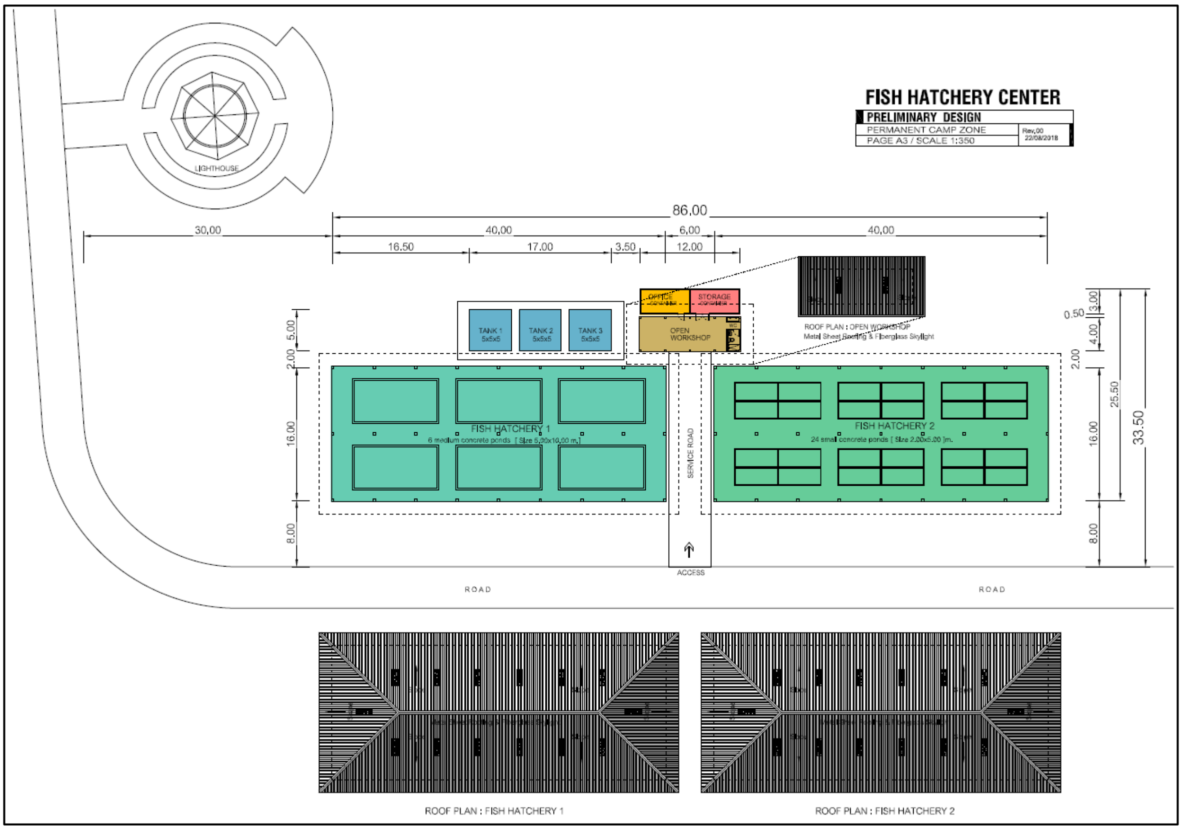
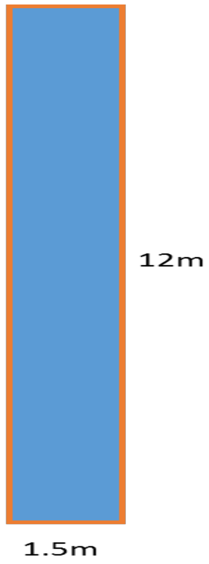
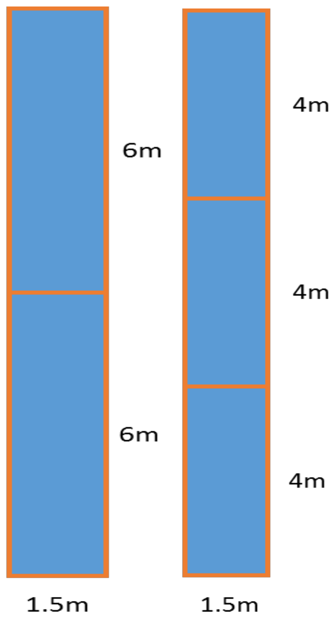
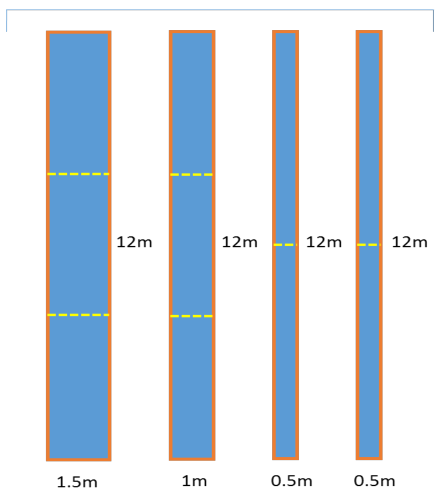


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	Diagram	Comment
12 m x 1.5 m		Large "slot" antenna. Unknown if tags will perform optimally at this width. Never before tested under such dimensions when operating from a single control unit. The target is 99% read efficiency of 12 mm tags with no "dead spot" in the middle region. Fastest read speed; but these dimensions stretch the limits of PIT technology
12 m x 1.5 m (alternatives)		Two alternative configurations. These will need to be assessed to cover individual slots should a single large design provide sub-optimal results. The target is 99% read efficiency of 12 mm tags with no "dead spot" in the middle region of any of the tag locations.
Maximum predicted number of antennas		The diagram on the left represents the maximum number of antennas for each baffle = 10.

4.2.4 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. But this is a harsh technique which can cause stress and, in extreme cases, impact survival. Tagging a fish which has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish. It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL will provide all funds to purchase the vessel assuming that CSU can guide construction and train Lao government, University and XPCL in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish. It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival. It is widely used in Australia, and Charles Sturt University staff can advise on specifications and can run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river. So combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. For this component, we will need to manipulate the voltage settings (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into regional guidelines documents.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Table 2. List of migratory species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Greed indicates the upstream migration season and yellow the downstream migration season.

species	local name	month											
		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Cyclocheilichthys enoplos	Pa Joke												
Cyclocheilichthys repasson	Pa Joke-sai												
Henicorhynchus lobatus	Pa Sroi												
Labeo chrysophekadion	Pa Pia												
Hemibagrus nemurus	Pa Kod												
Mekongina erythospila	Pa Sa-ee												
Sikukia gudgeri	Pa Mang												
Chitala sp.	Pa Tong												
Pangasius macronema	Pa Yorn												
Hemisilurus mekongensis	Pa Dangdaeng												
Phalacronotus apogon	Pa Sa-ngua												
Bagarius suchus	Pa Khae												
Paralaubuca typus	Pa Teab												
Tenulosa thibaudeaui	Pa Mak-pang												
Pangasianodon hypophthalmus	Pa Sway												
Cyprinus carpio carpio	Pa Nai												
Yasuhikotia modesta	Pa Kiaw-Gai												
Macrochirichthys macrochirus	Pa Fak-pa												
Pristolepis fasciata	Pa Chang-yeab												
Pangasius bocourti	Pa Phor												
Pangasius conchophilus	Pa Mong												
Pangasius larnaudii	Pa Thay-po												
Phalacronnotus bleekeri	Pa Sa-ngua												
Wallago attu	Pa Kaow												
Hemibagrus filamentus	Pa Kod-rueng												
Pangasianodon gigas	Pa Buek												

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

4.2.5 Research component 4: Measuring fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. The steps need to be taken in chronological sequence prior to implementing the fish pass monitoring program.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation. Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing real-time data uploads. A series of Xayaburi specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the entrance antennas).

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. Mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with to flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team are aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (assume commencement after SRA concludes in August 2019)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged	Commencement	Salaries and travel secured for Australian partners Existing SRA MOU's transfer to full project	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	XPCL staff to Australia Can align with another trip for Indonesian scientists	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	Conclude tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update MRC	Continue to meet with MRC to work on dam guidelines document	Annually, twice	MRC are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in MRC guidelines Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	July 2020	All milestones are met	Project progress is on track
1.6	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing

Year 2 (Aug 2020 – Jul 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting and project steering committee meeting	Annual reporting to GoA Hold annual workshop on site in Lao PDR or at XPCL HQ in Bangkok	July 2021	All milestones are met	Project progress is on track
2.2	Attend AFS Columbus, Ohio	Conference presentations Conference papers	Aug 2020	Funding is available to attend	All project staff present the work in an international forum The project team results are introduced into the public arena
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update MRC	Continue to meet with MRC to work on dam guidelines document	Annually, twice	MRC are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in MRC guidelines Commence dialogue with other developers in terms of applying outputs to their site

Year 3 (Aug 2021 – July 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other hydropower developers and MRC	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.5	Regular reporting to industry and regulators commences	First formal report to regulators and industry completed	Jul 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated
3.6	Final reporting	Final report to DFAT/ACIAR completed	Jul 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are three main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities and it has been suggested, by the Mekong River Commission, that these facilities must have equal, or better, functionality than those at Xayaburi.

The Mekong River Commission is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “mainstem dam hydropower guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin. The latest draft of this document is considering the considerable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. Thus, the research program is an integral part of influencing that document. Our project team subsequently includes Prof. Martin Mallen-Cooper, who is on the MRC guidance document development panel. We aim to not only influence and shape the final contents of the document but to also ensure that standard research methods are included. Thus, our aim is to ensure that the research work scoped and implemented at Xayaburi Dam becomes the minimum standard implemented at other dam sites. Hence there is a strong need to ensure our methods have been rigorously defined, are scalable and defensible.

Project extension

Project extension will be limited and controlled. There are two commercial entities which wish to limit broader messaging into the public arena. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam. There is a community of lobbyists who will not change their opinion regardless of the level of investment in mitigation. Making broad statements through an outreach program will mobilise this lobby and distract the team from project objectives. Xayaburi are also bidding for a second dam project on the Mekong and releasing too much information into the public domain could have commercial implications. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect and is unwilling for the technical details of its product to enter the public domain during the research phase. With these issues in mind, the project team has entered into a confidentiality arrangement where no project messaging will be made public without the explicit approval of all parties. Thus, extension and outreach is likely to be limited, at least initially, whilst the research methods are developed and refined.

4.4.2 Capacity building

Partner countries
Fish passage technology and implementation, as pertaining to hydropower dams will be provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL have a 30 year concession period and will own and operate

the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Australian capacity
Australian researchers will benefit from involvement in the project. The tropical rivers offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes that they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with broader hydropower development activities into the future.

Donor bodies and developers
The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, it is essential to link with the Mekong River Commission and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Quarterly Action Plans', which take the activities in three month blocks and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These Quarterly Action Plans are devised before each new quarter, and assessed at the end of each quarter during the 'co-ordination' meetings with the partners and the coordination team. These Action Plans then become Quarterly Progress Reports. The quarterly progress reports form the basis for the bi-annual Technical Progress Report, which forms a reflective process of the last 6 months for each activity. In addition to reviewing the result progress, the coordination meetings will also allow to strengthen the linkages between the different result areas and partners.

Medium-term cycles

The quarterly reports culminate in yearly reports and a 'Learn and Adapt' forum, in line with overall yearly project reporting. In the dry season of each year a 'Learn and Adapt' forum is held in each country for the respective countries, where a review from each partner country of the previous year's achievements, challenges and learnings is presented, and plans adapted for the next country specific workplans.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored against to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of ‘success indicators’ (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam fish pass effectiveness is quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. Guidelines developed (ii; vi; v) No. New mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through access to increased food and other resources if the Xayaburi facilities are demonstrated to work. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program
- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- International recognition for project team scientists at a major regional conference
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) *Factors influencing PIT antenna efficiency at high dam fishways*
  (b) *Tag retention and mortality in key Lower Mekong Basin species*
  (c) *Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers*
  (d) *Optimising electrofishing for deployment in the Lower Mekong Basin*
- A project final report
- Presentations given at the Fish Passage 2018 conference (Albury, Australia, 2018)
- Abstracts published in conference proceedings

4.6 Intellectual property and other regulatory compliance

This will be completed at full proposal stage. There are several issues which will need to be considered.

Firstly, the fish pass design itself is considered commercial-in-confidence by Xayaburi Power Company Limited. XPCL are happy to disclose details to team members and research partners. However, distribution outside the team requires approval from the managing director. XPCL have invested significant capital into the fish pass design and are bidding for other mainstem dams. Thus, there are confidentiality considerations to be respected (See Appendix 1; XPCL-CSU MOU).

Secondly, the PIT system itself, and the associated database, is a proprietary product which has been designed and patented by Australian company KarlTek Pty Ltd. The company is obviously happy for the system to be promoted. However, the components and assembly are protected by patent and cannot be publically disclosed without written approval from KarlTek Pty Ltd.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant 'expectation' being placed upon this site and overall fish pass performance has implications at a site, national and international level. Site based-impacts related to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the "gold standard' to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require "research" to influence the broader regional hydropower "development".

Firstly, we seek to create "impact" by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we hope to influence the design and construction of other dams into the future (Figure 5). A key aspect of this project is including team members who are presently involved in the development of the Mekong River Commission mainstem dam guidelines.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The "gold standard" Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs

Long term (strategic):

1) PIT tagging incorporated into Mekong River Commission dam guidelines
2) PIT tag systems installed at other mainstem dam sites

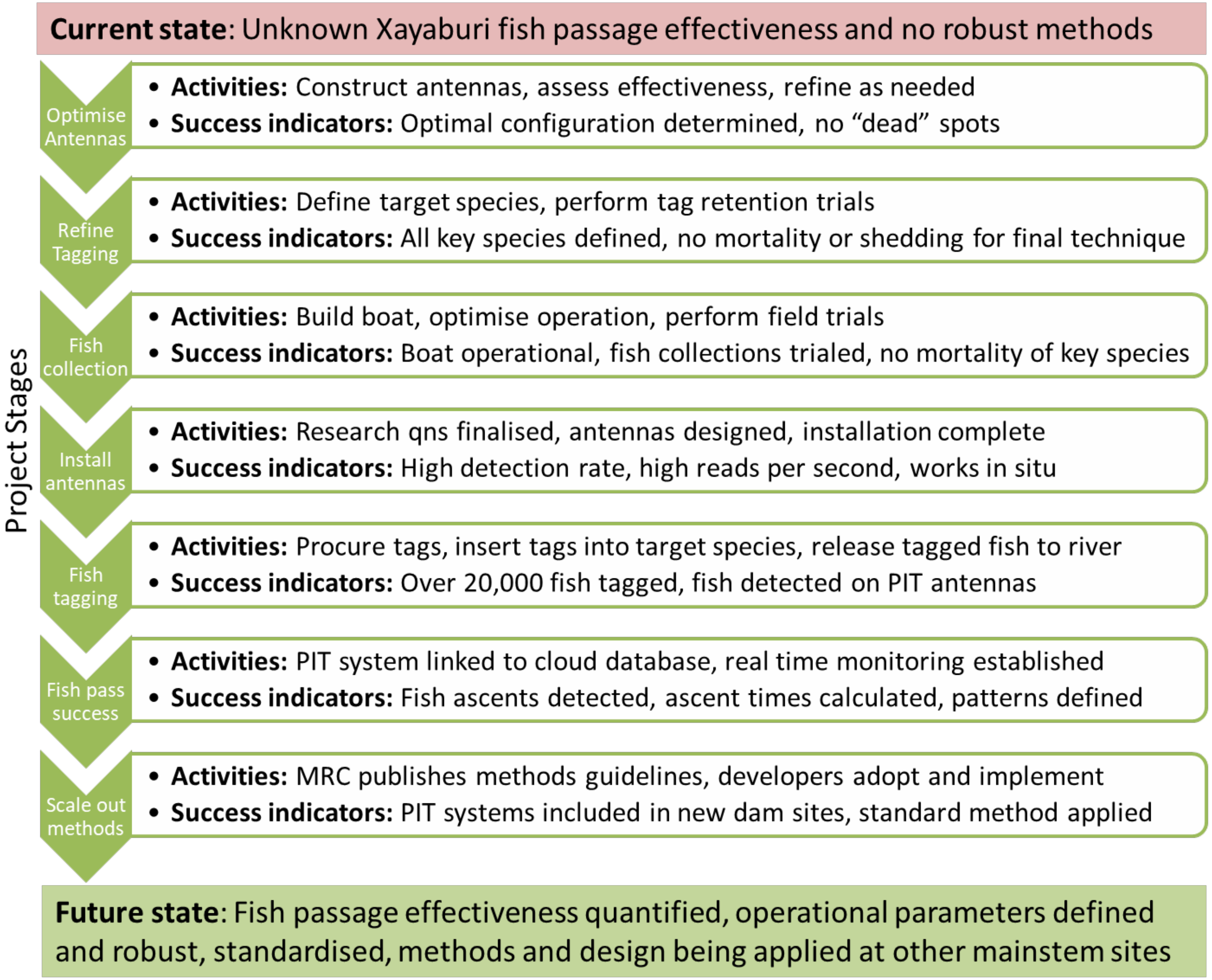


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key SE Asian economies on a common issue (via the MRC).

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across SE Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the Lower Mekong Basin and globally. It is important to note that the methods being developed will be applied in the Lower Mekong Basin for the first time. Further, they are being implemented at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. But, FishTek has since completed nominated project task pertaining to fishway design. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility to the research and monitoring, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. PIT tagging: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data

mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. Electrofishing: A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating master students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is, over the short term, imported from outside and, over the longer term, built from within through a steady stream of learned graduates. Our approach to deal with institutional capacity deficits will occur on two levels.

The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hand’s on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.1 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by regularly inviting other developers to site and participating in MRC dam guidance discussions and development.

5.4 Community impacts

The science justifying fish passage implementation is sound. Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems.

The research impact of this project is within the footprint of the Xayaburi Dam site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity to set the bar for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner which can influence these outcomes.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards. The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction costs is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $380M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year. Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to work, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region.

5.4.2 Social impacts

The construction of a privately-managed asset can be a driver for local cohesion and cooperation. It is expected that fishway construction will ultimately increase fisheries production, which generates substantial interest. The local benefits are increased food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls.

In areas where fish passage has already been considered, there are several major social benefits which flow:

Team cohesion: Our team is united in their desire to see the project succeed, and this is evident when local staff are keen to work on the fishway project. The project team will replicate successes at low-head site in Lao PDR and actively employ local staff to assist with fieldwork, attend project workshops, coordinate community co-management meetings and disseminate information about the project widely within the community. This includes seeking and supporting active participation from women as well as men.

Improved community knowledge of floodplain fisheries: Capture fisheries ecology and productivity are difficult concepts to understand for people without university-based education. Many local fishers have a rudimentary understanding of fisheries, based largely on fish they encounter frequently. Previous ACIAR funding has determined that up to 85 per cent of citizens engaged in fishing activities had not completed secondary school (**FIS/2009/041)**. Thus, the XPCL community program is important for demonstrating the benefits of fish passage to the broader community.

Improved community co-management frameworks: Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed, and operated, it is expected that the fish will move upstream and become more accessible to the other villages (thus creating a more equitable access to the resource).

Therefore, demonstrating fish passage success through robust research is very important for Xayaburi Power Company to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The most likely environmental outcome will be to ensure fisheries at the Xayaburi Dam site do not decline. The overall aim is to demonstrate, through sound operation and integration into dam operations, that the dam will not lead to adverse environmental impacts. Fishway construction can lead to measurable rehabilitation outcomes within 12 months of construction. Measurable differences for short-lived species are expected within 12 months (Category 1), and for longer lived species, these differences are expected within 5 years (Category 2). The flow on effects to livelihoods and nutrition will be measurable and experience from Lao PDR suggests that these timeframes are realistic.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the target countries can be measured by the ability to influence MRC guidelines, ensuring new dams includefunctional fish passes, as well as developing standard methods which will be applied at other sites.

6 Project management

6.1 Management aspects

6.1.1 Project governance

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be responsible for resourcing its own staff. The team will link with the MRC and other developer through its governance team.

The plurality of partners and significant interest across governments and agencies require the establishment of a multi-agency governance structure (Figure 2). Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work.

An outcome was to establish a project reference panel who would be regularly briefed on project progress and outcomes. The panel would contain representatives from Charles Sturt University, Department of Foreign Affairs and Trade, Xayaburi Power Company Limited, Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines.

There was general agreement and commitment to publication of project outputs but a communication plan will be in place to protect and background intellectual property and to ensure transparency and consistency of any outward communication activities. These will largely be established in the form of a memorandum of understanding between Xayaburi Power Company and Charles Sturt University (Appendix 1). The MOU will extend to partners sub-contracted by Charles Sturt University.

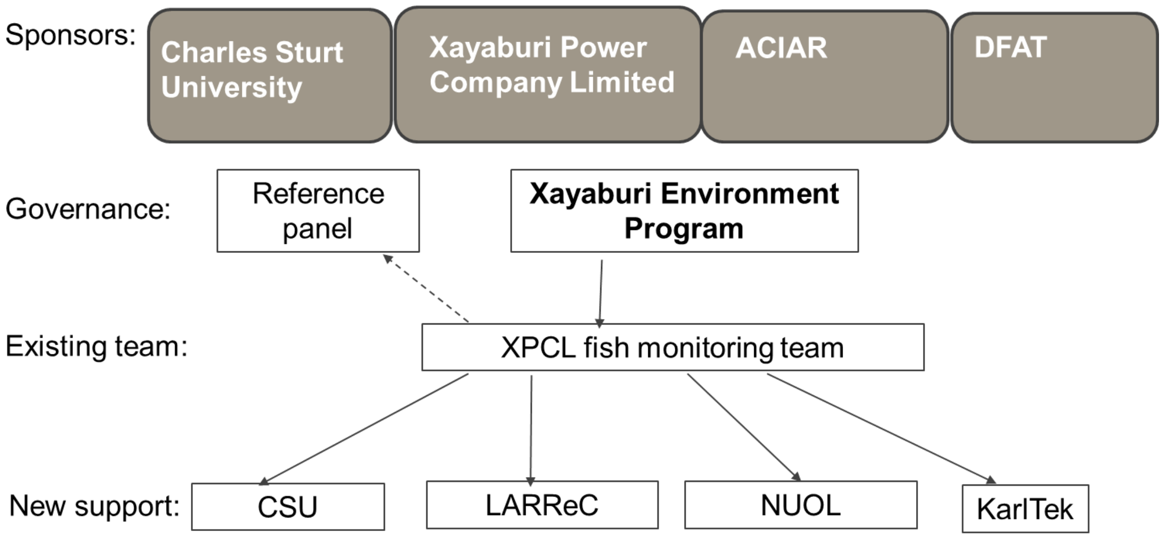


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will ingrate within existing governance arrangements. Importantly, the team will support existing monitoring efforts at the dam and augment the substantial research already underway.

6.1.2 Internal project communication and management approaches and plans

The team have been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Madame Khampheng Homsombath (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Role in project	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Collaborating Scientist	Collaborating Scientist	
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	Collaborating Scientist	
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	Collaborating Scientist	
Michael Raeder	M	Xayaburi Power	Owner Representative	Collaborating Scientist	Collaborating Scientist	
Dominique Vigie	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	Collaborating Scientist	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	Project Leader	
Lauren Withers	F	Australian Volunteers	Volunteer	Research Assistant	Project support	

6.3 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	[redacted]
Jarrod McPherson Charles Sturt University	[redacted]
Thanasak Phomisajiev Xayaburi Power Company	[redacted]
Dr Michael Raeder Xayaburi Power Company Limited	[redacted]
Garry Thorncraft National University of Laos	[redacted]

Name	[redacted]
Dr Oudom Phonekhampheng National University of Laos	
Khampheng Homsombath Living Aquatic Resources Research Centre	
Karl Pomorin KarlTek Pty Ltd	
Dr Nathan Ning Charles Sturt University	
Dr Chris Barlow Fish Matters IP	
Lauren Withers (and others) Australian Volunteer	

FOI Act s. 47

6.4 Description of the comparative advantage of the institutions involved

The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 50 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (FDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

Fishway Consulting Services: Fishway Consulting Services (FCS) is one of the most respected Australian businesses in the field of water management. The organisation develops technical solutions that mitigate ecological impacts of human development in aquatic ecosystems and natural resource management. FCS collaborates closely with engineers, managers and diverse interest groups, to resolve fundamental issues over conflicting issues arising from resource development schemes that are not only site-based but integrate ecological objectives over different spatial scales.

7 Appendix 1: Supporting documentation

MOU between XPCL and CSU

Charles Sturt University

Memorandum of Understanding – Research Cooperation

Charles Sturt University

and

Xayaburi Power Company Limited

2017 Version: 1.0

Reference: LA17/9

Schedule 1 - Memorandum of Understanding Details

This Memorandum is made up of this Schedule and the Agreed Principles.

Item 1	**Parties**	**Charles Sturt University** (ABN 83 878 708 551) being a university incorporated in New South Wales under the *Charles Sturt University Act* 1989 and having its registered office at The Grange, Panorama Avenue, Bathurst, NSW 2795 (***CSU***) **Xayaburi Power Company Limited of** 215 Lane Xang Avenue Vientiane Lao PDR (***Cooperating Institution***)
Item 2	**Commencement Date**	1/01/2018
Item 3	**CSU Coordinating Officer**	**Name:** **Ashlea Dobson** **Position:** Partnership Officer **Division:** Office of Global Engagement and Partnerships **Organisation:** Charles Sturt University **Address:** [redacted] **Telephone:** **Email:**
Item 4	**Cooperating Institution Coordinating Officer**	**Name:** **Dr. Michael Raeder** **Position:** Owner Representative **Division:** N/A **Organisation:** Xayaburi Power Plc. **Address:** [redacted] **Telephone:** **Email:**

[redacted]

Execution

The signatories hereby personally warrant that they have express and sufficient legal authority to execute this Memorandum (which includes the **attached** Schedule and Agreed Principles) on behalf of the party on whose behaf they have signed.

Signature for CSU

SIGNED for **CHARLES STURT UNIVERSITY** in the presence of) [redacted]) Signature

[redacted]
Signature of witness

Pro-Vice Chancellor, Global Engagement (Research & Partnerships)

Joss Ninness
Name of witness (print)

Professor Heather Cavanagh

Assistant
Position

15 December 2017
Date signed

Signature for Cooperating Institution

SIGNED for **XAYABURI POWER COMPANY LIMITED** in the presence of) [redacted]) Signature

Sig[redacted]

Thanawat Trivisvavet
Name (print)

Michael Raeder
Name of witness (print)

Managing Director
Position (print)

Owner Representative
Position

13 June 2018
Date signed

FOI Act s. 47

Letter of support from the Lao Ministry of Energy and Mines

LAO PEOPLE'S DEMOCRATIC REPUBLIC
PEACE INDEPENDENCE DEMOCRACY UNITY AND PROSPERITY

MINISTRY OF ENERGY AND MINES
CABINET OFFICE

No. 1098
Vientiane, 27 APR 20

To: Mr Thanawak Trivisvavet
Managing Director Xayaburi Power Company
[redacted]
Dinaeng District, BANGKOK 10400

Subject: Research Collaboration at Xayaburi Dam

We understand that a collaboration on fish research at Xayaburi Dam is proposed between Charles Sturt University (Australia) and Xayaburi Power Company Limited which will involve support from National University of Laos and also the National Agriculture and Forestry Research Institute.

The Ministry of Energy and Mines incorporating the Department of Energy, Policy and Planning have reviewed all of the proposed project documentation, consulted with the Ministry for Agriculture and Forestry, and sought endorsement from the Ministry for Planning and Investment.

Based on these consultations I am pleased to provide my endorsement for this collaboration to proceed. My ministry and staff will follow the collaboration with interest and expect that it will generate information that will benefit hydropower development in Lao PDR now and into the future.

- Enclosed here is subsidiary arrangement between the government of Australia and the government of the Lao people's democratic republic relating to assessing fisheries mitigation measures at Xayabury dam in Lao PDR

I wish the research team every success in its endeavours for this important work.

Sincerely,

[redacted]

Dr Daovong PHONEKEO
Head of Cabinet
Ministry of Energy and Mines

Letter from the Lao Ministry of Planning and Investment endorsing National University of Laos and Living Aquatic Resources Research Centre involvement

ສາທາລະນະລັດ ປະຊາທິປະໄຕ ປະຊາຊົນລາວ
ສັນຕິພາບ ເອກະລາດ ປະຊາທິປະໄຕ ເອກະພາບ ວັດທະນະຖາວອນ

ກະຊວງແຜນການ ແລະການລົງທຶນ

ເລກທີ 0498 /ກຜທ.ຮມສ-ອປອ.05
ນະຄອນຫຼວງວຽງຈັນ, ວັນທີ 1 ມີນາ 2018

ແຈ້ງການ

ຮຽນ: ທ່ານ ລັດຖະມົນຕີ ກະຊວງພະລັງງານ ແລະບໍ່ແຮ່

ເລື່ອງ: ອະນຸມັດຮັບເອົາໂຄງການຕິດຕັ້ງອຸປະກອນການເກັບກຳຂໍ້ມູນການຂຶ້ນ-ລ່ອງຂອງປາຢູ່ເຂື່ອນໄຊຍະບູລີ (Assessing Fisheries Mitigation Measures at Xayaburi Dam in Lao PDR) ໂດຍໄດ້ຮັບການຊ່ວຍເຫຼືອລ້າຈາກປະເທດອົດສະຕຣາລີ

- ອີງຕາມ ດຳລັດຂອງທ່ານນາຍົກລັດຖະມົນຕີ, ສະບັບເລກທີ 75/ນຍ, ລົງວັນທີ 20 ມີນາ 2009 ວ່າດ້ວຍການຄຸ້ມຄອງ ແລະນຳໃຊ້ທຶນການຊ່ວຍເຫຼືອທາງການເພື່ອການພັດທະນາ;
- ອີງຕາມ ໜັງສືສະເໜີຂອງກະຊວງພະລັງງານ ແລະບໍ່ແຮ່ ສະບັບເລກທີ 0262/ພບ, ລົງວັນທີ 14 ກຸມພາ 2018.
- ອີງຕາມ ການຄົ້ນຄ້ວາ ແລະສະເໜີຂອງກົມຮ່ວມມືສາກົນ, ກະຊວງແຜນການ ແລະການລົງທຶນ ສະບັບເລກທີ 047 /ກຜທ.ຮມສ-ອປອ.05 ລົງວັນທີ 22 ກຸມພາ 2018

ກະຊວງແຜນການ ແລະການລົງທຶນ ຂໍຖືເປັນກຽດແຈ້ງມາຍັງທ່ານຊາບວ່າ: ກະຊວງແຜນການ ແລະການລົງທຶນ "ເຫັນດີ" ອະນຸມັດຮັບເອົາໂຄງການຕິດຕັ້ງອຸປະກອນການເກັບກຳຂໍ້ມູນການຂຶ້ນ-ລ່ອງຂອງປາຢູ່ເຂື່ອນໄຊຍະບູລີ (Assessing Fisheries Mitigation Measures at Xayaburi Dam in Lao PDR) ໂດຍໄດ້ຮັບການຊ່ວຍເຫຼືອລ້າຈາກປະເທດອົດສະຕຣາລີ, ໃນມູນຄ່າ 2,591,551 ໂດລາອົດສະຕຣາລີ, ເລີ່ມແຕ່ເດືອນມັງກອນ 2018 - ເດືອນມັງກອນ 2021 (ກຳນົດ 04 ປີ).

ກະຊວງແຜນການ ແລະການລົງທຶນ ສະເໜີໃຫ້ພາກສ່ວນທີ່ກ່ຽວຂ້ອງນຳໄປຈັດຕັ້ງປະຕິບັດແລ້ວລາຍງານຜົນສຳເລັດຂອງໂຄງການ ຫຼື ກິດຈະກຳຕ່າງໆໃຫ້ກົມຮ່ວມມືສາກົນ, ກະຊວງແຜນການ ແລະການລົງທຶນ ຊາບທຸກໆ 06 ເດືອນ ເພື່ອສາມາດຕິດຕາມວຽກໄດ້.

ດັ່ງນັ້ນ, ຈຶ່ງຂໍຖືເປັນກຽດແຈ້ງມາຍັງທ່ານເພື່ອຊາບ ແລະຈັດຕັ້ງປະຕິບັດຕາມລະບຽບການດ້ວຍ.

ດ້ວຍຄວາມນັບຖື,

ລັດຖະມົນຕີ

[redacted]

ປອ ສຸພັນ ແກ້ວມີໄຊ

ບ່ອນນຳສົ່ງ:

1. ຫ້ອງວ່າການສຳນັກງານນາຍົກລັດຖະມົນຕີ 01 ສະບັບ
2. ກະຊວງການຕ່າງປະເທດ 01 ສະບັບ
3. ກະຊວງການເງິນ 01 ສະບັບ
4. ກະຊວງກະສິກຳ ແລະປ່າໄມ້ 01 ສະບັບ
5. ເກັບຮັກສາໄວ້ 02 ສະບັບ

Letter of support from the Lao Head of Mission (Australian Ambassador) providing DFAT support for the initiative

AMBASSADOR

AUSTRALIAN EMBASSY
VIENTIANE

H.E. Dr Phouangparisak Pravongviengkham
Vice Minister
Ministry of Agriculture and Forestry
Lao PDR

Re: Request to co-chair a meeting on the Xayaburi Dam's Fish Passage Facilities Study

Your Excellency,

To fulfil requirements under the Concession Agreement between the Government of Laos and Xayaburi Power Company Limited (XPCL) on fish migration through the Xayaburi Hydropower Dam, XPCL reached out, in June 2017, to the Australian Centre for International Agricultural Research (ACIAR) and Charles Sturt University (CSU) to assist in the independent monitoring and evaluation of effective fish passage at the site.

In response to this request, the Government of Australia (represented by ACIAR and the Department of Foreign Affairs and Trade) in collaboration with CSU, the Lao Ministry of Agriculture and Forestry (MAF), the National University of Laos (NUoL) and XPCL are in the process of finalizing a joint research project called "Assessing fisheries mitigation measures at Xayaburi Dam in Lao PDR." Please find attached a project brief for your reference.

Technical consultations are scheduled to take place with relevant officials at MAF, NUOL, Ministry of Natural Resources and Environment, and Ministry of Energy and Mines on 7 November.

In order to further discuss the project, I would like to request your Excellency to join me in co-chairing an inter-ministerial meeting on 8 November 2017 at 9:00-11:00 AM. The purpose of the meeting is to present and discuss the proposed research initiative and seek views from relevant ministries and stakeholders on ways to proceed with the project. The meeting will be held at Setha Palace Hotel.

I would be grateful if you could please confirm your availability with Mr Ounheuan Saiyasith on 020 28201884 or ounheuan.saiyasith@dfat.gov.au.

Yours sincerely

[redacted]

Ambassador
13 October 2017

[redacted]

Definitions

Research outputs: These are the result of activities of the project. Examples include new varieties, methods and practices.

Research outcomes: Research outcomes are defined as the use made of the outputs by the stakeholders *directly involved with the research project*. This involves practice change and changes in knowledge, attitudes, skills and aspirations within the research project. Examples include productivity increases resulting from the adoption of new varieties or practices by farmers participating in the project at pilot sites, or strengthened capacity of project partners.

Development outcomes: Development outcomes are the use made of the research outputs *beyond the sphere of the research project*. An example is an increase in crop yields by farmers as a result of the adoption and promotion of a new crop variety (the research output) by the extension services.

Research impacts: Research impacts are social, economic, environment and community impacts of the stakeholders *directly involved with the research project.* Examples include increased household income as a consequence of adopting new farming practices developed by the project at pilot sites, or strengthened capacity of project partners that is used for other, non-project activites.

Development impacts: Development impacts are social, economic, environment and community impacts that occur *beyond the sphere of the research project*. These are large-scale, usually longer-term impacts to which the research project contributes. An example is increased income and improved livelihood of smallholder farmers in a country. The research project may have contributed to this impact by developing new crop varieties that were adopted and promoted widely by next-users such as the extension services.

Gender: Gender refers to the socially constructed roles and responsibilities of women, men, girls and boys, including the relationships, roles and expectations of each in different socio-cultural contexts. For more information see *ACIAR Gender Guidelines for Project Proposals*

Impact pathways: Impact pathways describe how research results are intended to contribute to the overall goal of the project (e.g. improving food security and livelihoods of smallholder farmers in a country). This is also referred to as the 'theory of change'.

Next-users: Next-users are clients of the research project who will use and promote the research outputs to end-users. Examples of next-users are institutions such as extension services, non-government organisations (NGOs), policymakers and businesses. Research outputs will only be useful and contribute to development impacts if they are taken up and promoted by next-users. Some individuals of these institutions are likely to be involved in the actual research project (e.g. as part of participatory research at pilot sites).

End-users: End-users are the beneficiaries of the Reseach & Development process. For example, these may be resource-poor smallholder farmers in a province or state who have adopted new farming practices that were developed by the research project and extended by next-users. The research project will not be directly involved with these end-users, except with a subsample who may be involved in research activities such as surveys or participatory research at pilot sites.

Australian Government

Australian Centre for International Agricultural Research

Project Proposal

Variation 1

ACIAR Program(s) area	FIS
Project Title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Project Number	FIS/2017/017
prepared by	Lee Baumgartner
ACIAR Research Program Manager	Fleming, Ann

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Project outline

ACIAR Program(s) Area	FIS
Project number	FIS/2017/017
Project title	Assessing upstream fish migration measures at Xayaburi Dam in Lao PDR
Proposal stage	Full Proposal
Commissioned Organisation	Charles Sturt University
Proposed start date	1/09/2019
Proposed finish date	~~31/08/2022~~ 31/12/2022

Key contacts

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FOI Act s. 47

Contents

1 Project Summary

1.1 Background and Justification

Productive fisheries in the Lower Mekong Basin (LMB) will be negatively impacted if all planned large-scale mainstem hydropower dams are completed. There are presently nine large hydropower dams scheduled for the mainstem of the Mekong River in Lao PDR, and two more in Cambodia that have divided public opinion. On one hand, there are those who clearly see the benefits of dam construction for creating jobs, supplying and exporting electricity and reducing poverty. On the other hand, there is concern about the impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which, in turn, interrupts access to vital spawning, nursery and feeding habitat. The LMB fishery has been estimated to be worth US$17 billion annually, but dams are expected to reduce, by more than half, this important source of food and income for many people.

One of the first dams, at Xayaburi, in Lao PDR, will be operational in 2019. Xayaburi Dam blocks the entire width of the river, presenting an impassable barrier to all fish species. Significant investment (US$300M) to provide for fish passage was incorporated into the final designs. The level of investment, and the complexity of the fish passage facilities, are unprecedented anywhere in the tropical or sub-tropical world. Nevertheless, the facilities need to be rigorously assessed to determine if they meet the design specifications.

The Xayaburi fish pass facilities have been designed for large biomasses of more than 100 species of fishes, varying in size from a few centimetres to more than one meter. The dam design includes a series of 70 different moveable gates which can be configured to alter fish pass flow in order to improve passage rates for specific species and/or specific seasonal flows. The project team will be able to, within the funding envelope on offer, adaptively alter the configuration of the fishway and determine if different settings alter passage rates for particular fish species and their life stages, and for different seasonal flow rates. This will provide XPCL with operational recommendations to optimise the performance of their facilities overall. This represents a substantial challenge and the question of whether the fish passage facilities will be effective in allowing a large proportion of fish numbers and species to pass is a question that the developer, Government of Lao PDR and scientists are all keen to see answered. If the fishery in the Mekong is to be maintained, then all other planned dams in the mainstem cascade will need to match or exceed the fish passage performance at Xayaburi. A structured research program is therefore essential to be developed in regions where poor people are dependent on natural resources. The Xayaburi facilities provide an opportunity to design and commence experiments to test the efficiency of the fish passage design, and to apply/adapt learnings to other sites.

1.2 Significant activities and outputs

The project builds upon a 12-month SRA which is currently underway to scope and refine the major methods that will form the basis of the research program. It is extremely important that methods implemented at the dam site are fit-for-purpose and are effective. Early scoping activities identified electrofishing, passive integrated transponder tagging and direct trapping as most suitable. The first 18 months will be largely technically focused on method development. Activities include operational optimization, tag efficiency trials, antenna interference assessments both in the laboratory and *in situ*. These trials will be used to install a functional tag detection system which will be used. Refined methods will then be scaled up and applied to the hydropower project to allow a calculation of the overall fish passage efficiency.

1.3 Aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities. Because the dam site is so large, and the methods are untested on such a scale, the project will both develop and establish robust approaches to calculating fish pass efficiency. The specific objectives of this research are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Assess upstream fish passage within the Xayaburi Dam fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

1.4 Key partnerships

The project will be implemented as a private-public partnership. Charles Sturt University will lead the collaboration, which will include Xayaburi Power Company as the main private stakeholder, and Lao government entities, Living Aquatic Resources Research Centre and National University of Laos, as implementing partners. Furthermore, key Australian businesses KarlTek Pty Ltd an Australian-tech manufacturer, along with fishway Consulting Services and Fish Matters IP will provide both technical and strategic advice. The project will also link with the Mekong River Commission who are finalising a mainstem dam construction guidance document. Xayaburi Power Company Limited (XPCL) has requested an experienced Australian/Lao team, led by ACIAR/Charles Sturt University, to collaborate for the purposes of research. This offer was made on the basis of XPCL paying for all infrastructure and on-site research (several millions of dollars over the 30-year concession period), if the Australian/Lao PDR team can fund its own direct costs (namely salaries and international travel). [redacted] XPCL are providing an estimated $560,617, as significant additional in-kind support over the three year time frame.

1.5 End of project outcomes

The overall outcome of this project is a robust, and scientifically-defendable, research program which, in-conjunction with XPCL, will contribute significantly to the body of knowledge required to mitigate the impacts of large dams in the LMB. The project will enable enhanced operations at Xayaburi to ensure fish passage is fully integrated into day-to-day dam operations. However, scaling out from this project is the ability to influence other mainstem dams. It is expected that the overall effectiveness of Xayaburi Dam facilities will be used to improve the design of other fish passes at future mainstem dams. The project has been subsequently developed with these broader development outcomes in mind. Furthermore, XPCL has expressed its support or publication of results, especially in conjunction with capacity-building of its own staff, provided all parties are in agreement.

1.6 Project impact pathways and benefits

Strategic benefits are expected to be extended to other dams in the region. There is a direct impact pathway to other sites, for example, both Pak Beng and Pak Lai, two additional mainstem dams scheduled for construction over the next decade. These dams will both require fish passage facilities and monitoring programs. The research methods developed here may lead to a new set of standards that can be applied at other sites.

2 Background and justification

2.1 Partner country and Australian research and development issues and priorities

2.1.1 Hydropower development in the Mekong

Hydropower — both now and in the future — will greatly impact aquatic resources and water use in the Lower Mekong Basin (LMB). Current hydropower output (3,325 MW) is expected to rise 7% per year over the next two decades, necessitating the construction of 134 new dams (11 mainstem dams, and 123 tributary dams) (Commission 2010). The capture fisheries industry is important since fish comprise 50-80% of the animal protein consumed in the Mekong catchments of four lower Mekong countries, and support the livelihoods of 60 million people living in the LMB (Hortle 2007, Baumgartner et al. 2016). Without effective hydropower mitigation strategies, capture fisheries could decline by over half (880,000 tonnes annually), destroying this major source of animal protein (ICEM 2010). Lower Mekong governments constantly field questions from their citizens, scientists and media on the effects of new dams on migratory fish, crucial to support employment and food security. However, governments are unable to provide answers because they lack robust science of regional significance. Even if international consultants are engaged, they often lack LMB-specific information, and can only provide advice based on experiences elsewhere. Ineffective strategies, developed for completely different fish species, are then applied to mitigate hydropower dam effects. For instance, mitigation techniques developed for North American species were used at the Pak Mun Dam (Thailand), which led to the local extinction of 65 fish species, decreased fish catches, lost income and large-scale protests; all within five years of construction (Amornsakchai et al. 2000). The number of large-scale water resource development projects in the LMB, especially hydropower, is growing. Given the mainstem and tributary dams planned within the LMB in the next decade (Commission 2010), there is a desperate need to define methods and strategies for these projects that prevent widespread species loss or declines. Without these methods and strategies, the long-term sustainability of the Mekong's productive inland fishery will be challenged.

2.1.2 Xayaburi Dam

Xayaburi Dam is the first of 11 dams planned for the mainstem of the Mekong in the LMB (Orr et al. 2012). All of these dams are highly controversial. The major criticism relates to their impacts on the livelihoods of people currently dependent on the river, and the difficulties of mitigating those impacts. This is especially the case for the barrier effect of dam walls blocking fish migrations, which disrupt important life-cycle events, thus diminishing a productive river fishery. Construction of Xayaburi Dam will cost approximately US$3 billion. Construction started in 2012 and is now approximately 95% complete, with the first turbines due to be operational in 2019. As planning for the dam and associated public and regional government discourse developed through 2007–2014, the Xayaburi Power Company Limited (XPCL) increased its commitment to mitigation, with significant design changes incorporated especially for sediment transport and fish passage. This work was done by a US company and did not involve Australian expertise. XPCL has invested US$300 million to massive infrastructure for upstream and downstream fish passage. This level of expenditure and the complexity of the fish passage facilities are unprecedented anywhere in the tropical world. In fact, they are matched only by the facilities on rivers in North America (Williams 2008), but where investment only targets salmon species. XPCL invited a team of fish passage experts involved in the ACIAR-funded fishways research and development in Lao PDR to visit the site. The purpose was to exchange information especially in relation to possible future

research, monitoring and evaluation at the dam. The outcome of that meeting was an exclusive opportunity to develop and implement a fisheries research program at the site.

2.2 Alignment with ACIAR corporate plan and strategy

(i) Food security and poverty reduction

South East Asian countries understand protecting freshwater fish is a major priority to ensure food security for many rural households (Hortle 2007). Most rural Asian citizens are actively involved in inland capture fisheries and river, and fishery health is crucial to securing food and income for local communities (Dugan et al. 2006, Millar et al. 2018). The Xayaburi Dam was expected to have a potential impact on upstream food resources; which is why a fish pass is being constructed. Our project will contribute to the overall knowledge of mainstem dams and ensure dam operations are optimised to minimise any harmful impacts.

(ii) Natural resources and climate

The factors contributing to fisheries productivity are unknown for most inland regions in South East Asia because hard research data does not exist. This project will provide the first recorded information on passage through a large fishway at a mainstem dam on the Mekong River. It will also address an important planning need across the region.

(iii) Human health and nutrition

Fish have exceptional nutritional value and are important for early child development (Dugan et al. 2006). Irrigation development has negatively impacted inland fisheries (Dudgeon 2000). This project aims to redress this imbalance and determine if the fish pass facilities at Xayaburi are facilitating positive outcomes for both fish and livelihoods.

(iv) Empowering women and girls

Women across the region actively participate in many fisheries activities including co-management, policy development, the construction of fishing gear, fish sorting, fish handling, trading and fish processing (Siason et al. 2010). Women also directly engage in fishing activities with their family members in lakes, rivers and streams. The Xayaburi project was specifically required to develop a gender strategy and our project team will work within those frameworks to ensure the gender targets are being achieved.

(v) Value chains and private sector engagement

The hydropower sector is becoming increasingly receptive to considering fishways during planning and construction activities and is looking to external and private sector expertise for assistance. The private sector also plays a key role in shaping government regional decisions and policies. The Xayaburi project has brought together an international team of private, developmental and governmental sectors to recognise the value of fisheries resources and how to maximise those resource returns even when hydropower projects are undertaken.

(vi) Building capacity (individual and institutional)

At an individual level, Australian professionals with a proven track record in building capacity in developing countries will develop rapport with local stakeholders. At an institutional level, this proposed project will partner regional governments with private industry to develop a research and development program which seeks to develop methods which will be available to quantify fisheries migration studies into the future.

2.3 Relationship to other ACIAR investments and other donor and partner-country activities

2.3.1 Government priorities

The overarching need for this work is largely driven by the *1995 Mekong Agreement*, which explicitly requires LMB countries to work together to identify and mitigate transboundary impacts of river development (Mekong River Commission 1995). The subsequent DFAT strategies for Cambodia, Lao PDR, Myanmar and Vietnam explicitly mention the need to achieve a balance between hydropower, irrigation and fisheries sustainability to maintain food security in the region (Australian Government AusAID 2012). By connecting key stakeholders in these areas, across the public and private sectors, this activity will contribute to food security and livelihood protection in direct alignment with DFAT strategies if the fish pass is effective. The activity will address country and development goals that are not being addressed by other donor bodies by:

- establishing research infrastructure (in the form of a fish tracking system) (**DFAT Priority: Essential infrastructure**)
- training some of the most promising female professionals to use the newly established research infrastructure (**DFAT Priority: Empowering Women and Girls; Education and Health**)
- obtaining robust fisheries-related data that can be applied directly to hydropower mitigation strategies (**DFAT Priority: Fisheries Protection**).

Protecting migratory fish from hydropower impacts is a priority for all Mekong riparian countries, is recognised by many foreign aid agencies, and is of major interest to the hydropower industry. This activity is therefore directly related to DFAT's strategic outcome ‘Agriculture, Fisheries and Water’. Hydropower development is one of the most significant water management issues in the LMB; and Xayaburi Dam, being the first site, is of particular significance and international interest. [redacted] Additional in-kind was provided (in terms of salaries) by all project partners. To meet the strict construction deadlines associated with the project, the most time-efficient mechanism to commence the project was through an ACIAR SRA (**FIS-2017-016**) followed by a Phase 2 submission (**FIS-2017-017**) to advance the additional three years. The SRA is presently underway and will conclude operations in August 2019; with a final report due in December 2019. To maintain continuity for project staff, the large follow-on project must commence in August 2019.

2.3.2 Industry priorities

Outside the Mekong agreement, the Lao government (through the Ministry of Natural Resources and Environment – MONRE; and the Ministry of Energy and Mines - MEM) has entered into a 30-year concession agreement with XPCL. XPCL will own and operate the site for that period, at which time ownership will transfer to the Government of Lao PDR. XPCL took substantial steps, during construction, to minimise environmental impacts at the dam site to provide successful passage for fish species. Substantial investment was made in researching the required infrastructure to achieve this, but now, a research program is required to assess whether fish are passing when the hydropower facility is operating. To this end, XPCL has invested in a team of young Thai (and within this proposal Lao) graduates undertaking fish movement studies on all aspects of fish passage (upstream and downstream). XPCL believe that the team would greatly benefit from the input of international scientists, with experience in the latest technology for tracking fish movements nearby and past dams. XPCL have made a substantial commitment to invest in required infrastructure and resources to enhance the chance of success; but requested that international scientists fund their own salaries and travel.

2.4 Research questions

2.4.1 Xayaburi fishpass overview

Specific design parameters were incorporated into the dam design to provide passage for fish through the dam site. The fish pass design was engineered to allow the passage of the slowest swimming fish species in surrounding waters. A series of 70 different moveable gates can be adjusted to alter and improve fish pass flow. The project team will work with XPCL to alter the configuration of these gates within the fishway and determine if different settings alter passage rates for specific species, life stages and seasonal flow rates. A key output of the project will be advice to XPCL on dam operational management to optimize fish passage for selected target species (including for their life stages and/or times of year) through the dam for different seasonal flows and migration patterns.

For upstream migration, the dam engineering includes a complex fishway system (Fig. 1). To successfully pass upstream:

(a) fish enter through one of several different entrance points (red dots Fig. 1),
(b) they then proceed through a 'gallery' toward the fish pass (green channel Fig. 1),
(c) they then enter a large fish pass facility (left-bank facilities, Fig. 1) and
(d) then proceed through a locking system into the weir pool (orange shading, Fig. 1); or
(e) alternatively they can move through the navigation lock.

It is important that fish are able to successfully reach each of these checkpoints (a–d; or e) to gain passage. As such, the research project needs to be able to track fish to each point.

To successfully pass downstream, fish need to:

(a) be able to physically approach the dam
(b) 'choose' to be passively diverted through either the powerhouse, spillway, navigation lock or a fish collection channel on the intermediate block
(c) survive the passage process and avoid damaging processes that could injure or kill.

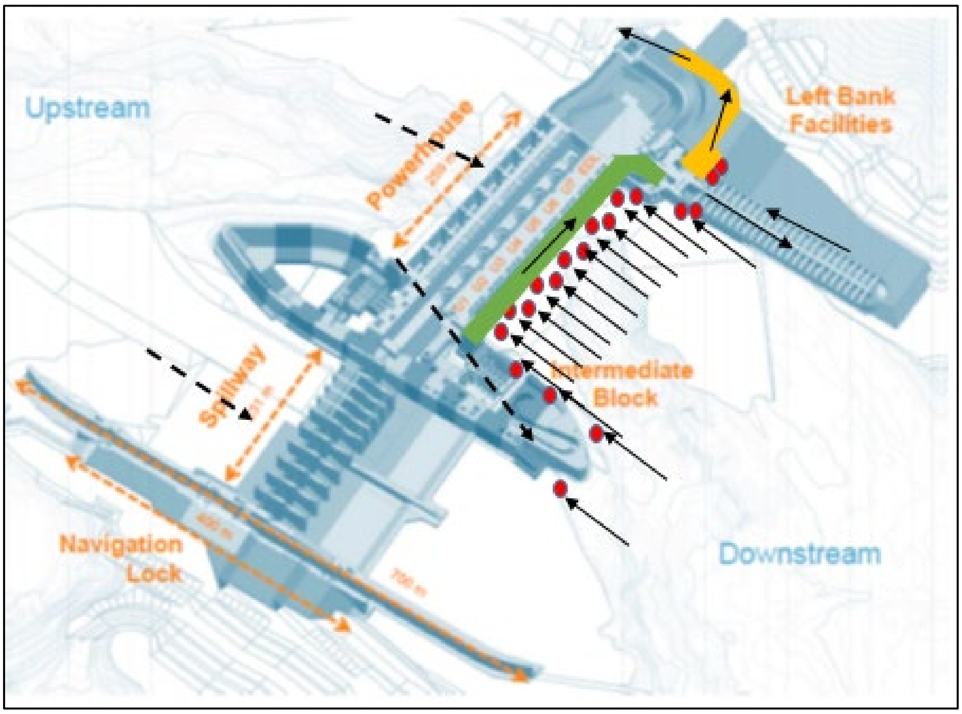


Figure 1. Plan view of facilities at Xayaburi Dam. Solid black arrows show fish movement direction. Red dots highlight entrance points, the gallery is green and the fish lock and associated exit channels are orange. Dotted arrows are downstream passage routes.

2.4.2 Terms of reference / research questions

A preliminary site visit in May 2017, and subsequent (current) SRA, by a team of Australian, Lao and US fisheries scientists (fish experts) scoped several key research questions in order to determine if the design principles are working. The research questions ensure that the research methods are robust and sufficient to enable reporting on scheme effectiveness. Based on that remit, critical research questions were summarised as:

Upstream passage

Research questions	Potential research methods
Question 1 - What fish (biomass and type) are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What fish are finding an entrance?	Passive Integrated Transponder (PIT) tags, acoustic tags, Dual Frequency Identification Sonar (DIDSON)
Question 3 - Do fish enter the gallery system?	PIT tags, acoustic tags
Question 4 - Do fish pass through the fishway?	PIT tags, acoustic and radio tags, direct trapping
Question 5 - What fish pass through the fishlock and exit upstream?	PIT tags, acoustic tags, radio tags, direct trapping

Downstream passage

Research questions	Potential research methods
Question 1 - What fish are approaching the dam?	Acoustic tags, radio tags, fish surveys
Question 2 - What influences which route is taken (spillway, fish collector or turbines)?	PIT tags, acoustic tags
Question 3 - Do fish survive the downstream passage process?	PIT tags, acoustic tags

2.4.3 Request from XPCL: Final selection of Research Questions

Despite recognising that there are significant research questions that could be posed (as outlined above), the project team was requested by XPCL to focus **only** on the development of Passive Integrated Transponder (PIT) tagging as a tool to measure upstream passage. Downstream passage, and the application of non-PIT techniques, is beyond the scope of the available budget so the ACIAR/DFAT team is only focusing on methods to assess upstream fish passage at this stage. Consequently, the research questions posed are:

Q1 – Can tools and methodologies be developed to monitor upstream migration of fish through Xayaburi Dam?

Q2 – Do migratory fish species pass upstream through the dam, and, if so, at what percentage rate of success?

Q3 – Can standardised methods for dam assessments be developed based on the methods we are trialling?

2.4.4 Previous work on fish species selection for passage

There have been a number of fish studies done in the region of the dam as part of the environmental approval process, as well as earlier studies – in both the published and grey literature. These have generated a list of 308 potential adult species in the region, many of which are migratory.

Part of the GoL conditions of approval was that XPCL are required to provide for migratory fish to pass through the dam. To ensure the fish passage design catered to the slowest swimming species, FishTek, a British consulting company, performed a series of fish passage trials to identify the swimming abilities of key species. The swimming abilities of the slowest species formed the basis for the final design decisions for the fishway engineering. The GoL and XPCL agreed on a list of 26 potential migratory adult species (Table 2) that were the most important to monitor for effective passage. Their criteria for importance were based on a combination of food security and conservation significance.

XPCL contracted fishermen surveys to identify important species to the local fishers and communities (Team consulting, 2014). Using this study and others done in the region, we have highlighted in Table 2 (in bold) those species considered important for food security for local communities.

Thus, fish species selection in the project will be based on:

i) Those species that have been listed as important to pass through the fish passage by the GoL/XPCL, which includes species important to food security for local communities and conservation significance, and

ii) Those species that can be successfully tagged, released and monitored.

2.5 Gender focus

Consideration of gender within affected communities

As the Xayaburi Hydroelectric Power Plant is a run-of-river type dam (without a large reservoir of stored water), its construction and operation has directly affected 15 villages located on both sides of the Mekong River bank in Xayaburi and Luang Prabang provinces, with seven of these requiring relocation to new resettlement sites with full provisions of housing, infrastructure, public facilities, compensation and support. A Social Impact Assessment (SIA) required a Resettlement Action Plan (RAP) to be formulated in compliance with the provisions of the Lao PDR's National Policy on Resettlement and Compensation, Decree on the Compensation and Resettlement of the Development Projects, the Environmental Management Standards for the Electricity Projects and the Technical Guidelines on Compensation and Resettlement in Development Projects.

The principles underlining these documents are that the XPCL's RAP has to enhance the quality of life for the project affected people (PAPs) and to minimize and mitigate adverse social impacts; which impact both male and female members of the community. The XPCL's RAP was formulated using a participatory approach through intensive studies, field surveys and consultation meetings with PAPs. It sought to respond to all levels of concern raised by government officials across central, provincial and district governments, which specifically ensured all gender perspectives were captured.

The RAP includes a Social Development Program for community development, livelihood restoration for PAPs and host communities towards a better quality of life and environment. This program is directed at all 15 villages directly affected by the dam development. The program requires full extension programs with communities and specific programs to ensure gender-balanced outcomes. This includes programs that are led by a female executive within the Xayaburi Power Company, ensuring that gender perspectives are considered at the highest level within the company.

Our research team is playing a very small, but important, role within XPCL's community consultation process. Our team will participate within the XPCL monitoring framework. In particular, we will engage with the XPCL consultation framework through our Lao government partners to ensure our decisions about fish species selection in relation to food security are endorsed by locals; including men and women. We also plan to include a Lao national on a project reference panel, so will report to them on our level of engagement with communities and inclusion of gender perspectives on key decisions, particularly regarding species selection.

Consideration of gender within the research team

Our research team consists of XPCL staff, Laos government (LARReC) and university staff (NUOL) and the Australian team. The XPCL monitoring team was selected by the company and staff were allocated to our team. Likewise, the LARReC and NUOL teams were selected from within their institutions on the basis of existing technical capacity. Unfortunately, this has provided a gender structure among the project team which is predominantly male.

Outside the nominated project team in-country, the Australian team strive to address our gender imbalance by recruiting equally. For instance, preliminary tag retention work was performed by a female Australian honours student and our team will be joined by a female Australian Volunteer for the next 12 months. The National University of Laos plans to deploy masters students to assist the project on site and already two of these are female-nominated positions. Thus, through these mechanisms we can ensure not only that all gender perspectives are brought to the table, but that the team is more balanced.

3 Research strategy and partnerships

3.1 Research and development strategy

Adaptive management strategies have been applied to fish passage projects worldwide for several decades. Fishway designs are constantly being developed, implemented, refined and then modified for implementation at other sites. Australia has a long history of successfully applying adaptive management strategies to improve fish migration. Initially, Australian fisheries managers applied North American technology to increase fisheries productivity. As the technology was originally designed for salmon species, results were sub-optimal, providing limited passage for Australian native fish due to inherent biological differences. Targeted research determined how to apply the technology in Australia.

At Xayaburi Dam, a team of British researchers (Fishtek Consulting Ltd) determined internal fishway hydraulics based on the swimming ability of a subset of Mekong fish. These data were analysed and applied to construct fish passage facilities based on criteria gained from swimming experiments undertaken on site at Xayaburi. The efficacy of the facilities to pass, upstream, large biomasses of many species of fish varying in size from a few centimetres to more than one meter is an open question. So **research and operational modification** will be required to validate how well the elaborate passage facilities actually work. It is essential to research whether the Xayaburi facilities work and also whether such an approach can be applied to future hydropower projects along the Mekong and in other tropical systems.

The logical sequence for the proposed research is to:

1. Perform laboratory and *in situ* trials of three techniques (PIT detection antennas, electrofishing boat and a long-term tagging study) to optimise tag and recapture methods
2. Implement these methods at the dam site

3. Perform real-time monitoring of upstream fish movements and perform a critical analysis linking movements to dam operations
4. Analyse seasonal and annual upstream fish movements rates and calculate overall fish passage effectiveness
5. Collate, analyse and refine results, to report on the daily operation of the fish pass
6. Communicate the relevant outcomes to other dam developers and NRM agencies to guide broader hydropower development practices in the catchment.

4 Objectives and research design

Dealing with fish-passage issues is a challenging and evolving area. Often, solutions can be developed for large-scale implementation but criteria can vary at specific sites depending on species, flow, geography or local social/cultural issues. Most of the current knowledge pertaining to the effectiveness of fishway designs has been for temperate species, and/or has come from laboratory-based trials (Mallen-Cooper 1992), whereas very little knowledge has been obtained via *in situ* field-based evaluations (Baumgartner et al. 2012). Indeed, only two *in situ* fishway evaluations have been published thus far in the LMB (Baumgartner et al. 2012, Baumgartner et al. 2018). At Xayaburi Dam, although facilities have been designed and constructed, an adaptive approach is required to integrate fishway benefits into overall dam operation including scale-out to other sites.

The research needs to be robust but flexible so that:

a) Methods work and are scalable at both Xayaburi and to other sites;
b) Are scientifically defendable; and
c) When combined, provide an overall picture of upstream fish pass effectiveness.

4.1 Project aims and objectives

The project ultimately aims to develop research methods than can be used to determine the overall effectiveness of the fish pass facilities to move fish upstream.

The project team has been asked to provide advice on optimizing fish passage performance, not to set targets for triggering changes in operational procedures. We will select a subset of the 70 moveable gates within the fish passage design as reference points for fish pass performance. Each of these reference points will be analysed against different criteria such as river flow, season, power generation rates, and rainfall to identify patterns of peak fish migration. The results for various species, life stages and times of the year will be used to establish maximum achievable passage rates for each target species. These rates will be used to advise when and what operational changes should be made to the fishway to optimise the fishway's effectiveness for the target species, life stages and/or times of year.

The specific objectives are to:

1. Develop a suite of robust techniques to assess performance of mainstem dam fishways in the Mekong catchment.

2. Scientifically assess the effectiveness of the Xayaburi fish pass facilities.

3. Provide a standard for monitoring and constructing other mainstem dam fishways in the Mekong catchment.

We note that passing fish downstream, including eggs and larvae, is also a significant challenge at the site. However, at this stage the team has only been asked to focus on upstream moving fish through the fish pass facilities. Downstream movement studies are equally important but, at this stage, are beyond the scope of the available budget and

request from XPCL. The team are very experienced with downstream movement work and can consider additions at a later stage if requested and appropriately resourced.

4.2 Research activities, methods and outputs

4.2.1 Monitoring upstream fish movement at large dams

Globally, hydropower development is generally associated with declines in fisheries productivity, associated value-chains and livelihoods (Williams 2008). Since 1950, significant investment has been made into targeted research and development, especially in the USA, to identify mechanisms to reduce hydropower impacts on fish (and other river parameters) (Williams 2008). In terms of fish monitoring research, technologies range from direct trapping, tagging, sonar and community surveys. Quite often, fisheries-related impacts are only one aspect of hydropower operation on river environments, so monitoring programs often consider hydrology, sedimentation, thermal regimes and other water quality parameters. Nevertheless, research and monitoring are integral components of hydropower construction and operation in terms of documenting impacts and streamlining any mitigation technology.

4.2.2 PIT tag systems

Radio Frequency Identification (RFID) technology has been around for over 50 years. (Ahson and Ilyas 2008). RFID tags are used every day for tracking livestock, identifying pet cats and dogs, for toll road transponders and numerous other applications. Modern day RFID tags have evolved from technology first developed in the early 1970's and so have greater read ranges, increased precision and are cheaper than earlier technology. As technology advances further, scientists gain an increased ability to collect information on the movements of individuals, providing essential information for sound management decisions for wild populations.

Many electronic technologies have been used to monitor the upstream movements of fish. Radio telemetry and acoustic tags are widely used to monitor the movements of individuals. (Thorstad et al. 2013). These technologies, however, have high capital costs which usually limit studies to small sample sizes of fish. The development of passive integrated transponder (PIT) technology has provided opportunities to monitor fish migrations (Castro-Santos et al. 1996). A PIT tag is a small glass capsule (23mm or 12mm long; half or full duplex) which contains electronic circuitry that is individually coded with a 16-digit identification number. PIT tags do not require internal battery power to operate; they are powered electromagnetically when moved within the vicinity of an antenna. The electromagnetic field generates a small voltage which charges the circuit and transmits the unique number. In most standard applications, tag details are recorded on a laptop computer, along with any number of peripheral information such as time, date or temperature.

PIT reader technology is extremely useful as a mechanism to detect fish responses to environmental flows. PIT readers are advantageous in that they:

1. Provide continuous data on fish migrations (i.e. 24 hrs a day)
2. Allow fish migration to be correlated with environmental variables such as season, flow or water quality (i.e. by combining fish passage data with real time water quality variables)
3. Enable fish to be tagged for life and provide data over many years
4. Are proven to be suitable for fish greater than 60 mm (and offer smaller tag sizes that may prove to be suitable for smaller species)
5. Are relatively inexpensive when compared against the cost of sending a research team into the field

6. Use tags that have a low capital cost (<$AUD5) vs other tag systems (~$US300 for radio or acoustic tags).

PIT reader systems generally have a moderate initial capital cost (depending on the complexity of the required system), but have low overall ongoing running costs. Properly installed and designed systems have little need for ongoing maintenance and researchers can receive data and diagnostic reports remotely (Castro-Santos et al. 1996). At other dam sites world-wide, PIT data is being used to advise daily operations in relation to upstream migration rates. For instance, Bonneville Dam on the Columbia River (USA) has an elaborate set of fish passes and PIT systems (Williams 2008). The PIT systems report daily fish movement rates, both upstream and downstream, to a cloud-based database. Scientists monitor, in real time, passage rates and species arrivals. The PIT systems also report entrance efficiency and percentage passage rates based on pre-calculated algorithms. When different species arrive, or passage rates change, the flow rates through the dam gates or fishway channel are changed to maximise efficiency. These are ways in which PIT data can be used to provide real-time feedback between fish movement efficiency and dam operations.

4.2.3 Suggested technology

The KarlTek 5000 is the only system on the market which uses a combination of auto-tuning technology, dual tag detection capabilities combined with custom software and seamless integration with a centralised database. It provides a complete system which can be tailored to almost any animal tracking program. KarlTek Pty Ltd (an Australian registered private company) custom-designs, assembles and installs all units to ensure the systems meet strict operational standards and maintain a high level of functionality. The systems' database (FishNet) is cloud-based and can be accessed from anywhere in the world, with data access restricted to designated users only, or shared with the greater research community. This means that fish movement data at Xayaburi Dam can be tracked from Australia, USA, Bangkok, Vientiane or on site by simply logging into a web-page. Ensuring a standard tagging system is installed at multiple sites will ensure that fish tagged in other parts of the LMB, can be detected anywhere and that the data collected is standardized.

4.2.4 Key aspects of a well-functioning PIT system

<u>Integrity:</u> This is the critical component of any system. A well-designed PIT system must have diagnostic capabilities and reporting mechanisms to inform the user when it is not working properly. It also needs to have a good set of checks and balances to ensure that it is working properly 24 hours a day, 365 days a year. A well-functioning system a) has a design that suits the research questions, and b) is always working effectively.

<u>Veracity:</u> It is essential that any data detected by the system and transmitted to the user represents a true and accurate account of animal movements at the study site. The entire system must faithfully process, archive and report only valid tag detection events. Prior to installing any system, a series of robust quality assurance procedures must be in place to ensure mark/release/recovery data and interrogation data are checked. PIT data comprises two important components: (1) the detection data, which is the transmitted data from an antenna in the field; and (2) the contributed data, which is the data pertaining to tagging events.

<u>Reliability:</u> This is where system design, tag selection and equipment are important. A system must detect any tagged animal, and do it accurately. All tag numbers therefore must be unique. Repeat tag numbers will corrupt the data and the only way to ensure unique numbers is to use only ISO 11784/5 & ICAR compliant tags from reputable providers. A system that checks diagnostics frequently is essential to ensure all detectors are scanning for fish. Thus, there is a need for a system to be able to compare the performance of one detector against another; and have redundancy to ensure efficiency.

In addition, procedures for handling and tagging fish need to be established to a high standard to ensure tags are not being shed (i.e. falling out of the fish) and that fish survive the tagging process.

Availability and access to data: There is no point amassing terabytes of data if no one can access or interpret these data when needed. Well-functioning PIT systems should send data from the field to the end user frequently. Ideally that data will be stored in a centralised database, accessible via a web page. A set of queries must also be developed that suit the end user and also their stakeholders. Data must be able to be accessed quickly, and be clean from errors. It is also useful to control who can see the data so a database with user level access is essential.

Consistency, context and documentation: PIT systems, when properly designed and installed, can operate indefinitely with minimal maintenance (Castro-Santos et al. 1996). They can transcend the life of the average biologist or manager, and data can be contributed and accessed by future generations. So how does a researcher/manager/dam operator 20 years from now understand why an antenna was put in a specific position or why certain fish were tagged? It is essential that this type of context is captured into the functionality of any system, so that the decisions made today can be understood many years from now. Capturing this metadata is important so that the context of any data can be correctly interpreted now and into the future by other managers and scientists not familiar with your program or methods. Documentation of project objectives, protocols, detection activities and tagging data need to be captured in both an operational and environmental context.

4.2.5 Selection of fish tracking technologies relevant to Xayaburi Dam

Xayaburi Power Company have a range of *conditions* included in the 30 year concession agreement with the Lao government. These include ensuring that the dam project has not affected fish communities, that local communities and villagers are not impacted, that there is no net impact on river hydrology or sediment transport and that, in general, the dam is contributing more good than harm. XPCL need to demonstrate through their research and monitoring program that each of these goals are being achieved. The company has established an environmental monitoring team which has been charged with establishing work programs to address these issues. The team, recognizing a deficiency in specific upstream fish passage monitoring skills, commenced dialogue with Charles Sturt University, and KarlTek Pty Ltd, to specifically implement a biological monitoring program to contribute to the specific requirements to demonstrate fish are moving upstream.

PIT tags were determined to be a suitable technology upon which to base initial trials for upstream migration studies. This decision was based on the fact that (a) PIT tagging has been trialed elsewhere successfully (Castro-Santos et al. 1996, Baumgartner et al. 2010), (b) there are existing infrastructure (databases) which could be accessed, and (c) tagging has been piloted in the local context and shown to be reliable for Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). Importantly, the infrastructure also fell within the funding envelope for the developer (Xayaburi Power Company Limited). However, the Xayaburi facilities represent the largest fish-ladder, globally, that this technology would have been fitted to. Thus, there is a strong need to assess and validate system effectiveness prior to installation.

The first step is to refine and develop robust methods that can be applied at the dam site to answer the posed research questions (described in Section 2.3.2). Constructing a full-scale fish detection system at Xayaburi Dam would require a commitment to a sizable initial capital investment. As such, it is important to validate that the technology (in terms of both antennas and actual tagging of fish) will work prior to installation. Thus, we propose a staged approach to validate the technology which will involve testing both *in*

and *ex-situ*. Based on successes at other dam sites internationally (Castro-Santos et al. 1996, Baumgartner et al. 2010), PIT tagging has been identified as the most suitable technique. If the PIT antennas work reliably, they will provide a good opportunity to assess migration success once the left bank fish pass is in operation.

The work would be broken down into two standard components:

(1) Technical phase (18 months): There is the actual testing (offsite) and installation of PIT tag equipment at the Xayaburi Dam site. This involves a field validation of a suitable tagging technique to ensure usable data can be obtained. The work requires strong scientific design to ensure the methods are fit for purpose. Considering the scale of this site (in terms of size) it is necessary to validate the technology prior to implementation.

(2) Operational Implementation (18 months): Once the technical methodological details are validated and the system installed, the research focus will shift to an operational implementation phase. This is where the installed system will be deployed to determine overall success of the Xayaburi facilities, optimise the Xayaburi fishway's adjustable settings and integrate fish movement requirements into dam operation management.

4.2.6 Relevance to other mainstem dams

PIT tag systems have significant application to hydropower cascades. There are 11 dams planned for the Mekong mainstem and there is a requirement that all of them include fish passes. Developers will be responsible for overall fish pass design and construction. It is important to determine that, considering the potential impacts on livelihoods and biodiversity, these structures are well designed and pass the majority of fish. Thus, post-construction there will be a need to develop robust monitoring techniques to assess the success of (a) each individual structure, and (b) the cumulative success of all mainstem fish passes at sustaining the resource base. There are presently two more dams scheduled to commence construction within the next five years and a further two beyond that will commence within ten years. Thus, with Xayaburi facilities commencing operation in April 2019, there is an opportunity to learn from this investment and influence future fish pass design. Furthermore, the MRC are presently preparing a "high dam" fish passage guidance document, which will include standard practices for monitoring. The MRC are keen to learn from the Xayaburi experience to ensure best-practice construction techniques and scientific methods are applied to all projects.

PIT systems have a demonstrated ability to contribute substantially to R&D programs for hydropower (and irrigation) cascades. The largest-scale PIT system exists on the Columbia River (USA) (Williams 2008). More than 20 mainstem dams have been constructed on this river and most have a fish pass installed. The sites with fish passes have been integrated into the PIT TAG Information System (PTAGIS) framework. PTAGIS is a large, spatially integrated upstream fish migration monitoring system. All PIT tag systems within fishways are linked to a large cloud-based database. Information on PIT tagged fish are uploaded (several times a minute) into the database. There are large scale tagging programs underway across the Columbia River catchment. Agencies upload tagging data into the database regularly so that tag events (when a tag is inserted into a fish) can be linked to fish pass detections (when a fish is 'pinged' within a fish pass). The hydropower dam operators have access to this data and regularly analyse fish movements and modify dam operations to maximize fishway efficiency during times of peak fish movement (Downing et al. 2001, Williams 2008).

Similarly, an analogous system was installed along the Murray River (Australia). There were 14 mainstem irrigation weirs along the Murray River. Each was blocking fish migration and between 2002 and 2012 the Australian government invested $77M in fish pass installation. A key part of the construction program was installing PIT reader systems within each completed fish pass (Barrett and Mallen-Cooper 2006). Again, the reasoning was that operations at each site could be optimized to maximize fish movements on a seasonal basis. The PIT systems also allowed for an assessment of the cumulative

benefits of fish pass installation in a transboundary system (i.e. South Australia, Victoria and New South Wales) (Barrett and Mallen-Cooper 2006). The technology (developed by Australian company KarlTek Pty Ltd) has now operated without fault for over 8 years and is monitoring the repeat movements of over 40,000 tagged fish. The system is analogous to that based on PTAGIS (See https://www.ptagis.org/). With two such systems operating successfully in cascade rivers internationally, and with a cascade proposed for the LMB, it is appropriate that PIT systems be considered for larger-scale uptake. Xayaburi Dam, being the first in the cascade, has the opportunity to set the standard for design and monitoring. Anything successfully implemented and demonstrated to work at Xayaburi has a high likelihood of being adopted at other sites.

4.2.7 Research component 1: Optimising antenna design

Rationale

For a PIT detection system to assess fishway success, the primary component is a functioning antenna. The antenna is usually placed into an area of migration constriction (such as a fishway slot or baffle) where fish are known to pass. The antenna must be constructed as a 'loop' that the tagged fish must swim through. It is important that the antenna can detect fish with greater than 95% efficiency (K. Pomorin pers. comm.). PIT tag antennas are limited largely by physics. The antenna generates an electric field. This field charges the tag which emits a signal that is transmitted to the antenna. Traditionally, PIT systems are installed into fishway 'slots' to assess fish as they pass through. In most fishways, the slots are limited in width — usually to around 30 cm, which is well within the technological limitations. But the size of the slots at Xayaburi are of unprecedented width for fishways. Indeed, the fishway slots are extra-large (up to 1.5 m wide) in order to pass large fish and biomasses on the Mekong River at this site. Whilst PIT systems are extremely effective at detecting fish moving through fishways, they are limited by the range of the detecting device (antenna) — in terms of both width and height — required to provide an optimal tag detection range.

Research activities

The broad aim of this component is to validate the optimal size of large antennas needed for installation at Xayaburi to minimise dead zones and maximise fish detection.

Stage 1: Conceptualize fish movement at the site and refine research questions. The team have identified research questions that could be answered using a PIT system installed into the slots (of various widths) located along the length of the fish passage (Table 1). Proposing the questions in this manner provides detailed information on the behaviour of fish as they progress through the various components of the fishpass system. As such, it would enable the percentage of fish passing to be calculated, and thus assist in reporting back to the Lao government. However, the ability to answer each question, and calculate the percentage, will be contingent on whether antennas can be designed to meet the logistical constraints on site. Each location in the fishway has different dimensions, and validating the effectiveness of antennas for each is necessary.

Stage 2: Obtain detailed engineering drawings. The team have already worked with XPCL to obtain relevant engineering drawings and investigate potential antenna placement locations (Figure 2; Table 1). A preliminary design workshop was held and draft antenna locations have been scoped to identify optimal design configurations.

Stage 3: **Construct prototype antennas and set up 'in the dry'.** KarlTek Pty Ltd will be formally engaged by XPCL and will work in collaboration with Charles Sturt University scientists to construct and assess the efficiency of antennas based on five options (each relevant to the research questions; Figure 2). The antennas, as indicated in the options diagrams over page, will be constructed. The efficiency tests will be performed scientifically. Antennas will be tested for a range of width's and length's and two tag sizes will be assessed (23 mm tag and 12mm tag). The 12 mm tag is preferable as it is much smaller and produces a lower "tag burden" on fish. However, it has a smaller read-range

than the 23mm tag. Determining if 12 mm tags will perform efficiently with large antennas is essential. The approach will be to construct and establish each antenna, take five tag readings (each of a 12 mm and 23 mm tag) and record the read distances (in cm). These readings will be plotted to provide an efficiency map for each antenna morphology. This approach is considered world-standard for antenna efficiency tests.

Figure 2. Slots where antennas are proposed to be installed and possible configurations.

Stage 4: For all antennas which pass the efficiency tests, actual antennas are then proposed to be installed on site at Xayaburi. Assuming all antennas pass the *ex situ* test in stage four in terms of percent number of tagged fish detected (See Table 3 for list of fish passage criteria to be assessed), we would aim to install: (a) one at the entrance directly in to the fishpass, and (b) a series of four antennas at one set of four slots in the fishway. The efficiency tests would then be re-run (this is essential to account for potential interference at the site, which could stem from the generators, pumps, rebar in the concrete, etc., and subsequently influence the tag read range). The success of these *in situ* tests will then advise the locations where fixed antennas should be located.

Additionally, and based on *ex situ* testing, it could be considered to install, at a bare minimum; one antenna at the entrance and exit of the fish pass, and, if a solution can be found one at the final exit to the overall fishpass at the headpond.

Stage 5: The optimal designs scoped in Stage 3 and 4, if successful, will be used to install permanent antennas in the relevant locations prior to watering the fishway. Here we will initially focus on the entrance and exit locations of the fishway. A 'bank' of antennas will be fitted to the entrance slots; a second 'bank' will be fitted to the exit slots.

Stage 6: Install reader systems and link them to a cloud-based database. All locations for antennas will be defined by the research questions which are posed. The entire system will need to be fit-for purpose and large scale tagging can commence in the river.

4.2.8 Research component 2: Tag technique validation studies

Rationale

Once a suitable antenna design has been determined and installed, the next, equally important component is to determine whether the tagging process either (a) has a high degree of shedding, or (b) alters normal fish behaviour. Neither of these is desirable

because tag shedding will lead to lost data and behavioural alterations will reduce data veracity. A key benefit of PIT tags is that the do not contain a battery. The tag itself is charged by the electromagnetic field from the antenna. So, a fish can technically be tagged and contribute information over its entire life. Such a situation is highly desirable in a river system which is about to have a cascade of mainstem dams with fish passes installed. It means that any tagged fish could be tracked for thousands of kilometres, over many years, and provide information on the operation of many different fishways. But for a fish to do so, it must retain the tag.

Internationally, it has been shown that some species have high tag shedding rates and/or mortality post tagging (some species are more robust than others) (Thorstad et al. 2013). Considering tagging is a significant investment, and many Mekong species have never been tagged before (this project will be the first large-scale tagging project ever attempted in the Mekong), there is a need to validate tag retention and mortality for the key target species.

Research activities

The broad aim of this component is to refine the tagging process to ensure that maximum data can be obtained from a PIT tagging study. PIT tagging is tolerated by many species worldwide and has already been demonstrated to work for two Mekong species (Grieve *et al*, 2018). But there are over 300 migratory species at the Xayaburi site and at least 26 are considered to be of key importance. To gain assurance that PIT tags can generate useful data, the tagging technique needs to be refined.

Stage 1: Two previous fish studies have been conducted at the site. The first, by “Team Consulting”, and the second by “FishTek”. These studies firstly, quantified the species present on site and, secondly, determined the swimming ability of these species to inform fishway design. These data, along with information from the community consultations as to which species are important food sources, was used to generate a shortlist of potential priority species for fish passage. (Table 2). The fish pass infrastructure was designed specifically to accommodate these species. What is unknown is whether these species are optimal candidates for PIT tagging. It is proposed, to test the efficacy of PIT tagging for each species under laboratory conditions.

Stage 2: Construct a fish hatchery facility to house the wild caught fish. Part of the Xayaburi cash contribution to the project is a fish hatchery to act as a research facility for tag retention trials. The facility will be capable of holding 5 species at a time. CSU and XPCL staff have scoped facility design and construction is due for completion in June 2019 (Figure 3).

Stage 3. Fish will be sourced from the Mekong River, on a seasonal basis, and placed into the fish hatchery. A series of replicated experiments will take place to determine tag retention and any tagging-induced mortality. Initial ACIAR-funded work has indicated that the “gut” is the best tagging location for some Mekong species (Grieve et al. 2018a, Grieve et al. 2018b). So the team will focus on gut tagging and test two tag types (12 mm glass Biomark tag and 23 mm glass Biomark tags). The rationale for testing two tag types is because larger tags have bigger read ranges but are not suitable for small fish (Grieve et al. 2018a). So there is a need to experimentally determine which species can accommodate a 23 mm tag. Twelve millimetre tags do not have large read ranges and are suited to small fish. Determining the smallest fish that can accommodate a 12 mm tag is equally important. The tag trials will be replicated across the expected list of Mekong species and 20 individuals will be used per species. For each species, tag retention and mortality will be assessed for 50 days (Grieve et al. 2018a). However, the species are highly seasonal (Table 2), so it is likely that it will take 12–18 months to complete all trials.

Stage 4. All fish that survive the tag retention trials will be released to the river and essentially become the batch of tagged fish to inform on fishway operation.

Stage 5. All work will be published in high impact journals and also reported within the project team and outside to relevant organisations.

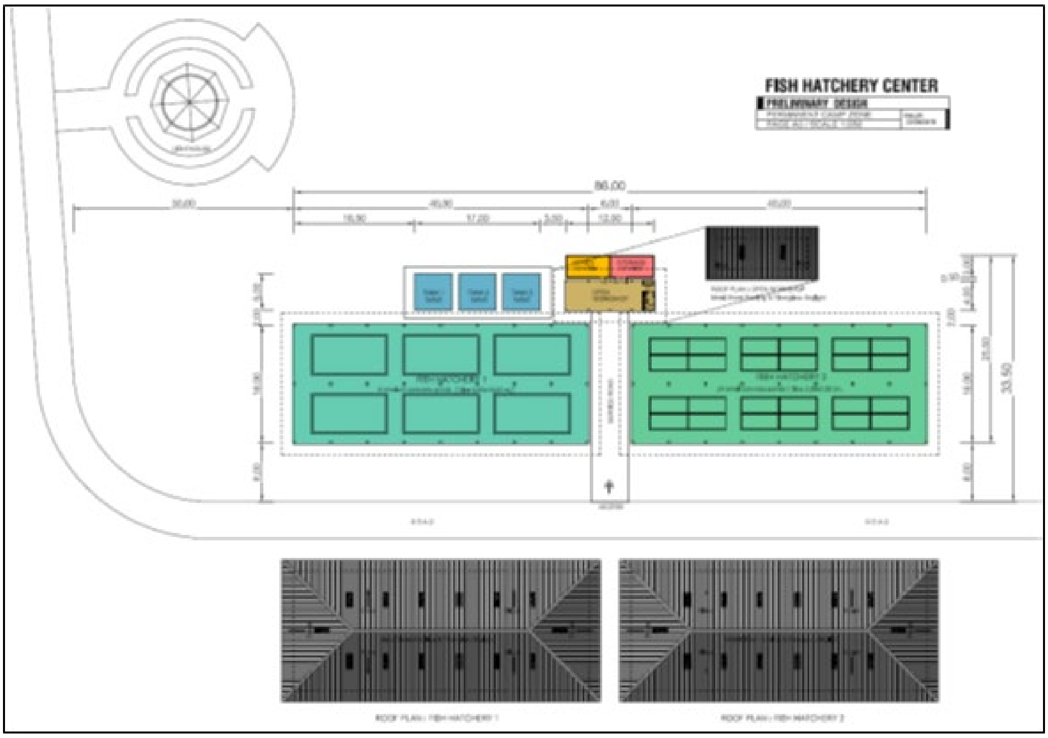
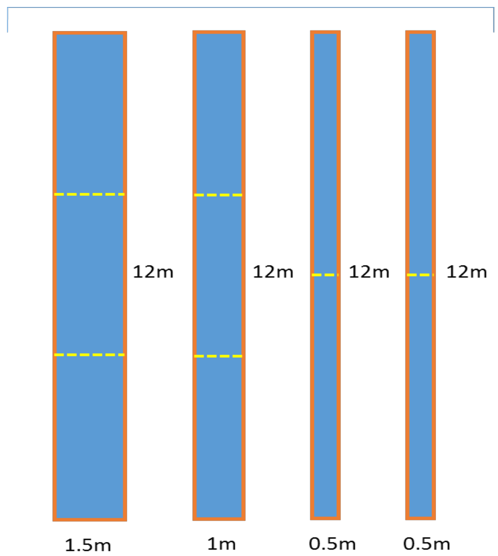


Figure 3. Design of the Xayaburi hatchery and fish holding facility proposed for construction to support activities of this project.

Table 1. Antenna configurations to be tested as part of the Xayaburi Dam project.

Antenna design	Diagram
Maximum predicted number of antennas for each width of fish slot in the fish passage: three antennas for the wider slots (1.5 and 1m), and two for the two narrower slots (0.5 m). antenna fitted into the 12m high fish slots. Number of slots to be fitted = 8.	

4.2.9 Research component 3: Develop electrofishing as a research method in Lao PDR

Rationale

Once an antenna design has been determined, then a tagging technique optimised, the final stage is to develop a fish collection technique which allows fish to be captured for tagging trials with minimal harm. Traditionally, fish collections at the Xayaburi site have been done via gill netting. However, gill netting is a harsh technique that can cause stress and, in extreme cases, impact survival. Tagging a fish that has a reduced chance of survival runs the risk of compromising the effectiveness of a tagging program.

In both Australia and the USA, electrofishing is commonly applied to tagging programs as a mechanism to collect fish (Sigourney et al. 2005). It is safe, fish recover quickly and there is potential to collect many fish in a short period of time. Electrofishing has not been used before in the Lower Mekong Basin; and is presently a banned technology under government legislation. The team has negotiated a 'research exemption' from the Lao government to use the equipment exclusively at the Xayaburi site. XPCL has provided all funds to purchase the vessel and will allocate contractors to fit out the vessel. This was on the basis that CSU can guide operation and train Lao government, University and XPCL staff in its safe and efficient use.

Activities

Stage 1: Procure an electrofishing vessel and commence training and capacity building (Figure 4). Electrofishing is by far the safest and most reliable way to collect fish (Bohlin et al. 1989). It works by putting a DC current into the water and is powered by an on-board petrol generator. Fish are stunned by the current and float to the surface. Boat crew then gently net the fish and place into a live-well. The fish recover, are anaesthetized and tagged. The entire process works well for fish, is very productive and allows fish to have a much greater chance of survival (Burkhardt and Gutreuter 1995). It is widely used in Australia, and Charles Sturt University will run the on-site training for XPCL and Lao fisheries staff.

Electrofishing is not just of value to collect fish for PIT tagging. It could also be used for acoustic tagging work and to conduct fish surveys upstream and downstream of the dam. It may not be able to efficiently collect fish in very deep sections of the river; therefore, combining its use with the collection of fish from local fishers would be worthwhile.

Stage 3. Optimise electrofishing settings. Electrofishing efficiency is best achieved when the conductivity of the target fish, matches that of the surrounding water. If the balance is achieved, fish are attracted to the boat and collected safely. For many Mekong species, electrofishing has not yet been trialled. So the optimal settings are unknown. There are two commonly applied approaches to electrofishing; the "grunt method" and the "power transfer" method.

For the "grunt" method, the boat is started and the voltage settings gradually raised until the generator is significantly working to input electricity into the water. It is the most commonly applied approach in Australia.

For the "power transfer method", the electrofisher settings are optimised to the water conductivity. "Power transfer theory" predicts that electrofishing will be optimised when the conductivity of the fish matches that of the water. As such, voltage and amperage settings can be optimised depending on the water conductivity in order to match, as closely as possible, the target species.

For this research component, we will compare the "grunt" and "power transfer" fishing methods. We will need to firstly determine the "conductivity" of the target species. This is achieved by using a multimeter to measure the conductivity of target fish. Then we will

manipulate the voltage settings of the electrofishing unit (between 0–1,000 DC) and frequency (pulses per second) that most efficiently transfers power from the boat to the fish. A series of replicated trials, using different combinations of settings (100V, 250V, 500V 750V and 1,000V) and duty cycles (10pps, 20pps, 30pps, 60pps and 120pps) will be undertaken to determine the most efficient settings for expected conductivity in the Lower Mekong. For each electrofishing “shot” all species will be collected, measured and weighed. Statistical analyses will be performed to determine if any differences exist between the two methods.

Stage 4. A power transfer table will be completed for Lower Mekong species to determine the best combination of settings which safely collect fish. A guideline document will then be prepared for both XPCL and the Lao government to demonstrate the benefits of electrofishing. The results will also be discussed with the Mekong River Commission for inclusion into the Mekong River Commission Design Guidelines for Mainstem Dams.

Stage 5. The technology will then be used, at the dam site, to seasonally collect migratory fish for use within future tagging programs. Work will be published in a combination of Lower Mekong media and international journals for purposes of dissemination.

Figure 4. A large water electrofishing vessel in action. Electrofishing vessels work best when water has conductivity levels within an optimal range (usually 50–1000 micro siemens).

Table 2. List of migratory adult species found at the Xayaburi site which will be used in the tag retention trials. This list encompasses the most important species identified by both XPCL and the Lao government. Green indicates the upstream migration season and yellow the downstream migration season. Imp column indicates the primary importance of the species whether for food, conservation or income.

Species	Imp	Local name	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Cyclocheilichthys enoplos	F	Pa Joke												
Cyclocheilichthys repasson	F	Pa Joke-sai												
Henicorhynchus lobatus	F	Pa Sroi												
Labeo chrysophekadion	F, I	Pa Pia												
Hemibagrus nemurus	F, C, I	Pa Kod												
Mekongina erythospila	F	Pa Sa-ee												
Sikukia gudgeri	F	Pa Mang												
Chitala sp.	F, I	Pa Tong												
Pangasius macronema	F, C, I	Pa Yorn												
Hemisilurus mekongensis	F, C, I	Pa Dangdaeng												
Phalacronotus apogon	F, I	Pa Sa-ngua												
Bagarius suchus	F, I	Pa Khae												
Paralaubuca typus	F	Pa Teab												
Tenulosa thibaudeaui	F	Pa Mak-pang												
Pangasianodon hypophthalmus	F, C, I	Pa Sway												
Cyprinus carpio carpio	F, I	Pa Nai												
Yasuhikotia modesta	C	Pa Kiaw-Gai												
Macrochirichthys macrochirus	F	Pa Fak-pa												
Pristolepis fasciata	F, C	Pa Chang-yeab												
Pangasius bocourti	F, C, I	Pa Phor												
Pangasius conchophilus	F, C, I	Pa Mong												
Pangasius larnaudii	F, C, I	Pa Thay-po												
Phalacronnotus bleekeri	F, C, I	Pa Sa-ngua												
Wallago attu	F, C, I	Pa Kaow												
Hemibagrus filamentus	F, C, I	Pa Kod-rueng												
Pangasianodon gigas	C	Pa Buek												

4.2.10 Research component 4: Measuring upstream fish passage success

Rationale

The steps leading to this stage represent (1) antenna optimisation; (2) tag technique validation; and (3) fish collection. These steps are important because the Xayaburi Dam site is internationally significant. Indeed, there is significant interest in the outcomes, and the methods will be highly scrutinised. It is essential that each of these elements has a strong, robust and tested scientific basis. A biostatistician experienced in the Australian hydroelectric research field will be consulted at the project initiation stage to review the methods for each step to ensure that they are statistically robust. The team (and biometrician) have extensive experience in these techniques from an Australian context. PIT tag data on over 40,000 fish has been extensively analysed from an existing system in the Murray-Darling Basin (KarlTek 2018, unpublished report). In this study the project team were to use PIT data to report on the success of a large-scale fish passage program. This required the development of analytical algorithms, data presentation techniques and sample size calculations which are all being applied to the work at Xayaburi. So the team are starting from a strong knowledge and experience base.

For application at Xayaburi there is a defined chronological sequence that needs to be completed in order to arrive at this research component. For example, the antennas must be installed, then it will be possible to use the PIT system to determine the overall efficiency of the fish pass. The tag validation trials must have been completed, and we must be able to collect sufficient sample sizes of fish. Some of this is seasonal and some will vary annually. So the proposed species list will need to be revised on an opportunistic basis.

Once all stages are completed, and if the PIT tag system reveals that the fish pass is demonstrated to be sub-optimal (for one or more species), then the dam constructors have incorporated a series of 70 different moveable gates which can be configured to alter fish pass flow in order to determine if improved passage has been achieved. So the project team will be able to adaptively alter the configuration of the fishway and determine if different settings alter passage rates.

It is important to emphasise here that optimal passage rates are difficult to set at this fish pass facility. Our approach will be to record the current rates, seek to understand where design points could be improved and manipulate the adjustable gates to optimise passage rates. So our aim is to achieve a change in percentage passage due to information from this project. A higher aim is to make recommendations to future designs based on an understanding of where design features hindered fish passage.

Activities

Stage 1: Large-scale tagging will be undertaken to ensure that a good population of tagged fish exists prior to operation (using methods developed in research component 2). Using the electrofishing vessel, it is proposed to capture fish downstream of the Xayaburi Dam structure as they approach the dam. The team is striving to tag approximately 20,000 fish annually (1,000 fish per target species). These numbers are consistent with international studies (Sandford and Smith 2002) and assume roughly a 10–20% return rate; we can make good inferences on passage success rates, with good statistical power, if we detect more than 100 fish per species annually. Because, inevitably, some fish will shed tags, there will be a need to re-tag fish in every year to maintain a sufficient sized pool of tagged fish.

Stage 2: Ensure that the cloud-based database (FishNet) is configured and that the on-site readers are providing daily data uploads. Subject to XPCL approval, a series of Xayaburi-specific queries will be developed to allow rapid data extraction into a format suitable for XPCL dam operators.

Stage 3. Monitor fish movements through the fish pass based on expected seasonal occurrences. Data will be extracted from the database and several performance indicators will be monitored. The main metrics will include:

% success: This is a simple algorithm to calculate the percentage of fish which enter the fishway (antenna located at the entrance) with those that successfully ascend (fish detected at the exit antennas). The output is % successful ascents per species.

Mean ascent time: A critical factor associated with success is the time it takes to ascend a fishway. The Xayaburi facilities are over 500 m long, which is a long distance for a fish to apply a sustained swimming performance. The output is mean ascent times will be calculated for all ascending species.

Total successful ascents: For all species, a complete tally of all individual fish (and the size at which they were tagged will be plotted) per species.

Unsuccessful ascents: These are fish which enter the fishway but never make it to the exit (plotted per species).

Seasonal movements: XPCL are interested in adjusting dam operations on a seasonal basis to accommodate fish movements where needed. Seasonal fish movement patterns will be explored and reported.

Flow relationships: Fish movements will be correlated with flow releases from the dam to determine if there are flow-related patterns that could be influenced by dam operations.

Repeat movements: Xayaburi Dam includes an elaborate downstream passage detection system. Fish which are detected moving through the fishway, successfully ascending, and then again at the entrance will be indicative of downstream movements. A specific database query will be developed to detect these movements.

Each of these metrics will be analysed against different criteria such as river flow, season, power generation rates, rainfall to identify patterns of peak fish migration. These will then be used to develop operational protocols to ensure the fish pass is operating at maximum efficiency.

Stage 4: Continue to tag fish on an annual basis so that fishway operation can be linked to dam operations, optimization of fishpass operation and XPCL fish passage efficiency reporting requirements back to the government of Lao. The team will calculate how many fish need to be tagged each year to ensure enough tags are present to answer broader scientific questions on fish passage success with sufficient statistical power.

Stage 5: Publication, reporting and reporting to other developers and the MRC.

4.3 Activities and outputs/milestones

The project team is aligning with a significant infrastructure project which is following defined chronological timeframes. Furthermore, the objectives frameworks established for this project have a defined dependency. Thus, objectives need to be completed in chronological order for the next one to proceed. For instance, first antennas need to be optimised, then tag retention trials need to be completed, then a safe collection method for fish needs to be determined, then fish need to be tagged in the wild, and then the fishway can be assessed. Whilst there is some flexibility around the ordering of these items, there is a clear temporal hierarchy to be followed. Simply commencing tagging in the river without due consideration for the impacts on fish welfare could result in a loss of data. Similarly, without understanding the optimal dimensions for antenna construction, sub-optimal detection systems may be installed. With these factors in mind, the project activities and milestones are presented here in a chronological order (by year, rather than listed by objective). The strategic links to project objectives are included in the table to comply with project development requirements.

Year 1 (Sep 2019 – Aug 2020)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Approvals to commence	MOU's and agreements exchanged Panel membership confirmed with Communication and Publication Plan discussed Terms of Reference endorsed	Commencement	Salaries and travel secured for Australian partners	Establish the project team
1.2	Antenna systems installed (commenced during SRA)	Meeting minutes and agreed workplan Site selection finalised Monitoring systems conceptualised	Within three months	All drawings obtained. Antenna specs developed Funds transferred to KarlTek	Antenna specifications from SRA are applied to the dam site Functional system installed Linked to cloud-based database
1.3	Conclude antenna design experiments (commenced during SRA)	Ensure that all antennas on site are operating optimally	Within six months	Approvals for travel obtained Conditions suitable for Australian research Access to Australian research sites negotiated	Training on PIT tagging and electrofishing XPCL/Lao staff assist with experiments on antennas
1.4	~~Conclude~~ Continue tag retention trials (commenced during SRA)	Design document completed and species selected	Within nine months	GoL and XPCL agree on species list Equipment can be purchased and established on site	Final layout known and construction plans can be finalised

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site
1.6	Project steering committee meeting	Hold team meeting on site	Nov 2019	All milestones are met	Project progress is on track
1.7	Construct electrofishing boat	XPCL purchase and build boat under guidance of CSU staff	Within first year	Assume that river conductivity suits electrofishing	Ability to procure fish in a safe manner XPCL/Lao staff trained in electrofishing
1.8	Training in PIT tagging and safe fish husbandry	Perform training of XPCL, NUOL and LARReC staff in fish tagging	Aug 2020 (but ongoing in each year)	Covid has provided significant travel restrictions. The team has performed some on-site training. But whilst restrictions are in place, the team will need to work with a videographer to develop a series of instructional videos Assumes that remote training will be effective To minimise risk, training will continue under the instruction of Dr Wayne Robinson (whilst he is based in Laos)	Instructional videos which can be used for others who wish to perform tagging after the project has concluded A series of best practice manuals for XPCL staff which can act as reference guides

Year 2 (Sep 2020 – Aug 2021)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Annual reporting	Annual reporting to DFAT	March 2021	All milestones are met	Project progress is on track
2.2	Organise a reference panel discussion about technical aspects (this may be virtual depending on Covid-restrictions)	Meeting on site	Nov 2020	Funding is available to attend	Discuss the technical aspects of the project design with independent international scientists
2.3	Refine cloud-based database	New queries specific to Xayaburi added	Oct 2020 (ongoing)	XPCL approve expenditure All antennas are working and the system is robust	Data can be cloud accessed anywhere in world
2.4	Monitoring and evaluation program initiated	Large-scale tagging activity	All year based on seasonal fish movement Field trips led by NUOL and LARReC during Covid travel restrictions	Weather permits commencement All equipment installed and functioning XPCL approve purchase of tags	Monitoring of animals in relation to hydropower operations becomes possible Preliminary analysis of movement data and correlation to dam operations
2.5	Update other groups	Liaise with MRC and other interested groups where work overalps	Opportunistically	Other groups are keen to engage XPCL happy to discuss outcomes with MRC and other developers	Include tagging in design of other dam projects Commence dialogue with other developers in terms of applying outputs to their site

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.7	Project steering committee meeting (May need to be delayed depending on Covid-19)	Hold team meeting on site	Nov 2020 Or pushed into early 2021 if travel restrictions continue	All milestones are met	Project progress is on track

Year 3 (Sep 2021 – Aug 2022)

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Monitoring and evaluation continues	XPCL now regularly reporting to GoL without assistance from international fish team	Jul–Dec 2021	Weather permits commencement All equipment installed and functioning	Monitoring of animals in relation to hydropower operations becomes possible
3.2	Scientific papers produced	International Fish team produce scientific papers	Jul–Dec 2021	Data is publishable	International recognition of work
3.3	Hold annual meeting Annual reporting	Fish scientist team meet on site Steering committee meet on site	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.4	Hold stakeholder workshop and final project review	Fish scientist team meet in Vientiane with other interested parties as agreed by the project team	May 2022	Project has progressed to this stage All tasks on track	Project on track and annual report accepted
3.5	Regular reporting	The team assist XPCL with preparation of formal reporting	Aug 2022	Report meets government and industry needs Enough data has been collected	Research is relevant and fit for purpose Industry relevance demonstrated

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.6	Final reporting and project review meeting	Project final review meeting Final report to DFAT/ACIAR completed	~~Aug 2022~~ Dec 2022	All work has been completed as expected	Conclusion of project requirements, dissemination of outputs

4.4 Crosscutting activities, methods and outputs

4.4.1 Communication

Dissemination to interested parties

There are four main target audiences: Xayaburi Power Company Limited, other developers and the Mekong River Commission and community beneficiaries.

Xayaburi Power Company is the main beneficiary. Concession agreement terms require reporting on fish pass success. It is important that such messaging is based on robust science. Thus, the ability for XPCL to continue to meet concession conditions and profit from power generation is contingent on a successful and functioning fishway for upstream migrants.

Other developers: There are at least two other mainstem dams which have been scoped and have entered the prior notification / prior consultation period. These include Pak Beng and Pak Lai. Both dams must include fish pass facilities. These facilities must have equal, or better, functionality than those at Xayaburi. We have an opportunity here to develop standard methods that could be applied at other sites.

The Mekong River Commission (MRC) is a very important stakeholder in the context of broader hydropower development. It is governed by the 1995 *Mekong Agreement* and this requires it to play a role coordinating the transboundary impacts of river development. A major current focus of the MRC is to re-draft the “Mainstem Dam Hydropower Guidance” document. This is a resource tool which sets the minimum standards for hydropower planning in the Lower Mekong Basin and is also associated with a “Joint Environmental Monitoring Initiative” (JEM). The latest draft of this document is considering the sizable effort that went into designing the Xayaburi fishway. It recognises that Xayaburi Dam, being the first fish pass, is setting the standard for all other dams. The Xayaburi design must be matched or exceeded at future dam sites. There is some overlap between the JEM initiative and the proposed research plan. Where overlap exists, then is an opportunity to ensure that so that results can inform the environmental monitoring requirements and standards for future dams. We will also be the first to have trialled many of these technologies on the Mekong. So there is significant interest from the JEM team, where there is obvious mutual interests, to integrate their training of local staff with the technologies being implemented on site. Of prime importance is that the process of fish selection for testing considers the food security needs of impacted communities. The interests of community beneficiaries will be considered by inclusion of a civil society representative on the Advisory Panel.

Project extension and communication

Project extension and communication will be promoted to the extent agreed by project partners, and by the terms negotiated through the reference panel. There are two reasons for this. Firstly, there has been substantial negative press associated with Xayaburi Dam

and it is important research results are presented in a defendable manner. Secondly, there are commercially sensitive items being developed and installed. Australian company, KarlTek Pty Ltd, has patent rights to protect these items and is unwilling for the technical details of its product to enter the public domain during the research phase. XPCL also have commercial-in-confidence considerations. With these issues in mind, the project team has entered into a confidentiality arrangement where no public project messaging will be made without the approval of all parties. Thus, extension and outreach will need to be carefully managed throughout project implementation.

4.4.2 Capacity building

Partner countries

Fish passage technology and implementation, as pertaining to hydropower dams, will provide the capacity for National University of Laos, Living Aquatic Resources Research Centre and Xayaburi Power Company Limited to tackle fish migration challenges beyond the life of this project. XPCL has a 30 year concession period and will own and operate the dam for this time. So it is important that sufficient institutional capacity is developed so that the XPCL team can implement ongoing studies beyond the development and initial analysis phase. During the earlier projects, national and district fisheries staff without scientific training received personal instruction from our research staff. The challenge when entering the scale-out space is to ensure that these research skills (and outcomes/outputs) are translated outwards to policy makers, managers and donors.

Covid has created significant disruptions to international travel. The disruption has restricted access to the Xayaburi site and created additional administrative requirements to obtain permission to gain access. A reduced ability to visit site will place an increasing reliance on remote learning. The team as had discussions with Darren Grigg, a videographer from Grigg media, to develop a series of instructional videos. These will be developed and passed onto Lao-based staff as reference items. These will be important over the short (during Covid restrictions) and long term (if new staff enter the project team).

Australian team

Australian researchers will benefit from involvement in the project. The tropical rivers of South East Asia offer a far greater range of unique fisheries ecologies than any river system in Australia. Thus, Australian scientists have the opportunity to work with a diverse fish community (including a wider range of species and size classes than they normally experience). The project will also provide an opportunity to develop stronger collaborative links between Charles Sturt University and private industry in the Lower Mekong Basin by linking together the Xayaburi Project with future hydropower development activities.

Donor bodies and developers

The monitoring program is being developed on the assumption that (a) other hydropower dams will inevitably be constructed in the future; (b) they will include fish passes; and (c) there will be a need to monitor effectiveness. Thus, there is potential to link with the Mekong River Commission’s JEM initiative and extend the outcomes to other hydropower developers grappling with fish-related issues. Australian capacity impacts will be strengthened through the involvement of private industries which are specialists at dealing with fish migration issues. Impacts over a larger geographic scale will depend on donor body acceptance and investment, which would realistically be expected within 10 years (Category 2).

4.4.3 Monitoring and evaluation (project delivery evaluation)

Strategic monitoring and evaluation plan

The project's strategic monitoring and evaluation (M&E) will act as both a project design tool and guide outreach. To ensure that activities are reaching their output-outcomes, and to allow for real-time corrective actions, monitoring will be continuous, and evaluation cycles will be divided into short (quarterly), medium (yearly) and long-term cycles (mid and final).

Short-term cycles

The short-term cycle includes country-specific 'Action Plans', which take the activities and break them down into manageable sub-activities. Each Action Plan includes the main activities (from the logframe), sub-activities, timeline (in months/weeks), responsible person, and any comments. These annual plans are devised before each New Year, and assessed at the end. These Action Plans then inform Progress Reports.

Medium-term cycles

The yearly reports and a forum, will be held annually on site with the project oversight panel. In the dry season of each year a meeting will be held on site that will discuss activities for the previous year, and plan the next.

Long-term cycles

There is also a scheduled mid-term review which is an elaboration of the previous two years learnings. A final evaluation 6 months prior to the project end will take place which will include a facilitated lessons learned workshop, and a written final report.

4.4.4 Monitoring and evaluation (project-related impact evaluation)

There are a range of different factors that can be monitored to ensure the project is achieving measurable impacts. The links between project activities, project outputs and impact outcomes will be measured through a variety of 'success indicators' (Table 3). These will be monitored and reported against annually, but it is expected that, with regional buy-in, large scale impacts will accrue with time and may extend beyond the project funding envelope.

4.5 Research outcomes and impacts

Researchers in the collaborative team will benefit from training in large river survey techniques and PIT tagging techniques and mentoring from an Australian team which has over 50 years collective experience. Local communities and research teams will directly benefit through secured food security from their fish resources if the Xayaburi facilities are demonstrated to pass fish upstream. The international tropical river research and management community will benefit from improved monitoring techniques developed during this project to monitor upstream movements. The project will attempt the first detailed assessment of massive fish pass facilities which are the biggest ever attempted within a tropical river anywhere in the world. If successful, future dam projects will benefit from improved fish passage design and fish monitoring, and associated river communities will benefit from maintained food security through sustainable fisheries resources.

The project outcomes will include:

- The establishment of a partnership between the Australian government, university researchers, the Lao government and Xayaburi Power Company
- Validating a suite of research methods for integration into a long-term research program

- Implementing the first step needed to develop a standardised fish monitoring tool which could be applied across the Lower Mekong Basin
- Capacity building of Lao and Thai (XPCL employed) scientists into a suite of research methods
- Training of Lao and Thai scientists in Australia
- The first detailed attempt at significantly tagging fish in the Lower Mekong Basin
- Installation of detection systems within the Xayaburi fish pass

The project outputs will include:

- Publications in high-ranking journal; the team anticipates four in particular;
  (a) Factors influencing PIT antenna efficiency at high dam fishways
  (b) Tag retention and mortality in key Lower Mekong Basin species
  (c) Monitoring the effectiveness of fish migration facilities at large dams in tropical rivers
  (d) Optimising electrofishing for deployment in the Lower Mekong Basin
- A project final report
- Abstracts published in conference proceedings

Table 3. Success indicators linked to the long term outcomes expected to emanate from this project. ACIAR strategic plan outcomes summarises as (i) food security and poverty reduction; (ii) natural resources and climate); (iii) human health and nutrition; (iv) empowering women and girls; (v) value chains and private sector; and (vi) building capacity.

Expected outcome	Proposed activity/outputs	Link to impact outcome	Project success indicators relevant to ACIAR strategic plan
Robust methods developed and implemented at Xayaburi Dam	Validate tagging techniques Develop electrofishing guidelines Install PIT antenna system on site Link antenna system to cloud-based database	Targeted and relevant research Improved knowledge base Robust science informing decision making Ensure best available science is used	NUOL masters students enrolled/completed (vi) Manuscripts produced and citations (ii) Guidelines obtained and reviewed (vi; ii) Agencies consulted (vi)
Determining effectiveness of Xayaburi Dam facilities	Annual fish tagging Data analysis Linking fish movements to real-time dam operations	Mainstem dam passage rates quantified Australian-funded research is driving the hydropower development agenda Capacity building of local staff (XPCL, LARReC, NUOL) Improved environmental outcomes	% success of fish ascending (vi; iv; ii) Average time for fish to ascend (vi; iv; ii) % of tagged fish detected (vi; iv; ii) Number of fish tagged annually (ii; vi; iv) Fish pass operation integrated into dam operation (vi; iv)
Scale out of methods and fish pass design to other mainstem dams	Contribute to MRC guidelines development Engage with other dam developers Install PIT systems within fishways at other dam sites Other developers implement tagging programs Cascade-scale tagging undertaken	Guide development of applied research questions Lower Mekong countries better empowered to make development decisions Policy based on research outcomes Robust science is driving decision making	No. guidelines developed (ii; vi; v) No. new mainstem dams with functional fish ladders (ii) No. new tagging studies implemented using the developed methods (v) No. of Australian-patented PIT systems installed in the Mekong catchment (v)

4.6 Intellectual property and other regulatory compliance

See Section 7. Appendix A.

5 Impact Pathways – from research outputs to development impact

5.1.1 Lower Mekong impact context

The Xayaburi fish pass facilities are unprecedented in the tropical world. Such a level of design and investment is rarely applied to other sites. The fishway design process itself took over three years and incorporated developmental research combined with robust engineering. There is significant ‘expectation’ being placed upon this site, and the overall fish pass performance has implications at a site, national and international level. Site based impacts relate to achieving no changes in the fisheries resource base and ensuring local villagers and river communities are not impacted. National-scale government agencies, and other developers, are watching the Xayaburi site with interest. There was significant investment in the Xayaburi facilities and there are significant questions about how effective the systems are and if they should be considered the “gold standard’ to be applied at other sites. Internationally, this fits within transboundary fish management and hydropower development frameworks. Significant hydropower development is proposed for Thailand, Cambodia and Vietnam. Thus, the success of the Xayaburi facilities has a broader regional context in terms of future fish pass investment and the development of transboundary monitoring programs.

With these factors in mind, there are three proposed impacts from this project which require “research” to influence the broader regional hydropower “development”.

Firstly, we seek to create “impact” by developing robust scientific methods which have been tested in the local context and form the basis to be standardised and rolled out by other researchers into the future. International experiences have offered guidance on suggested approaches and techniques. There is no need to develop a new approach from scratch, but there is a pressing need to refine international approaches (largely developed in Australia and the USA) in a Lower Mekong Basin context.

Secondly, we will achieve impact at the dam site by influencing Xayaburi Dam’s day-to-day operations. Our research activities will enable operational impacts to occur. Once our PIT tagging system is established and operational it will monitor for fish 24/7 in real time. These data will be used to determine the total number of fish ascending, which species, the overall ascent times, migration seasonality and more specifically, compliance with the fishway design specifications.

Thirdly, we plan to influence the design and construction of other dams into the future (Figure 5).

Importantly, our team focusing on upstream migration only will limit the extend of applicability to other dams. It is important to note that, if the majority of fish are migrating upstream to recolonize habitat, or to spawn, it follows that these fish may need to move downstream at a later date to complete important life history stages. Focusing on upstream migration, at least initially, effectively mitigates a series of risks because our team is only focusing on one aspect initially. Thus, the political pressure to provide answers to all migration questions is significantly reduced by this focused scope.

5.1.2 Expected impacts – Lower Mekong Basin

Short term (tactical):

1) PIT tagging validated as a useful tool for the Lower Mekong Basin
2) Electrofishing confirmed as a safe fish collection technique (it is currently illegal in all Mekong countries)
3) Cloud-based repository for Lower Mekong tag data established
4) The “gold standard” Xayaburi fish pass design is assessed and validated
5) Improved capacity for National University of Laos, Living Aquatic Resources Research Centre, and Xayaburi Power Company staff to implement tagging programs.

Long term (strategic):

1) PIT tagging incorporated into the Mekong River Commission Design Guidelines for Mainstem Dams
2) PIT tag systems installed at other mainstem dam sites
3) Increased adoption of PIT technology over time
4) Increase in knowledge base and skill required to build effective mainstem fishways
5) Strengthened collaboration across several key South East Asian economies on a common issue.

5.1.3 Expected impacts – Australia

1) Improved linkages between Australian academics and South East Asia
2) Enhanced integration of Australian-developed and patented technology into major infrastructure projects across South East Asia
3) Improved publication rates of Australian researchers
4) Increased enrolment of Australia Award and JAF students at Charles Sturt University.

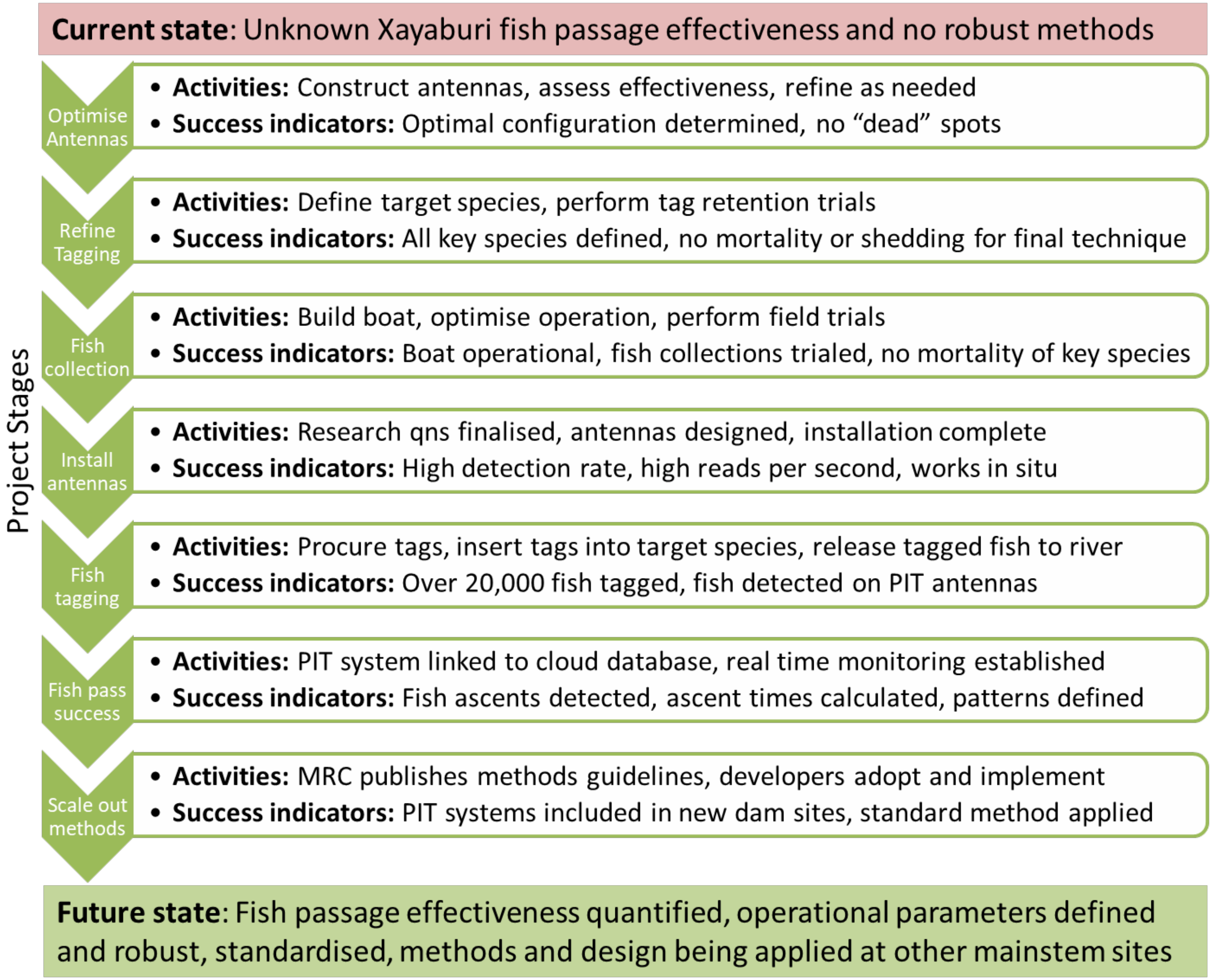


Figure 5. Proposed impact pathway demonstrating how the project will contribute new knowledge, taking us from a current state of 'unknowns' to a future state of "knowns" being applied to future projects.

5.2 Scientific impacts

Scientific impacts will be occur at two levels: (1) methods applied to the Xayaburi Dam project; and then (2) extension to other hydropower projects in the LMB and globally. It is important to note that the methods being developed will be applied in the LMB for the first time. Further, the implementation is occurring at the biggest fishway site in the world. Equipment such as transponder antennas, electrofishing vessels and microchipping have never been trialled on such a scale before. Therefore, the project will break new scientific ground, but we recognise that there are many assumptions and challenges that may lead to compromised data and outputs. To mitigate this risk, we have consulted with a biostatistician experienced in the Australian hydroelectric research field to advise on how to ensure statistically robust methods in the event of each possible failure point.

5.3 Capacity impacts

The need for this project primarily arose because the Xayaburi Fisheries Research Team were seeking advice from international experts who have expertise in fisheries monitoring upstream movement using novel techniques. Xayaburi Power Company strongly encouraged participation from Lao agencies so this provided the opportunity to build capacity at two levels.

5.3.1 Xayaburi Power Company

The organisation employs a small team of Thai fisheries scientists who are tasked with implementing research and monitoring on site. The team initially worked with a British company, FishTek, to perform fishway design research. XPCL are now entering a phase where determining fishway effectiveness is of paramount importance. To gain credibility for their research and monitoring program, establishing an international partnership was seen as a prudent way forward. The project team will primarily work with XPCL to build capacity in three key areas:

1. <u>PIT tagging</u>: To implement an effective tagging program it is essential that antennas detect fish, fish do not shed tags, and tagging does not influence mortality. Inefficiencies in any of these components lead to poor data quality. Therefore, a key aspect of capacity building is to train XPCL, and Lao, staff in antenna design principles. No antennas (of the size required at Xayaburi) have ever been constructed before in the world. So ensuring staff understand the principles of design and operation is crucial for long term monitoring. Further, staff have had no experience tagging fish. It is crucial that an effective method is developed as tagging will be the primary source of data to determine fishway effectiveness. If tagging influences fish welfare, then no fish will ascend the fishway. Therefore, the project team will establish robust tagging protocols and work to train XPCL staff to ensure best-practice methods are used. Finally, PIT systems can generate significant amounts of data, so it is important that XPCL, and Lao staff are trained in data mining and analysis so that, over the long term, they have significant capacity to generate data summaries and reporting. The team will work closely to ensure that all aspects of data management and future use are understood and implemented

2. <u>Electrofishing:</u> A commercial electrofishing research vessel has never been used before in the Lower Mekong Basin – but such vessels have been successfully used for several decades in the USA and Australia. Electrofishing is a very nuanced, and potentially dangerous, activity to implement correctly. The project team will focus on several aspects of electrofishing. Over the long term, operation and maintenance will be undertaken by XPCL (as they will own the vessel). The project team therefore aim to train, and develop operational guidelines, for XPCL operations staff who will be running the hydropower plant for the next 30 years over the concession period.

5.3.2 Educational institutions

A recurring discussion with universities in partner countries is that there is limited technical capacity to deliver courses. Lecturing staff are simply not trained in the subjects they are assigned to teach. This provides poor learning outcomes for graduates. This issue has largely arisen because academics have not been able to participate in international research efforts, which has slowed skills development and uptake. A secondary issue is that many education facilities in Lao PDR are unable to deliver PhD programs. Therefore, we will need to focus on educating masters students for a potential international PhD.

A key component of our approach is to partner with key higher education facilities (National University of Laos) to further develop the Masters program. Our project team members will then help build capacity (1) through support to design curriculums; (2) by holding targeted faculty masterclasses and implementing research projects; and (3) through the delivery of a new Graduate Certificate in Fisheries Ecology and Aquatic Engineering (Charles Sturt University). We also have conditional approval from XPCL and NUOL to host masters students on site and these will form important components of our project team.

5.3.3 Government departments

A flow-on effect from poor educational institution capacity is that graduates have a poor capacity to deal with fish passage issues. Subsequently all learning occurs in an employment context. If there is a poor educational foundation, little historical institutional capacity and no mentoring opportunities for graduates, this results in a self-defeating cycle. There is simply no ability for institutions to build capacity unless it is imported from outside over the short term and built through a steady stream of learned graduates over the longer term.

Our approach to deal with institutional capacity deficits will occur on two levels. The first will be short term and tactical, working to bring existing staff up to speed on the latest approaches and learnings on fish passage in a hands-on way. Staff will be trained both on-site and in Australia in the techniques and technologies we plan to implement. The second approach will be strategic, by focusing on the most promising graduates within educational facilities and providing international educational opportunities. We will explore and recruit suitable graduates to these programs if and where appropriate.

5.3.4 Developers and the MRC

Hydropower developers are funding and implementing a series of new dam projects as part of ongoing development plans in the region. Engaging with, and enhancing capacity, of other developers to include fish passage as part of regional hydropower programs is essential for large-scale uptake of such technology. We will manage this by participating in MRC dam guidance discussions and development where appropriate. An important platform for these discussions will be through the reference panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4 Community impacts

The science justifying fish passage implementation is sound (Williams 2008, Baumgartner et al. 2016). Yet, management agencies often consider that mitigating the environmental impacts of irrigation infrastructure is an unnecessary expense, and consequently many programs proceed without fish-related considerations. Such situations are exacerbated because, institutionally, irrigation and fisheries departments are separated. If agricultural production and fisheries yield are considered in a holistic manner, there is a substantial justification for fish passage outcomes being considered as an “impact investment”. That is, the costs of the initial capital outlay can be returned rapidly in highly productive systems. The research impact of this project is within the footprint of the Xayaburi Dam

site. We aim to implement the research and monitoring tools to enable XPCL to operate the fish pass and dam in a manner that maximises fisheries-related outcomes. If achieved and successful, the local community will benefit from accessing a resource that does not diminish.

The development impact of this project comes from participating in the broader discussions about hydropower development both in Lao PDR and among other Lower Mekong countries. If Xayaburi is setting the standard for fish pass design and construction, then it has a significant opportunity for future benchmarking. There is wide recognition that the facilities at Xayaburi must be matched or exceeded at future sites. This extends to both construction and research/monitoring. The project is being established in a manner that can influence these outcomes, particularly through the Advisory Panel that consists of representation of key stakeholders for dam planning, construction and policy.

5.4.1 Economic impacts

Commonly cited economic benefits of Lower Mekong mainstem dams include electricity for export, primarily to Thailand and Vietnam, and revenue for Lao PDR to develop the country and raise living standards (Commission 2010). The overall power output of the Xayaburi site is expected to be 1,285 Megawatts. The broad aim is that the $3.8B construction cost is rapidly returned and profits are realised. The XPCL will benefit from a rapid payback period of the capital outlay, and the Lao government will benefit through royalties generated from power sales. The investment in fish pass facilities (estimated at $300M) was necessary to obtain final approval for the project to proceed. Thus, extensive and elaborate fish pass engineering solutions were developed. Determining the success of the fish pass system is necessary to validate the economic argument.

The forecast profitability of Xayaburi is modest even assuming no impact on capture fisheries and the environment. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative economic impact, considering the capture fishery of the LMB is estimated to be worth $US17B per year (Nam et al. 2015). Thus, there is a call for a requirement that hydropower projects include full-cost accounting of social and environmental conservation mitigation measures in the committed capital investment. This project provides an important consideration in that context. If the Xayaburi fish passage facilities are demonstrated to meet the performance specifications set by the GoL, with minimal capture fisheries impact, then it provides substantial opportunities for broader hydropower development in the region. If the fish passage facilities are deemed to be sub-optimal, then research will need to focus on design aspects that require revision, and engineering designs at future mainstem dams will need to include those aspects. Thus, this project is highly visible from an economic perspective. The results emanating from this work could have substantial flow-on effects to other locations across the region, while recognising the immense technical challenges we face in realising these results.

5.4.2 Social impacts

It is expected that effective fishway construction on mainstem dams will ultimately maintain fisheries productivity, although many technical and operational challenges must be overcome before this is verified through the project. The local benefits to communities from this research are maintained food security and income for fishing families, and opportunities for equitable, diverse and inclusive participation of women and girls in decision-making (Siason et al. 2010, Baumgartner et al. 2016)

Local communities will directly benefit through unchanged access to fish for food and income if the Xayaburi facilities are demonstrated to work. Nonetheless, if the Xayaburi facilities are demonstrated to not work effectively, this research will be critical to informing XPCL’s business decisions about which aspects of the fish pass to target for maximising improvements to triple bottom line outcomes.

Inland capture fishery are largely regarded as a shared resource. In the Xayaburi region, many villages are located at varying distances from the fishway site; however, there is broad recognition within the community that the villages should benefit equally. Once the Xayaburi fish pass is constructed and operated, any fish that move upstream through the dam will become accessible to the upstream villages, thus creating an equitable access to the resource. However, there are likely to be considerable negative social impacts as there are numerous unknowns about the design and function of the fish passage infrastructure. A small percentage loss of capture fisheries caused by Xayaburi would result in a large, negative social impact, considering the reliance of the capture fishery of the LMB for food security and income (Nam et al. 2015). Apart from those adverse effects due to dam construction and forced relocation, is the likely overall reduction, to some extent, in fish passage compared to pre-dam conditions, leading to a reduced abundance and range of fish species accessible to fishers. The project is likely to indirectly improve social benefits by minimising this negative impact - through advice to XPCL on operational management to optimizing fish passage at the Xayaburi Dam, and more broadly to the GoL on standardised tools and protocols for fish tagging and monitoring, and improvements in fish passage design for future hydropower development.

Therefore, demonstrating fish passage functionality through robust research is very important for XPCL to maintain and improve social capital in the region. If fish are passing the site, the local communities will benefit.

5.5 Environmental impacts

The Xayaburi fish pass facilities were constructed to ensure fish are able to pass the dam. The overall aim is to demonstrate, through sound operation and integration into dam operations, fish pass effectiveness. The overall aim is to ensure fish communities upstream of the dam do not decline. The flow on effects to livelihoods and nutrition are being measured through the XPCL community program.

5.6 Policy impacts

The project will develop the tools, guidelines and in-country capacities required to include fisheries considerations in hydropower development in a more systematic manner. Hydropower investment programs, collectively worth billions of dollars in the region, coupled with increased awareness of the benefits of multi-functional ecosystems, provide the opportunity to apply considerable Australian expertise and technology to aquatic ecosystem management in the Southeast Asian region.

The project is innovative as it can blend both the best practice experience of Australia with development agendas. Policy impacts (short-term during project life) in the region can be measured by the ability to influence Mekong River Commission mainstem dam guidelines, ensuring new dams include functional fish passes, as well as adopt standard monitoring methods.

6 Project management

6.1 Management aspects

6.1.1 Project Reference Panel

The project will be led by Charles Sturt University, who will devolve funding and responsibilities to partners Living Aquatic Resources Research Centre, National University of Laos and KarlTek Pty Ltd as required. Xayaburi Power Company Limited will be

responsible for resourcing its own staff. The team will link with the MRC and other stakeholders through a Project Reference Panel, as described below.

Country-level consultation on the proposed research (November 2017) took place with three Lao government agencies (Ministry of Agriculture and Forestry, Ministry of Natural Resources and Environment and Ministry of Energy and Mines). The proposed research was also presented and discussed with the Mekong River Commission environmental team. Country consultation revealed high levels of support and interest for the proposed work. A recommendation from these consultations was to establish a Project Reference Panel consisting of the major stakeholders that would be regularly briefed and consulted regarding project progress and outcomes.

Under the contract terms of the first phase of research (the SRA), both DFAT and ACIAR also required the project to establish a reference panel to provide guidance and oversight to the project team. They stipulated the panel meet on an annual basis, at the dam site.

The Project Reference Panel will have advisory status, and consist of representative stakeholders from all cash/in-kind investors including Charles Sturt University, Department of Foreign Affairs and Trade, ACIAR, Xayaburi Power Company Limited plus representation of Lao nationals (Figure 2).

They will conduct their business in confidence which will be defined by a terms of reference will be established as the first agenda item at the project initiation phase. Their work may include advising communication and publication plans and developing agreed protocols on how various aspects of project findings are negotiated, resolved and communicated. A core role of the panel will be to manage stakeholder negotiations regarding the publication of results, recognising that some publicly-funded data must be openly available according to ACIAR’s contractual requirements, and also that that some IP will be required to remain commercial-in-confidence.

The XPCL has expressed a willingness to collaborate on publications that meet the interests of all parties, but understandably will have sensitivities on how the dam operation is portrayed in the public sphere. We need to respect that our research team are invited ‘guests’ on the project site. The XPCL team have been very accommodating in terms of making the facility available, sharing data and providing us with a unique global opportunity. They are also making a significant investment of their own funds into research infrastructure and support.

The data sharing and publication arrangements therefore need to be carefully considered and discussed and agreed to by all parties. It is envisaged that the reference panel will be a sounding board for these discussions. A draft membership has been proposed, but this will require negotiation with XPCL, ACIAR, CSU and DFAT should this proposal be approved.

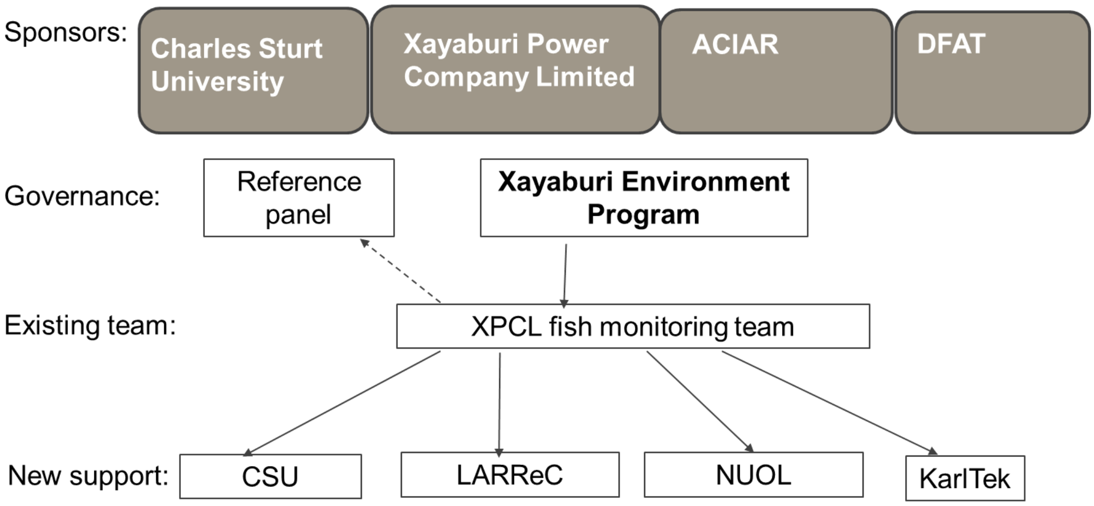


Figure 2. Proposed project governance arrangements. Project sponsors are those contributing resources. The team will integrate within existing governance arrangements.

6.1.2 Mid and final project review

Due to the political sensitivities of the work, it is likely that there will be intense scrutiny of the methodological work and research design of the project. These risks will be considered during the standard ACIAR "mid-project review" (after 18 months) and "end of project review" processes.

6.1.4 Internal project communication and management approaches and plans

The team has been active for some time and already established strong relationships (in Laos dating back over ten years). The team will communicate regularly using:

- Face to face meetings, on ground and in country visits and networking
- Internal information-sharing and communication strategy
- Bi-annual face to face planning workshops
- Work plans for each of the three pillars
- Regular work in progress meetings leveraging a full range of technology
- Document and distribute meeting minutes and action items
- Routine monitoring and status reporting of deliverables
- Development of instructional videos and manuals as reference items

6.1.3 Project coordination mechanisms and responsibilities

Project coordination will be largely undertaken by Dr Lee Baumgartner with support from the CSU research office and administrative staff within the Institute for Land, Water and Society, but he will work closely with Dr Michael Raeder from XPCL to ensure project activities are realistic and fit within XPCL expectations.

Jarrod McPherson will take the lead role on-ground in Lao PDR, where he was based for two years as an AVID volunteer and has an excellent grasp of local culture and law. Jarrod is a technical expert in his field and will lead on-site capacity building.

Finally, each agency will have a nominated "leader" who will coordinate activities and partnerships within the target country. These will be Dr Oudom Phonekhampheng (National University of Lao PDR) and Douangkham Singhanouvong (Living Aquatic Resources Research Centre). These officers will take local leadership to ensure the project team can effectively operate within local frameworks, including managing resourcing and project management.

6.2 List of participants involved in the project

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Oudom Phonekhampheng	M	National University of Laos	Vice President	Coordinator and Government rep	
Douangkham Singhanouvong	M	Living Aquatic Resources Research Centre	Deputy Director	Coordinator and Government rep	
Thonglom Phommavong	M	National University of Laos	Research Associate	Collaborating scientists	
Khampheng Homsombath	F	Living Aquatic Resources Research Centre	Director – Capture Fisheries	Collaborating Scientist	
Phousone Vorsane	M	National University of Laos	Research Associate	Field technical support	
Saleumphone Chantavong	M	Living Aquatic Resources Research Centre	Research Associate	Field technical support	
Karl Pomorin	M	KarlTek Pty Ltd	Managing Director	Collaborating Scientist	
Michael Raeder	M	Xayaburi Power	Owner Representative	Owner representative	
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Collaborating Scientist~~	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor	Project Leader	
John Dore	M	Department of Foreign Affairs and Trade	Manager – Water Resource Program	Collaborating Scientist	
Casual Staff	TBA	Charles Sturt University	TBA	Assistance with fieldwork or other project requirements	

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Wayne Robinson	M	Charles Sturt University	Research Fellow	Field and biometric support	
Lauren Withers	F	Australian Volunteers	Volunteer	Project support	
Garry Thorncraft	M	National University of Laos	Research Associate	Collaborating Scientist	
Thanasak Poomchaivej	M	Xayaburi Power Company	Environmental Monitoring	Project support	
Jarrod McPherson	M	Charles Sturt University	Research assistant	Field support and coordination	
Nathan Ning	M	Charles Sturt University	Scientist	Manuscript preparation and writing	
Chris Barlow	M	IP Matters	Director	High level support and writing	
Darren Grigg	M	Grigg Media	Videographer	To produce a series of instructional videos on PIT tagging and fish husbandry	

6.3 Proposed participants involved in reference panel (to be confirmed and agreed with XPCL, DFAT)

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Jody Swirepik	F	Department of the Environment and Energy (Australian Government)	Commonwealth Environmental Water Holder	Chair the project reference panel	
Elizabeth Pope	F	Snowy Hydro Limited	Environmental Manager	Reference panel member	
~~Jürgen Geist~~	~~M~~	~~Technical University of Munich~~	~~Chair of Aquatic Systems and Director of FITHydro initiative~~	~~Reference panel member~~	
Daniel Deng	M	Pacific Northwest National Laboratory	Principal Scientist	Reference panel member	
Michael Raeder	M	Xayaburi Power	Owner Representative	Reference panel member	
Lao citizen representative	F	Lao government or local community	Local	Reference panel member	

Name	Gender	Agency	Position at agency	Project Responsibilities	[redacted]
Ann Fleming	F	ACIAR	Fisheries RPM	Reference panel member	
~~Dominique Vigie~~	~~M~~	~~Department of Foreign Affairs and Trade~~	~~Manager – Water Resource Program~~	~~Reference panel member~~	
Lee Baumgartner	M	Charles Sturt University	Associate Research Professor (Fisheries and River Management)	Project leader and reference panel member	

It is expected that project team members may, at the request of the chair and pending available budget, be required to attend the annual panel meetings to clarify technical issues. This will be managed on a case-by-case basis as required.

Lao government officials, from a range of departments, have significant interest in this work and may also be required to attend meetings. Travel provision has been made within LARReC and NUOL budgets to facilitate this participation.

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6.4 Summary details of key participants' roles and responsibilities

Name	[redacted]
Dr Lee Baumgartner Charles Sturt University, Associate Professor	
Jarrod McPherson Charles Sturt University	
Thanasak Poomchaivej Xayaburi Power Company	
Dr Michael Raeder Xayaburi Power Company Limited	
Garry Thorncraft National University of Laos	

Name	
Dr Oudom Phonekhampheng National University of Laos	[redacted]
Douangkham Sinhanouvong Living Aquatic Resources Research Centre	
Karl Pomorin KarlTek Pty Ltd	
Dr Nathan Ning Charles Sturt University	
Dr Chris Barlow Fish Matters IP	
Lauren Withers (and others) Australian Volunteer	

Name	[redacted]
Phousone Vorsane (NUOL) and Saleumphone Chantavong (LARReC)	
Thonglom Phommavong (NUOL) Khampheng Homsombath (LARReC)	
Wayne Robinson (CSU)	
Darren Grigg (Grigg Media)	

6.5 Summary details of proposed reference panel participants

Name	[redacted]
Jody Swirepik (chair) Australian Government	
Dr Elizabeth Pope Snowy Hydro	

Name	[redacted]
~~Prof Jürgen Geist~~ ~~Technical University of Munich~~	
Dr Daniel Deng PNNL	
Dr Michael Raeder XPCL	
Lao citizen representative TBA	
Dr Ann Fleming ACIAR	
Dominique Vigie DFAT	

6.6 Description of the comparative advantage of the institutions involved

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The team contains a diverse mix of disciplines and the experience necessary to successfully complete the work outlined in this proposal. Team members have collectively managed over 100 projects relating to fish passage and have helped to coordinate over $AUD100 million in fish passage rehabilitation works in the last 10 years (not including

Xayaburi). The agencies have the scientific and financial capabilities to successfully complete an international collaboration.

The organisations include:

Charles Sturt University: Will lead the project. The organisation has a long history with ACIAR and in working in the South East Asian region. It has excellent administrative support processes and excellent networks in the Lower Mekong Region. It recently acquired staff from Fisheries NSW with previous experience in this research field, who collectively have over a decade of experience living and working in Lao PDR. CSU has extensive experience with PIT system data analysis and installations throughout Australia and has extensively collaborated with researchers and the Australian government on the installation of fish monitoring systems since 2001. There are no other universities in Australia with such extensive experience and networks for fishway monitoring.

Xayaburi Power Company: Will own and operate the hydropower project for the next 30 years under a concession agreement with the Lao government. The company is responsible for operating the hydropower plant, and fishway, and is mandated by the Lao government. A key part of its concession responsibilities is to report on effectiveness of mitigation strategies.

KarlTek Pty Ltd: Is KarlTek Pty Ltd is a Melbourne based, 100% Australian owned and operated, company that provides high quality radio frequency identification (RFID) solutions to a wide range of wildlife monitoring applications. KarlTek has a patented system and experienced staff that can assist with the design, assembly, installation and ongoing maintenance of RFID systems. The KarlTek 5000 is the only RFID system on the market which uses a combination of auto-tuning technology, dual full (FDX) and half duplex (HDX) capabilities combined with custom software to provide a complete system which can be tailored to any animal tracking program.

Fish Matters IP: Fish Matters IP provides consultancy services in areas of project design, management and implementation, principally in the Indo-Pacific region.

National University of Laos: Is the primary university in Lao PDR. It has been leading the area of fish passage research and has actively incorporated aspects of the research outputs into the undergraduate curriculum. The team have extensive networks in regional parts of Laos and the research equipment essential to the successful project delivery.

Living Aquatic Resources Research Centre (LARReC): Is the leading institute in the area of aquatic natural resource research in Lao PDR. Fish passage is mandated into the organisational mission. LARReC has detailed networks in district and provincial governments that are essential to facilitate local collaboration.

7 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to <contracts@aciar.gov.au>.

7.1 Administrative details

[redacted]

7.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

[redacted]

If "yes" to any of the above, for each applicable country provide brief details of the material to be exchanged:

If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.

If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	Details of plant or animal germplasm exchange

Proprietary materials, techniques and information

[redacted]

"Data" means all data produced, acquired or used by a Party for the purposes of conducting the Project including technical know-how and information reduced to material form by that Party.

If "yes" to any of the above, for each applicable country provide:

brief details of the materials or information, the organisation providing, and the organisation receiving the materials

a copy of any formal contract between the parties.

[redacted]

Other agreements

[redacted]

If "yes" to any of the above, for each applicable country provide:

brief details of the agreements and conditions

a copy of any such agreement before project commencement.

[redacted]

7.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project and any data that is created under the Project that will be reduced to a material form.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

[redacted]

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP including any data that is brought to a Project by a Party that will be used for the purposes of the Project and the creation of Foreground IP should be provided to ACIAR prior to project commencement.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Background IP; whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it; any conditions or restrictions on its use.

[redacted]

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

[redacted]

If "yes", for each applicable country provide brief details of: the source of the Third Party IP; the applicable country/ies; the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements); any conditions or restrictions on its use.

[redacted]

Other contracts, licences or legal arrangements

[redacted]

If "yes", for each applicable country provide brief details.

[redacted]

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