Mekong River Commission

PRIOR CONSULTATION PROCESS FOR THE

LUANG PRABANG HYDROPOWER PROJECT

SUMMARY OF THE SECOND DRAFT OF THE TECHNICAL REVIEW REPORT

20 December 2019

ACRONYMS AND GLOSSARY

AIT	*Asian Institute of Technology – Bangkok Thailand*
BOD	*Biological Oxygen Demand – a measure of the demand on oxygen in the water column exerted by organic and inorganic substances.*
CIA	*Cumulative Impact Assessment*
DSMS	*Dam Safety Management System*
EAP	*Emergency Action Plan – required for Dam Safety*
EIA	*Environmental Impact Assessment*
FS	*Feasibility Study*
GoL	*Government of the Lao PDR*
HPP	*Hydropower project*
ISH	*Initiative for Sustainable Hydropower – a initiative based in the MRCS.*
JAP	*Joint Action Plan – a post prior consultation process*
JC	*Joint Committee*
JCWG	*Joint Committee Working Group – established to guide the technical review process*
JEM	*Joint Environmental Monitoring – a monitoring programme being piloted at the Xayaburi and Don Sahong HPPs to evaluate the efficacy of the measures applied.*
Joint Platform	*A body created by the MRC to help improve the implementation of the Procedures in linked and cooperative manner*
LEPTS 2018	*Lao Electric Power Technical Standards 2018*
LMB	*Lower Mekong Basin - The Mekong River Basin falling in the territories of its Member States*
LPHPP	*Luang Prabang Hydropower Project*
LNMC	*Lao National Mekong Committee*
MC	*Member Country, one of the four parties to the 1995 Mekong Agreement; viz. Cambodia, Lao PDR, Thailand, and Viet Nam*
MRC	*Mekong River Commission – established by the MC to support their efforts towards collaboration*
MRCS	*Mekong River Commission Secretariat*
PAP	*Project Affected Persons*
PBHPP	*Pak Beng Hydropower Project*
PLHPP	*Pak Lay Hydropower Project*
PC	*Prior Consultation*
PDG2009	*Preliminary Design Guidance of 2009 – approved*
PDG2019	*Preliminary Design Guidance of 2019 – not yet approved*
PDIES	*Procedures for Data and Information Exchange and Sharing*

PMFM	*Procedures for Maintenance of Flows on the Mainstream*
PNPCA	*Procedures for Notification Prior Consultation and Agreement*
PPA	*Power Purchase Agreement*
Pressure flushing	*Use of low-Level outlets to scour sand deposited near the dam wall and turbines, primarily to project the infrastructure and power production.*
PWQ	*Procedures for Water Quality*
PWUM	*Procedures for Water Use Monitoring*
RAP	*Resettlement Action Plan*
RCC	*Roller Compacted Concrete – a new approach to dams*
RIS	*River Information System – a system that may be introduced to facilitate navigation on the Mekong mainstream*
SEE	*Safety Evaluation Earthquake – a seismic standard applied to possible ground motion.*
SIA	*Social Impact Assessment*
Sediment flushing	*Drawing down water levels to periodically induce channel erosion and discharge large volumes of deposited sediment.*
SMMP	*Social Monitoring and Management Plan – a process initiated with construction to evaluate and adapt to impacts due to construction and operations of the HPP*
Sediment routing	Drawing down water level during periods of high inflow to maximise sediment throughput.
TBIA	*Transboundary Impact Analysis*
TRR	*Technical Review Report*
XHPP	*Xayaburi Hydropower Project*

INTRODUCTION

Background

On the 31st of July 2019 the Mekong River Commission (MRC) Secretariat received notification from the Lao National Mekong Committee (LNMC) submitting the Luang Prabang Hydropower Project (LPHPP) for prior consultation under the Procedures for Notification, Prior Consultation and Agreement (PNPCA)[1]. The proposed LPHPP is the fifth proposed use submitted for prior consultation. The four earlier PC processes were for the Xayaburi (XHPP), Don Sahong (DSHPP), Pak Beng (PBHPP), and the Pak Lay (PLHPP) hydropower projects.

The 1995 Mekong Agreement

The Governments of Cambodia, Lao PDR, Thailand, and Viet Nam signed an Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, "The 1995 Mekong Agreement". The Agreement established the Mekong River Commission and re-affirmed the Member Countries' desire to develop the Mekong River Basin in a sustainable and collaborative manner. However, recognising that development could result in adverse impacts on the Mekong River System, Chapter III of the Agreement includes, *inter alia*, the following commitments by the Member Countries:

> *The 1995 Mekong Agreement is primarily developmental in nature but establishes a framework of objectives and principles through which the Member States agree to the fair and sustainable development of the Mekong River System for mutual benefit.*

- To protect the ecological balance of the Mekong River Basin;
- The reasonable and equitable use of the waters of the Mekong River System;
- To discuss and aim to agree (in the Joint Committee) on significant water uses on the mainstream in the dry season (prior consultation);
- Maintain flows in the Mekong mainstream;
- Make every effort to avoid, minimise and mitigate harmful effects on the river system;
- Take responsibility where harmful effects result in substantial damage to the other Member States, and to cease these activities when notified with valid evidence;
- Incorporate navigational uses in mainstream projects so as not to permanently impair navigation; and
- Warn other Member Countries of water quality and quantity emergencies.

The Member Countries aim to achieve these objectives and principles through the unique spirit of cooperation that has underpinned cooperation between the Member Countries since 1957, and which has been reaffirmed on many subsequent occasions.

[1] The documentation submitted by the LNMC is available at: http://www.mrcmekong.org/topics/pnpca-prior-consultation/luang-prabang-hydropower-project/

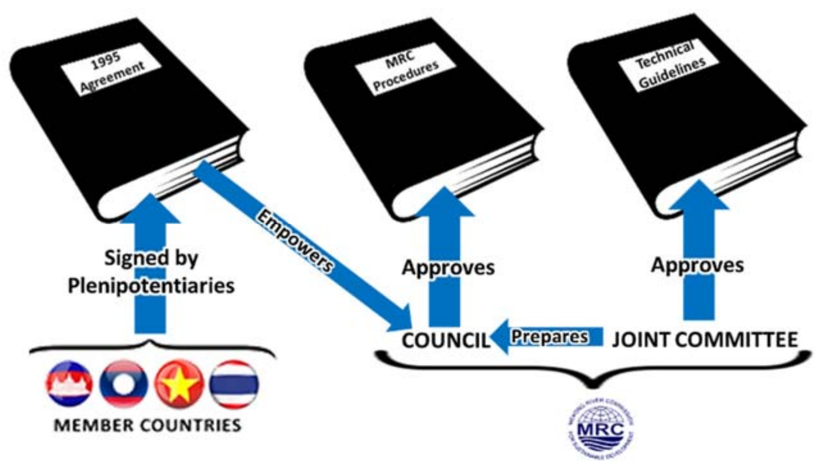
The 1995 Mekong Agreement also establishes the Mekong River Commission (MRC), and its institutional structures as a *separate* international body and gives certain powers and functions to these bodies.

In regard to the prior consultation process;

> *The MRC Member Countries established the Commission and its structures, and gave certain powers and functions to these bodies. The MRC can **only** function within these given mandates.*

- ***The Council*** is empowered to establish the 'Rules for Water Utilization and Inter-Basin Diversions' (now the five MRC Procedures). The Council agreed the Procedures for Notification, Prior Consultation and Agreement (PNPCA) in 2003.
- ***The Joint Committee (JC)*** is empowered by Article 5 of the Agreement and the PNPCA to undertake the prior consultation process, and Technical Guidelines to support the PNPCA were agreed by the Joint Committee on 31 August 2005.
- ***The Secretariat (MRCS)*** provides technical and administrative support to the prior consultation process, can take a pro-active role in assisting the Joint Committee in this regard.

The MRC can *only* work within this framework and functions given by the Member Countries through the 1995 Mekong Agreement. The Agreement also indicates that prior consultation is neither a veto right, nor a unilateral right to proceed without taking the other Member Countries' concerns into account. Prior consultation and all the other Procedures are, therefore, not regulatory mechanisms, but rather establish a framework for cooperation and discussion.



THE PNPCA AND THE PRIOR CONSULTATION PROCESS

Prior consultation is based on Article 5 of the Agreement in which the Member Countries agree to the reasonable and equitable use of the Mekong River System. Reasonable and equitable use is a nuanced and difficult concept on its own. The prior consultation process therefore takes a broader perspective, considering all the objectives and principles agreed in Chapter 3 of the Agreement.

Together these objectives and principles promote the fair and just development of the Mekong River System, while minimising the potential for transboundary harmful effects and impacts on the ecological balance of the shared ecosystems.

The Procedures for Notification, Prior Consultation and Agreement (PNPCA) specify three different types of process; i) **N**otification, ii) **P**rior **C**onsultation and iii) specific **A**greement.

Notification is applied to water uses on the tributaries of the Mekong System, and for 'wet season' use on the mainstream. ***Prior consultation*** is required for water use on the mainstream in the 'dry season', and for inter-basin diversions from mainstream in the 'wet season'. ***Specific Agreement*** is required for inter-basin diversions in the dry season.

These increasing levels of interaction reflect a balance between the likelihood of adverse transboundary impacts, and the principle of sovereign decision making and management. They are also, to some extent, a hangover from a time when the primary concern of the Member States was sharing water. The idea being that in the wet season there was so much water available there was less concern about the sharing of water, and that provided flows on the mainstream were maintained within agreed limits, tributary uses would have limited transboundary impacts.

However, the impacts of development of the basin on sediment transport, fisheries and ecological processes are also central to the fair use of the Mekong River System. We now know that significant impacts to fisheries and sediment transport can also occur due to tributary developments while the large storage hydropower reservoirs in China and on the tributaries can disrupt flow regimes affecting the timing and volume of the reverse flow into the Tonle Sap Great Lake and other wetland systems. This in turn affects the fisheries. The 2018 State of the Basin Report has also highlighted other impacts on the ecological balance of the system including, *inter alia*, overfishing, pollution and sand mining.

> *The Prior Consultation process is governed by the 1995 Mekong Agreement, and underpinned by all the MRC Procedures. It aims to promote the just and fair use of the benefits that derive from the Mekong River System.*

Some Things to Keep in Mind

The following principles are important to keep in mind regarding the prior consultation process;

- The determination of whether any proposed use is *reasonable and equitable* is beyond the scope of the technical review process.
- The Member Countries have committed to making *every effort to avoid, minimise and mitigate possible harmful effects* on the Mekong River System. The review process aims to identify design and operational measures that do this.
- The Joint Committee will aim to outline what measures the notifying country should consider in the final design and operation of the proposed water use, to minimise the risk of transboundary harm. This advice will be presented in a Statement at the conclusion of the prior consultation process.
- These measures can refer to either the Final Design, Construction or Operational phases.
- The measures need to be technically and financially viable. They would otherwise amount to a *de facto* veto of the development.
- The notified use is just one of a series of planned developments. It is important to consider the cumulative impacts of all the projects that have previously been notified.
- The Statement may refer to the joint management of several projects to minimise any potential impacts.

> *The Prior Consultation process aims to reach consensus on a Statement calling on the notifying country to make every effort to implement identified measures that further avoid, minimize and mitigate potential transboundary impacts.*

The main purpose of the technical review is, therefore, to highlight what *additional and viable* efforts could viably be made to avoid, minimise and mitigate any possible harmful effects.

Improvements to the Prior Consultation Process

The MRC strives to continually improve the prior consultation process. In the previous two processes the concept of the ***"Statement"*** calling on the notifying Country to consider a set of measures was introduced. The Joint Committee also agreed to a ***"Joint Action Plan"*** or post prior consultation process. This aims to work together with the notifying country to refine the proposed measures and to assess their viability. This intends to work towards a final set of measures that could be included in the Procedures for Water Use Monitoring. This will allow the Joint Committee to continually assess how effective the measures are, and to suggest adjustments to the operations that may provide better outcomes.

> *The LPHPP prior consultation process places greater emphasis on options to finance and monitor the implementation of the measures agreed in the Statement as a joint effort by all the Member States and HPP developers.*

The technical review for the Luang Prabang HPP will add to the development of the prior consultation process by placing greater emphasis on the importance of joint operations of the upper Lao cascade to achieve the objective. The use of the Statement and Joint Action Plan to further the aims of the prior consultation process will also receive more attention.

THE LPHPP PRIOR CONSULTATION PROCESS

The Prior Consultation Process Timeline

The initial prior consultation process and technical review takes place over six months and follows the steps presented below. This is a very tight timeframe, as a wide range of experts in various fields need to develop a common view of the intentions of the developer, and the implications for the shared Mekong River System.

> *More frequent and transparent engagement with stakeholders was identified as key to improving the outcomes of the prior consultation process.*

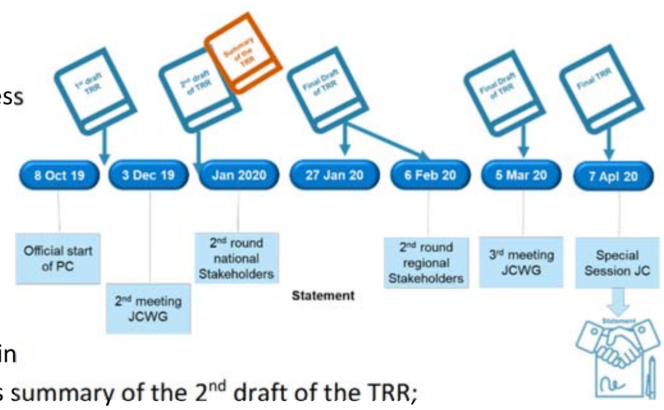
The prior consultation process can be extended by agreement in the Joint Committee. Following international practice, this would typically only be considered if there is special difficulty in undertaking the technical review, or if new information comes available late in the initial 6-month process. Any possible extension would therefore be modest and with reasonable timing to fit for technical review.

The Mekong River Commission (MRC) Secretariat received notification from the National Mekong Committee of the Lao PDR on 31 July 2019, submitting the Luang Prabang Hydropower Project for prior consultation. The Secretariat then started preparations for the prior consultation process, through the mobilisation of resources to undertake the process. The documentation provided by the Lao NMC was, including a scoping report outlining the proposed approach, was sent to the MRC Member Countries on 3 September 2019.

Under guidance from the JC Working Group (JCWG) on the PNPCA, the MRC Secretariat appointed several expert groups, made up of national and international experts, to provide independent specialist evaluations of the documentation submitted. The JCWG met for the first time on 8 October 2019 and agreed that the meeting would be the formal start of the prior consultation process. The initial 6-month process will therefore run until 7 April 2020.

Important Milestones

The key dates for the remainder of the process are therefore:



- This Summary of the Technical Review Report is based on the second draft dated **18 December 2019**;
- The second round of national stakeholder consultations takes place in **January 2020** and will be based on this summary of the 2nd draft of the TRR;
- The final draft of the TRR will be presented on **27 January 2020**, and will include feedback from the national stakeholder consultations;
- This Summary will also support the second regional stakeholder forum on **6 February 2020**;
- The final draft of the TRR and Draft Statement will be submitted to the 3rd meeting of the JCWG on **5 March 2020**; and
- Any final changes requested by the JCWG are made and submitted to the Special Session of the JC for discussion on **7 April 2020**.

Notification at the Feasibility Stage

Large infrastructure projects go through several phases;

This allows the developer to incrementally assess the viability of the proposed project before committing additional resources and allows them to identify specific design requirements before finalising the design. As with the previous prior consultation processes the LPHPP prior consultation is conducting in the feasibility stage, and the development of the project is ongoing. This means that the technical review process has aimed at a moving target, and many of the recommendations are already being addressed. The site visit on 4 December 2019 provided the opportunity for the review team to discuss the initial findings and get feedback on current progress from developer.

> *The TRR must be based on documents that have been formally submitted by the Lao National Mekong Committee.*

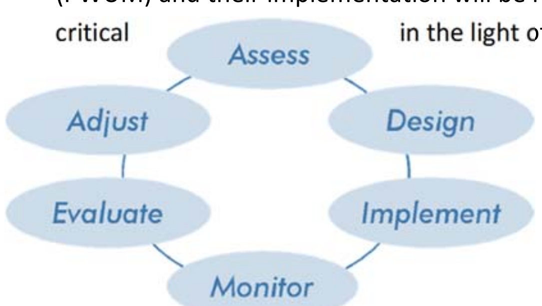
There are both advantages and disadvantages to notifying the project at the feasibility stage. This arrangement means that the prior consultation process can influence the final design and operation of the LPHPP. The Lao PDR and the developer can also make an earlier decision on the financial viability of the project based on the inputs from the MRC.

However, notification at the feasibility stage may mean that there is insufficient information available to undertake a comprehensive technical review, and an unnecessarily negative impression of the proposed project may arise by identifying issues that are already being addressed. This Summary of the TRR therefore includes the developer’s feedback after the site visit. The post prior consultation process is, nonetheless, still needed to work with the developer and notifying Country to adjust the proposed measures through the final design, construction and initial operations.

The Post-Prior Consultation Process

To address some of the shortcomings of notification at the feasibility stage a post prior consultation phase is planned. This aims at continual engagements between the Lao PDR, the developer and the MRC during the final design, construction and operational phases. The intention is to refine the measures to avoid, minimise and mitigate any possible harmful effects.

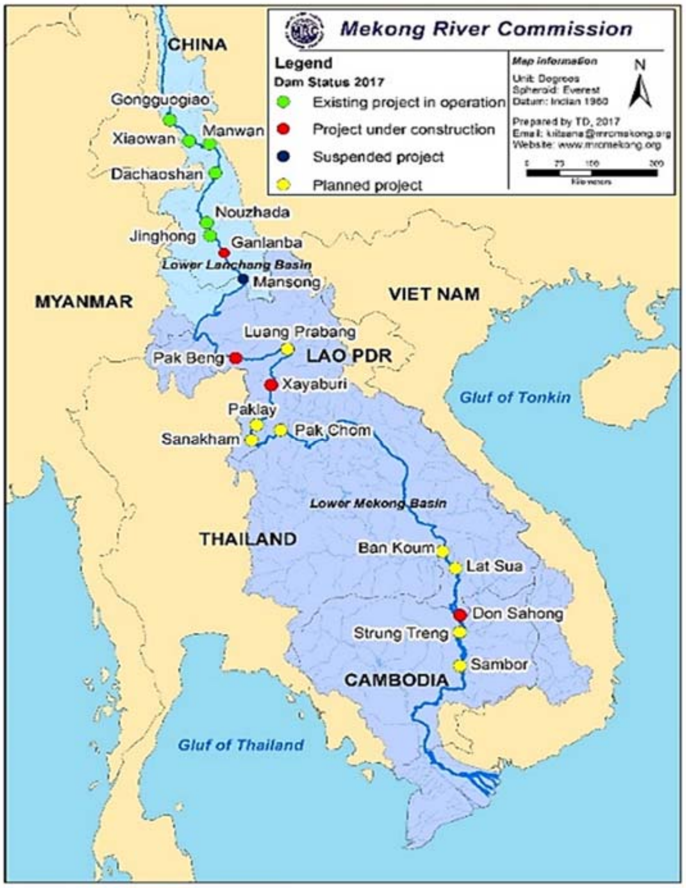
Ultimately, it is hoped, that a set of operational measures, for example regular sediment flushing operations, can be agreed which will become part of the Procedures for Water Use Monitoring (PWUM) and their implementation will be reported on at the regular MRC JC meetings. This is critical in the light of the conjunctive operations of all the mainstream HPPs in the cascade, and potentially some of the tributary storage HPPs. This together with the Joint Environmental Monitoring (JEM) programme may place the MRC in a better position to support adaptive management operations.



THE MAIN FEATURES OF THE LPHPP

Location

The Luang Prabang hydropower project is the 2nd project in the northern Lao cascade. It lies downstream of the Pak Beng HPP, and the upstream of the Xayaburi HPP. It is located on the Mekong River around 2,036 kilometres from the Delta, and approximately 25 km upstream of Luang Prabang City.



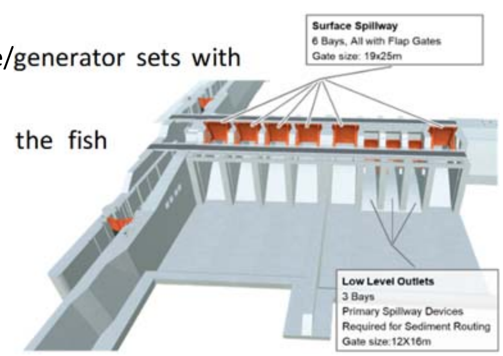
> *The LPHPP lies some 25 km upstream of Luang Prabang City, and between the upstream Pak Beng, and downstream Xayaburi HPPs. This makes both dam safety and cascade operations critical.*

The Luang Prabang Power Company Limited (LPCL) has been established in the Lao PDR and will undertake the development of the LPHPP under a Memorandum of Understanding (MoU) between the Government of the Lao PDR and PetroVietnam Power Corporation, which was concluded in October 2007.

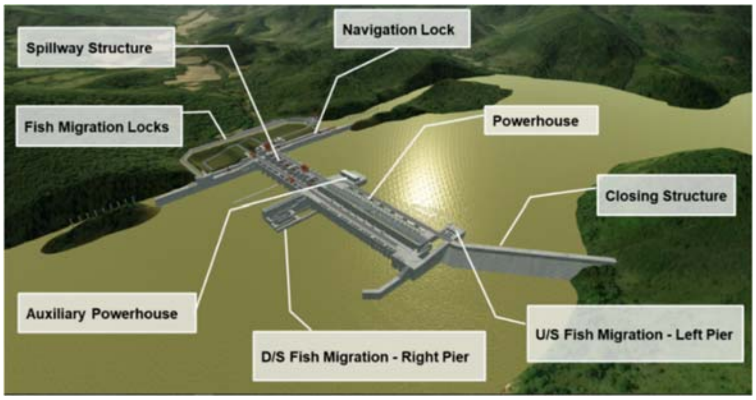
Main engineering structures

The proposed Luang Prabang HPP is a barrage type hydroelectric run-of-river project consisting of:

- A powerhouse equipped with seven Kaplan turbine/generator sets with total installed capacity of 1,400 MW;
- Three Auxiliary Kaplan turbines using water from the fish attraction flows, totaling 60 MW;
- A spillway structure with six surface gates;
- Three low level outlets (LLO);
- A closing structure;
- A two-step Navigation lock system;
- Fish pass systems for upstream and downstream migration;



- A 500kV transmission line to Vietnam with an approximate length of 400 km to the Vietnamese border and 200 km to the next suitable substation, and / or to Thailand with an approximate length 250 to 300 km[2].



The energy output model for the LPHPP is based on 67 years of daily inflow for the years 1951 to 2017, after taking the Lancang Cascade into account.

A Run-of-River Project

The LPHPP will be operated as a run-of-river hydropower project, with inflows roughly equivalent to outflows. This means that the HPP will not impact on the season flow regimes further downstream. However, the residence time (i.e. the time inflow water will take to flow through the dam) will be from 3-9 days.

Operating Rules

The feasibility stage operational rules are based on inflows and are outlined as follows;

- Up to 5,355 m^3/s, all the flow water passes through the turbines, this will be for about 80% of the operation time;
- Once inflows reach 5,355 m^3/s, the low-level outlets (LLO) will be opened, removing sediment deposited close to the dam structure.
- Between inflows 5,355 m^3/s and 10,650 m^3/s both the spillway (low level outlets and surface gates) and powerhouse are operational. This will occur for some 20% of the operation time, and most likely on an annual basis. The process is;
  - The LLO are opened first, and this will occur in August and September of most years. These LLO have a capacity of 3,530 m^3/s;
  - The surface spillways will come into operation at inflows of some 8,885 m^3/s, when the LLO reach their capacity. That will occur for less than 5% of the operation time, and most likely not every year;
- When inflows exceed 10,650 m^3/s the turbines are shut down and all the flow is passed through the spillways and LLO. The reservoir operating levels may drop, returning the river closer to free-flowing system. This would happen occasionally.

This means that under the feasibility level operating rules, pressure flushing of sediments near the dam structure would happen in most years. Sediment flushing and routing is not yet being considered at this stage.

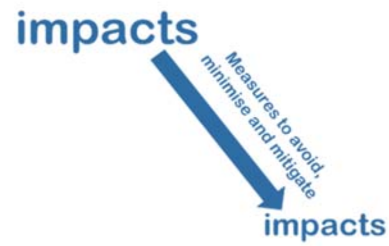
[2] The Power Purchase Agreements have not yet been concluded, and hence the transmission lines routings have not been finalised.

A SUMMARY OF THE TECHNICAL REVIEW

Background

The technical review has been undertaken by seven expert teams covering hydrology and hydraulics, sediment transport, water quality and aquatic ecology, fish passage and fisheries, dam safety, navigation and socio-economic issues. These teams work under the guidance of a Joint Committee Working Group for the PNPCA, who in turn report to the Joint Committee.

The review is based on the Feasibility Study and designs provided by the Lao National Mekong Committee. It is understood, therefore, that the detailed design of the LPHPP is ongoing and that many of the issues raised in the review are already receiving attention.



The TRR aims to identify additional measures that can be considered to further avoid minimise and mitigate possible adverse impacts.

The review provides:

- Comment on impact assessment and monitoring processes followed by the developer to date. This is intended to support the Lao PDR in their oversight of the implementation of the project;
- Comment on the use of data for the design and financial assessments. This affects the financial and technical viability of the project and any measures to avoid, minimise and mitigate harmful effects; and
- Additional measures that can be considered to avoid, minimise and mitigate potential transboundary harm. The Joint Committee will consider including the measures that will limit the potential for transboundary harm in the Statement.

For the purposes of the technical review;

- *Avoid* means the measure, if implemented, would ensure that any residual harmful effects will be negligible;
- *Minimise* means the measure, if implemented, would reduce harmful effects, or the risk of harmful effects, considerably; and
- *Mitigate* means the measure, if implemented, would reduce the *impact* of any residual harmful effects on other users of the Mekong River System.

The following sections summarise the outcomes of the expert teams' reviews. Stakeholders wishing to gain further insights and details should refer to the Technical Review Report and its Annexes.

Hydrology and Hydraulics

Why are the Hydrology and Hydraulics Important?

The *hydrology and hydraulics*[3] of the LPHPP will determine the most appropriate design for both the generation of power, and the financial and technical viability of measures to avoid, minimise and mitigate any potential harmful effects.

The future hydrology determines the financial viability of the HPP, and the feasibility of measures to limit adverse impacts

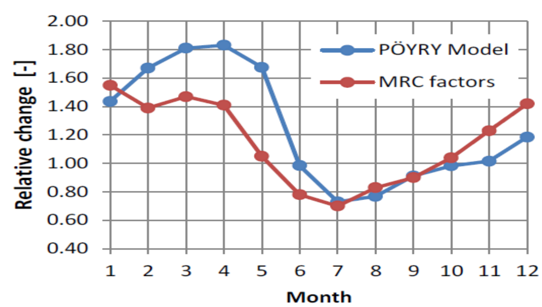
Hydrological Data used by the Developer

The Luang Prabang HPP is located between the flow gauging stations at Chiang Saen (at the border with China) and Luang Prabang. Both these stations were used to forecast future flows. These data provide an acceptable length of time series, but there are no data from the upstream tributaries. The rainfall data has been obtained mainly from remote sensing sources, but the manually recorded rainfall and weather data from nearby sites has not been used.

The developers have initiated monitoring at the project site. These data can be used to validate the approaches used to forecast future flows. The developer has also indicated that they have connected to the existing telemetric system for the Xayaburi HPP and have installed additional stations near and upstream of the LPHPP.

Forecasts of Inflows

Because there has been no long-term monitoring of flow at the dam site, the future inflows have been calculated from the Chiang Saen and Luang Prabang sites and a water balance model. Two approaches were used, the first used rainfall, temperature and evaporation data for 1951 to 2018 to calculate the contribution from the catchment between Chiang Saen and the LPHPP site. The second scaled the flows between the two flow measurement sites. While this is an oversimplification of the inflows from the tributary catchments, it is acceptable for a feasibility level study, and it is expected that the developer will apply more rigorous methods in the final design stage.



The relative change to historical monthly flows at Chiang Saen from the MRC and the Poyry Studies

The forecasts of future flows consider the changes due to the large storage schemes in China, which hold some water back in the wet season and release it during the dry season. But they do not consider climate change or the impacts of the Pak Beng HPP. The developer has indicated that these are expected to be small in comparison to the impacts of the Lancang Cascade. The MRC

[3] "*Hydrology*" is the amount and timing of water (volume) that reaches the project from upstream dams, rainfall and runoff processes, and hence what is available for power production, fish passage, navigation and sediment flushing.
"*Hydraulics*" is the water depths, velocities, turbulence, the transfer of flood waves, and other properties of flow in rivers and reservoirs.

studies do consider tributary dams and climate change and differ from those presented in the Feasibility Study.

There is therefore some uncertainty in the calculation of the future flows at the dam site. It is, therefore, recommended that more analyses are done.

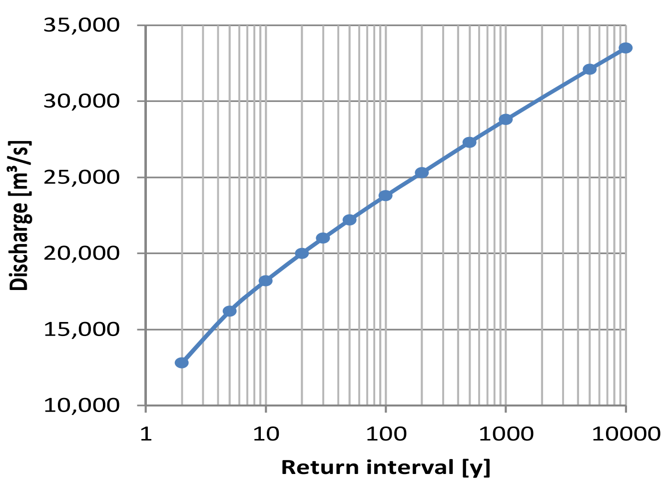
Downstream Water Levels

The downstream water levels affect the power output and will be determined by operation of the Xayaburi HPP. A mathematical model of the water levels covering about 2.5 km upstream and about 25 km downstream of the LPHPP site has been developed. However, there is limited data available for the calibration of this model, and the bed of the river in the downstream section may change due to the removal of sediment in the LPHPP and Nam Ou tributary cascade.

The developer has indicated during the site visit they have updated the calculations, and these show the backwaters of the Xayaburi HPP reach almost to the tailwaters of the LPHPP.

Flood Frequency and Design Floods

The size and frequency of floods are important to designing infrastructure that can withstand all possible floods. The records from 1960 to 2009 for Luang Prabang and to 2018 for Chiang Saen have been used for the Flood Frequency Analysis (FFA).



Flood peaks and frequency must be determined after considering the operation of upstream dams.

However, this does not account for any reduction in flood peaks due to the Lancang cascade. The developer indicates that this is justified as floods are likely to coincide with periods when the reservoirs are full, and the dominating storm events typically occur downstream of the cascade. This is acceptable as it provides a conservative estimate of the flood peaks when compared to other studies for this part of the Mekong mainstream.

The Probable Maximum Flood (PMF) is an important design consideration. The PMF is determined from the Probable Maximum Precipitation (PMP) and the water balance model. The PMP is derived from reports from the US Army Corps of Engineers and is appropriate for the determination of the PMF for the LPHPP.

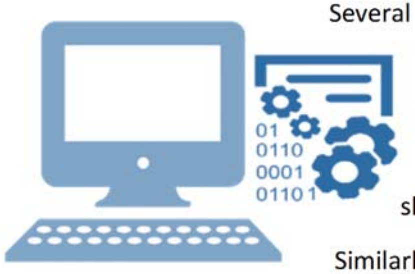
Reservoir Operating Rules

The Luang Prabang HPP is a Run-of-River (RoR) hydropower plant, i.e. the discharge through the infrastructure roughly equals the inflow. The Full Supply Level (FSL) will be maintained within a narrow range of 0.5 m with fluctuations only for operational reasons to adjust for very high inflows.

The Pak Beng HPP operator has raised concerns that the FSL of Luang Prabang HPP will reduce their power output. However, comparison of the LPHPP and the PBHPP outputs, shows there is a net gain in the total power output. The Government of Lao PDR has indicated that compensation payments may be required from the LPHPP to the PBHPP to address the latter's concerns around the impacts on their financial viability.

The Feasibility Study mentions the possibility, and necessity, of joint operations with the Pak Beng and Xayaburi HPP's. However, this is beyond the scope of the LPHPP developers' mandate. It is therefore important for the Government of Lao PDR (GoL) to develop joint operational to optimise hydropower output. The models developed by the MRC as part of the Council Study should also be used to optimise sediment management operations, and potentially to maintain fish larval drift. It is therefore recommended that the development of the cascade operating rules be a joint effort by the MRC and the Ministry of Energy and Mines (MEM) in the Lao PDR.

Modelling Tools for Impact Assessments



The use of computer and physical models helps the design process and improve the operating rules.

Several modelling tools have been used to support the feasibility level designs. Limited information on the model calibration has been provided at this stage and some of the models have been based on old data. The developer has subsequently indicated that the mathematical models have been updated, but no details have been shared.

Similarly, the physical model for Xayaburi has been used to support the feasibility level designs. The developer has indicated that the LPHPP physical model has been constructed at the Asian Institute of Technology (AIT) in Bangkok – Thailand, and that hydraulic tests are being undertaken. These have not yet been shared for the review process.

Hydraulic Impacts

The LPHPP developer recognises the potential for crosscurrents from the spillways affecting navigation in the downstream approach channel. However, the designs propose that an "island" is left during the excavation works which will prevent these cross currents.

The configuration, with the powerhouse in the middle of the structure, has both hydraulic advantages and disadvantages. The developer intends to undertake detailed hydraulic modelling to test and optimise this performance. An alternative layout where spillways are placed both left and right of the powerhouse may be considered for the final design.

During the first construction phase, the coffer dam claims around 75% of the river width at the dam site. Flows through the remaining gap will be higher, while lower flow velocities will occur immediately upstream. The developer has recognised this and will provide alternative navigation facilities during the period when the coffer dam is in place (about 5 years). However, these plans have not yet been elaborated.

The design of the spillway section is largely similar to the Xayaburi HPP, but with 6 surface spill ways (instead of the 7 at Xayaburi), and 3 low-level outlets instead of the 4 at Xayaburi. This is logical given the higher flows at the Xayaburi site.

The stilling-basin design is also similar to Xayaburi and the concrete aprons and end sill are identical. However, their performance must still be evaluated based on the conditions at the LPHPP site. As the tailwater and flood statistics differ between the sites, it is recommended that the developer explores these aspects in the ongoing design process. These studies should be shared as part of any post prior consultation process.

Alignment with the PDG 2009

The Preliminary Design Guidance (PDG 2009) does not contain clauses for hydrological and hydraulic parameters. It does, however, indicate that it is necessary to consider how much water needs to be released to maintain downstream ecosystems. However, the environmental flow requirements are somewhat redundant as the LPHPP discharges virtually directly into the backwaters of the Xayaburi HPP.

Key Concerns

The operator for the Pak Beng HPP has raised concerns that the operating level of the LPHPP has been increased from 310 – 310.5 m asl to 312 – 312.5 m asl. This appears to conflict with agreements made with the Government of the Lao PDR and will compromise the power output at the PBHPP. The Government of Lao PDR has indicated that there is a net gain in power output through this arrangement, and that compensation mechanisms between the two HPP operators will have to be agreed.

Sediment Transport and River Morphology

Why is Sediment Transport Important?

The downstream transport of fine and coarse grained sediment in the Mekong River is important to maintain the structure and functioning of downstream ecosystems.

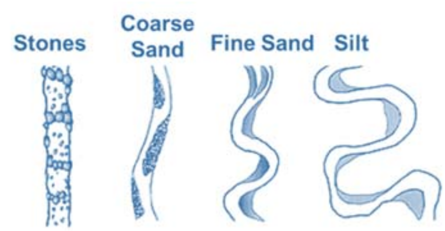
Sediment flushing infrastructure routing and operations are recommended by the PDG2009.

Sediment Data Used

The Feasibility Study provides a good review of the sediment data currently available for the upper Lao Cascade and the role that land use and upstream hydropower developments have played in affecting sediment transport on a regional scale. However, the documentation provided does not provide any site-specific sediment measurements. The developer has however indicated that this monitoring has been started, but no data have been shared yet.

The spatial data on geomorphology (the structure of the river) adequately covers the dam site and impounded area. Although, there is a lack of information for the downstream river channel. However, the site visit has indicated that much of this area has already been inundated by the Xayaburi HPP.

The developer has not drawn on sediment transport and trapping modelling recently completed by the MRC. The Feasibility Study (FS) presents a literature review summarising studies documenting the distribution of sediment input in the Lower Mekong Basin (LMB), the suspended sediment loads before and after construction of the Lancang cascade, and the grain-size distribution of suspended and bedload sediment. Some of these show a decrease in sediment concentrations and loads following closure of the Lancang dams, while others suggest that there will be little or no change. However, the developer concludes, as do the MRC studies, that there has already been a major reduction in sediment load.



The transport of coarse and fine sand and silt affects the downstream structure of the river

The Feasibility Study recommends collecting additional site-specific sediment data upon which a comprehensive sediment management strategy for Luang Prabang can be based. Specifically, it recommends additional investigations and modelling related to sediment deposition in the upper reaches of the impoundment and the remobilisation efficiency of flushing and sluicing, and collecting suspended sediment, bedload sediment including mass and grain-size determination to support these investigations. The developer has indicated that this work is underway and that the results will be presented in later phases.

The Pre-Project Analyses

The sediment analyses presented are a sound starting point. However, the planned additional studies should be implemented, and the results shared with the MRCS as part of any post prior consultation process. The current work focusses on past changes related to land use and damming, and only briefly mentions the potential impact of existing or future mainstream or tributary hydropower projects situated upstream of Luang Prabang, or how the LPHPP operations will affect the upper reaches of the Xayaburi HPP, and the impacts of the Nam Ou cascade.

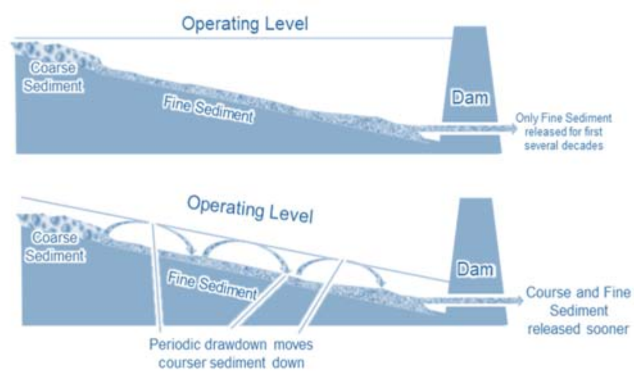
More attention needs to be paid, in the upcoming work, to the reach immediately downstream of the LPHPP. Here water and sediment released by the LPHPP will mix with flow and sediment discharged from the Nam Ou, and sediment transport in the upper reaches of the Xayaburi HPP will be governed by the combined inflows. This will affect flooding and erosion around Luang Prabang City and the overall movement of sediment through the cascade.

The Feasibility Study only includes limited information on the grain-size distribution of 10 riverbank and 6 suspended sediment samples collected in April 2019. Ideally there should be at least one year of site-specific sediment monitoring, which could confirm and forecast the reduction of sediment loads due to upstream developments and would provide the site-specific grain-size distribution in the wet and dry seasons. The developer has indicated that this monitoring is now ongoing, but no data have been shared yet.

The discussion of sediment transport management strategies and mitigation measures at this stage is very limited, and only includes the opening of the Low-Level Outlets (LLO) when flow rates exceed that required by the powerhouse and ancillary services (fish pass facility and navigation) – i.e. approx. 5,355 m^3/s. However, this will produce pressure flushing, which will remove sediment from a limited area upstream of the outlets but will not mobilise sediment deposited further upstream.

The documentation submitted notes that eventually a new sediment equilibrium will be established which will increase sediment discharge from the impoundment. However, given the length of the inundated stretch, this new equilibrium will require a very long time to establish. The developer has indicated that at this stage sediment management will be restricted to pressure flushing – but that the infrastructure will allow for sediment flushing and routing should this be decided on later.

It is therefore recommended that the operating rules to allow for periodic drawdown of the water levels are explored. This will move coarse and fine sediments through the impoundment more quickly and is recommended in the PDG 2009. However, this will only be effective if it is done as part of a cascade management strategy. It is also important to note that this will reduce the total power output during the drawdown period.



Periodic drawdown transports coarse- and fine-grained sediments through the impounded reach faster.

Geomorphological Information

The documentation presents relevant geomorphology information and the EIA Report includes detailed maps of the area of inundation showing the distribution of different land types / uses that will be drowned by the project (sand bars, forest, rock outcrops, plantations, gardens, etc.). However, the ecological value of the loss of these areas under the impounded reach has not been discussed. Similarly, the proposed area of inundation contains many deep pools which are recognised as important habitat for fish and are highlighted in the PDG 2009 as being important areas to understand and monitor.

The Feasibility Study notes that during operations some of the riverbanks will be prone to erosion due to the change in the surface and groundwater levels and is expected to continue until the slopes are naturally flattened. The risk of landslides associated with the water level changes is, however, considered to be low. The developer indicates that downstream sediment transport will change, and this may be transboundary in nature. But these impacts are not described in detail.

Sediment transport modelling

Some initial sediment transport modelling has been completed. However, the model used can't predict geomorphic changes to the channel such as bank erosion. The model setup was also based on cross section data collected some time ago, and the sediment grain size determined from the 10 sediment samples collected.

Historic sediment data from the MRC was used to guide the input loads and grain size distribution of suspended sediment. This shows that the fine material will be transported through the impoundment, but that the coarser material will be deposited. However, the samples collected from the banks of the river are not necessarily representative of all the sediment carried, and the bed and suspended loads vary across the water column. The model results show deposition throughout the impounded area. In general, the results are consistent with the results available from the MRC studies. However, while the models used are suitable for a feasibility level design, more sophisticated modelling and input data and reservoir morphology is recommended for the final design stage.

The Feasibility Study indicates that additional sediment transport modelling will be conducted to verify the currently proposed arrangement of the spillway and lower outlets to support sediment routing or similar sediment management operations, and the developer has verbally indicated that more comprehensive monitoring is being undertaken. It is recommended that these data be shared as part of a post prior consultation process.

Alignment with The PDG 2009

The feasibility study draws on reasonable and consistent information to provide an early basis for assessing the sediment related impacts of the project. However, many of the topics included in the PDG 2009 are only addressed at a general level, with insufficient detail to allow an evaluation of alignment. Important topics that require additional detail include:

- Sediment flushing and routing throughout the impoundment to improve the downstream transport of sediment needs to be addressed; and
- It would have been useful to describe the range of cooperative actions that could be applicable to the cascade, and to suggest potential ways to develop coordinated operations.

> *The sediment analysis is good for this stage of the project development. However, as the project proceeds to final design, consideration should be given to sediment flushing and routing operations to move sediment through the full length of the impoundment.*

KEY CONCERNS

- The work presented is at an early stage making a comprehensive review difficult.
- The sediment management strategy appears to be focussed on protecting the infrastructure and hydropower production, and not on limiting any potential transboundary impacts.

Water Quality and Aquatic Ecology

Why is Water Quality Important?

Construction activities and the storage of water can lead to changes in water quality, which can affect the use of the water and impacts on aquatic ecosystems.

Potential Water Quality Impacts

The Feasibility Study includes a review of data from the MRC water quality network and the results of a single field survey carried out in February 2019. It notes that the water quality was mostly good and suitable for protection of aquatic life, human health and for agricultural use. Some sites had slightly elevated levels of nitrate-nitrogen and ammonium-nitrogen, high TSS concentrations, and higher coliform bacteria counts. This probably reflects the increasing population in this reach and aligns with the MRC water quality data for this stretch of the mainstream. However, there is no discussion of changes in water quality in the region over time or how future developments, particularly those arising from population growth and urbanisation related to the LPHPP, might affect the water quality. The data reflect a risk of eutrophication in the impoundment, especially during the construction and filling phases.

The developers have provided an assessment of the likely impact of the LPHPP on the physical, chemical and biological components of the river ecosystem. These reflect the intensity, extent and duration of anticipated impacts. There is likely to be considerable impact during the construction phase due to the extensive excavation works needed, and the construction activities. These impacts can be limited through good practice guidelines, which the developer has highlighted. However, while these measures will limit the sediments and contaminants reaching the watercourses, they should be supplemented by cleaner production measures to reduce the risk of contamination at the source.

> *Baseline monitoring has been limited, and the proposed monitoring programs need to be implemented soon.*

Despite these measures, soil erosion, bank side collapses, spillages and accidents and malfunction of wastewater treatment plants will most likely occur. This will have a temporary impact on water quality downstream, particularly during low flows. It is therefore recommended that continuous monitoring of key water quality parameters is undertaken, and that this is linked to alarm and response mechanisms.

The flooding of terrestrial vegetation causes elevated high BOD and lowering of dissolved oxygen in the impoundment and in the immediate downstream reach if the water is released. The developer proposes dealing with this by removing surplus vegetation in the reservoir area prior to impoundment. However, removal of all the vegetation can result in reduced fish productivity. It is therefore recommended hard wood vegetation is removed selectively and areas left to enhance protection of the fish stocks by creating zones that are difficult to fish, and to enhance food resources for the fish.

The developer proposes that post-construction monitoring is based on the results of the pre-construction monitoring. This is normal protocol but requires sufficiently robust pre-construction monitoring to identify water quality variables of concern. It is unclear how any modifications will be made as greater clarity emerges on specific water quality issues.

Why is Aquatic Ecology Important?

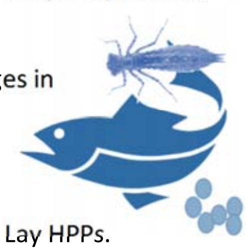
River ecosystems provide goods and services to the people of the Lower Mekong Basin, most importantly they are a source of food. The MRC Member Countries have also committed to maintaining the ecological balance.

Potential Aquatic Ecology Impacts

The developer has specified objectives with respect to protecting aquatic ecology during the construction and operation of the LPHPP. The baseline assessment comprises a review of fisheries studies, and data from a single field survey carried out in February 2019 for plankton and benthos, as well as a review of data collected during previous studies carried out for the Xayaburi (2010) and Pak Beng (2013) prior consultation processes, and surveys by the Xayaburi developer as part of the concession agreement.

These results from these surveys were variable. Total densities and diversity of phytoplankton and zooplankton samples were consistent with samples taken at Xayaburi and Pak Beng, but the diversity and abundance of benthic macroinvertebrates were inexplicably low, possibly reflecting the sampling methodology.

The documentation indicates that wet season sampling was planned for May 2019 to further assess the impacts of the project on aquatic biodiversity, but the results have not been provided. However, the developer did indicate during the site visit that this has been initiated. However, the sampling design is not aligned with international or MRC standards and should be expanded in scope. There is little attempt to relate plankton and benthic invertebrate surveys to previous results from MRC studies.



There are some comments on the impacts of the LPHPP on potential changes in aquatic habitats in downstream reaches and in the inundated area of the reservoir. A survey of the geomorphology of the reach has been done but this is not specifically related to the loss of and rarity of, these habitats given the previously reported losses under the Xayaburi, Pak Beng and Pak Lay HPPs. The river will be impounded for some 156 km with a total loss of riffle habitats, which are important for benthic macroinvertebrate and fish species. This will likely lead to loss of some species from the region including those that form much of the catch in this Zone of the Mekong mainstream. This includes many locally endemic and nationally/globally threatened species.

The change from a flowing river to an impounded section will eliminate important fish spawning and macroinvertebrate habitats.

Many drifting aquatic organisms, especially the egg and larval stages of fish, use flows to disperse downstream to nursery and feeding habitats. Generally, velocities greater that 0.3 m/s are required to maintain this drift of fish larvae. However, these aspects have not yet been addressed in the documentation provided. There is also no analysis of the impacts of changes in flow regime on in-channel habitats, especially the potential inundated area.

Studies of terrestrial fauna and flora were undertaken, including forestry products and wildlife in the Luang Prabang HPP area of influence. Species lists of various faunal groups were provided, highlighting their IUCN conservation status. Several tree species, reptiles, amphibians and birds were indicated as threatened but no specific actions to protect them were outlined.

The Mekong Giant Catfish is thought to spawn in the Luang Prabang area.

The LPHPP will discharge almost directly into the backwaters of the Xayaburi HPP. The length of free-flowing river just downstream of the LPHPP will therefore be lost. This is critical spawning habitat for Mekong species, especially the iconic Mekong giant catfish that is thought to spawn around the confluence with the Khan River. This loss of habitat is of growing importance within the upper Laos cascade of dams which will change some 600km of flowing river into a still water environment. The importance of this is addressed further in the section on cumulative impacts.

Monitoring for aquatic ecology parameters (plankton and benthos) is proposed at 5 sites, four times per year following standard techniques. It is recommended that the methodologies outlined in the MRC's Joint Environmental Monitoring are adopted so that the data can be compared.

Threatened species

The LPHPP EIA provides an overview of the most important biological resources in the upper zone of the LMB in the proximity of the LPHPP development. The region supports a rich fauna and flora, with many endemic species (only found in this region and nowhere else globally). Many are also reported to be threatened, including some iconic Mekong species. However, while the EIA lists endangered and vulnerable aquatic organisms and suggests potential impacts on these, it does not recommend specific monitoring or management plans for these species.

Alignment with the PDG 2009

The single sampling occasion reported falls short of the guidance provided in the PDG 2009, which requires longer periods of monitoring covering the full hydrological cycle to be included as part of the feasibility study.

There is also no evidence that an independent group of experts has been, or will be, established to assist with the design of the monitoring programmes.

> *The change from a flowing river, to a lake environment for most of the upper reaches of the Mekong Mainstream in the Lao PDR will result in the loss of important habitats.*

Key Concerns

The monitoring programme should be expanded to establish a solid baseline against which changes can be assessed.

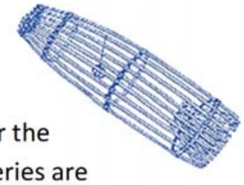
The monitoring system should highlight water quality and ecological health issues. During the construction period the system should alert the operators so that they can respond to problems encountered.

No budget is provided for the environmental monitoring.

The institutional arrangements for environmental management are outlined, but it is unclear how the plan will be implemented and enforced.

The loss of flowing water habitat, over and above that already lost to the Xayaburi, Pak Beng and Pak Lay HPPs will significantly alter the ecology of the Mekong mainstream in the northern Lao PDR

Fisheries



The Socio-Economic Importance of Fisheries Resources

The Mekong River System has the world's second largest fish diversity (after the Amazon) and the largest inland fishery with a value of some $7 billion. Fisheries are vital to sustaining the livelihoods and food security of many of the rural poor in the basin. However, many of the targeted Mekong fish species are migratory. It is therefore important to enable upstream and downstream migration and the inclusion of fishpass facilities at mainstream HPPs has become standard practice.

> *There is likely to be a reduction in the total fish catch in the area of the LPHPP, and this may impact on livelihoods.*

While most of the fisheries productivity is in the reaches below Vientiane, considerable fishing activity takes place in the LPHPP area, mainly based on the migratory fish species. It has been estimated that some 40,000-60,000 tons/yr of fish are caught in the river system in the upper zone. Fishing generally occurs during the period of upstream migration of many species and is associated with increasing water levels. However, migratory species are not the only ones captured; a wide diversity of finfish species is found in the markets, including the non-native species, plus a range of amphibians, snails and Crustacea. MRC Council Study has estimated a 40% reduction in short distance migrating whitefish.

Fisheries surveys were carried out and the diversity of fish caught reflects what is expected from the region, but the number of individuals caught was low. The sampling is however too limited to provide a good assessment of the fish community and population structures and establish a baseline for assessing changes. An extensive review of the fisheries in the Lower Mekong Basin is provided but does not make use of the information provided in the MRC fisheries database.

The fish sampling was supported by fish species surveys at local markets and interviews of fishermen. However, these did not include assessments on recent trends in catches, especially since the construction of Xayaburi HPP. It is therefore recommended that the fisheries surveys are expanded as soon as possible to establish a better baseline.

The social impact assessment suggests that fishing is not the main occupation among local villagers in the project area, but that between 24% and 50% of households are engaged in fishing. No indication of the contribution of fishing to income or food security is provided. A few households indicated that they have fishponds / tanks, presumably as some part of a fish farming activity, but the income generated is minimal. This suggests that some households may have the skills, but not necessarily the resources or infrastructure, to farm fish on a wider scale.

The developer notes that fisheries will be adversely affected by the disruption to migration and notes the potential loss of endangered and threatened species. The wild caught fisheries are likely to be compromised by the construction of Luang Prabang, as well as the rest of the upper Lao cascade. However, there is a proliferation of non-native common carp and tilapia from fish farms in the markets, which could potentially substitute for any loss of the capture fishery. But this source of fish will not benefit rural communities which do not have the capital or funds to establish aquaculture production units.

Fish Migration

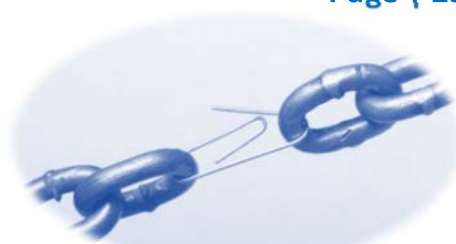
Why is Fish Migration Important?

Many of the fish species that form most of the catch are migratory and must move up and down stream to complete their lifecycles. There are three main migration systems in the Mekong mainstream, the lower zone below Khone Falls, the zone upstream from the falls to Vientiane and the third zone upstream of Vientiane. However, there are also many species that migrate between these zones, and some species (possibly as many as 30 and mostly commercially valuable white fishes) that migrate longer distances between zones. These require unobstructed passage upstream, as well as the capacity for adults, larvae and juveniles to migrate or drift downstream.

The LPHPP site and reservoir area are in Zone 1, which is associated with the spawning habitat of several important species, and which make up most of the catch in the upper zone. The LPHPP will affect these migratory patterns and inundate the spawning habitats of these species. There is likely to be a proliferation of non-native species, particularly common carp and Nile tilapia, which benefit from the changed environment. The dam will also likely inundate many deep pools that act as refuge areas for fish during the dry season.

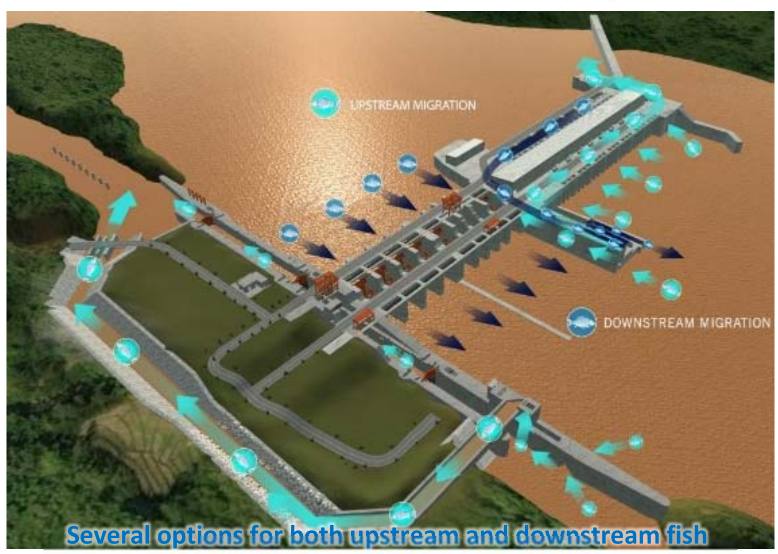
Principles of Fish Passage Design

Fish pass infrastructure requires consideration of several interlinked factors all of which must function well to allow fish to pass the dam in both an upstream and downstream direction. The weakest link in this chain of factors will determine the efficacy of the complete fish passage. Similarly, if fish can pass upstream but their spawning habitat is not available, or if the juvenile and larval stages can't pass back downstream their numbers will decline



The efficacy of the fish migration facilities is determined by the weakest link in the chain of factors required.

Migratory fish in tropical systems where hydropower has been installed have therefore typically died out. This has, however, yet to be demonstrated in the Mekong mainstream, and the inclusion of fishpass infrastructure and operations is recommended in the PDG 2009.



Several options for both upstream and downstream fish passage have been provided.

The developer has chosen to use the Xayaburi fishpass facilities as a basis for the LPHPP, including several options for both upstream and downstream migration. However, most of these facilities could be refined or modified to improve their functionality. These measures are highlighted on the following page.

RECOMMENDATIONS FOR THE FISHPASS FACILITIES

Upstream Passage

- Change minimum design flow from 1,170 to 793 m^3/s this will ensure that fish can find the entrances at lower flows. *The developer has however indicated that the flows are unlikely to be as low as in the past.*
- Add benthic fishway entrances and shape thalweg to guide migratory bottom fish. – *The developer has indicated that ramps will be built to guide the fish.*
- Add spillway entrances for fishways and optimise using physical modelling.
- If fish lock design is pursued, increase lock chamber length and entrance chamber length.

Downstream Passage

- Assess larval drift at various flows with hydraulic modelling and review reservoir management, if necessary.
- Change debris screen design to have a more acute angle to guide fish to the bypass; and design screen to ensure there are low water velocities to prevent impingement. – *The developer has indicated that this is not possible as the cleaning rakes need vertical screens.*
- Investigate a simple pressure acclimation weir in front of the turbines.
- Provide data on blade strike, shear and pressure of the turbines; and the size of fish passing through the debris screens. – *The developer has indicated that these studies have been done, but the results have not been shared.*
- Spillway: Use radial gates fully open to reduce impacts on fish, or replace radial gates with an overshot design, or use overshot gates within all the radial gates. Ensure design of radial gates and spillway has a smooth path for fish.

Passage during Construction

- Do detailed hydrodynamic or physical modelling for the Stage 1 coffer dam and provide a dedicated fish passage solution if required.
- Investigate using the navigation lock for fish passage.

RISK ASSESSMENT

The MRC fish passage expert team have evaluated the risks to fish migration by assessing the likelihood of impaired fish passage, and the consequences of that on the migratory fish populations. Those risks that are *Very High* or *High* are the highest priorities to address in any revised design.

Key: Low | Moderate | High | Very High

		Consequence				
		Insignificant	Minor	Moderate	Major	Critical
Likelihood	Very likely	M	M	H	VH	VH
	Likely	M	M	H	H	VH
	Possible	L	M	M	H	VH
	Unlikely	L	L	M	M	H
	Rare	L	L	M	M	H

The risks before and after the measures outlined above are outlined on the following page.

Risks Before Additional Measures

	Upstream Migration			Downstream Migration			
	Limited attraction and entry into fish passage facilities	Limited ascent of fishway	Ineffective exit – risk of fallback	Limited passage through impoundment	Limited attraction and entry into fish passage facilities	Mortality passing Luang Prabang site – including spillway and turbines	Poor exit; risk of predation downstream
Life Stage							
Larvae & fry	N/A	N/A	N/A	Very High	Very High	Moderate	Moderate
Small-bodied species (5 -30 cm)	High	Low	Low	Moderate	Very High	High	Moderate
Medium-bodied (30-150 cm)	Very High	High	Low	Low	Very High	High	Moderate
Large-bodied (150-300 cm)	Very High	Very high	Low	Low	Very High	Very High	Low
Behaviour							
Surface	Low	Low	Low	Low	Very High	High	Moderate
Mid-water	Moderate	Low	Low	Low	Very High	Very High	Moderate
Benthic (including thalweg)	Very High	High	Low	Low	Very High	Very High	Moderate
Migration Flow							
Low (dry season)	Moderate	Moderate	Low	Very High	Very High	Very High	Moderate
Moderate (early wet, late wet)	High	Moderate	Low	Moderate	High	High	Moderate
High (wet season)	Very High	High	Low	Low	Low	Low	Low
High Biomass	High	High	Low	Low	Very High	Very High	High

Key: Low Moderate High Very High

Risks After Recommended Measures Are Applied

	Upstream Migration			Downstream Migration			
	Limited attraction and entry into fish passage facilities	Limited ascent of fishway	Ineffective exit – risk of fallback	Limited passage through impoundment	Limited attraction and entry into fish passage facilities	Mortality passing Luang Prabang site – including dam turbines	Poor exit; risk of predation downstream
Life Stage							
Larvae & fry	N/A	N/A	N/A	Very high	Moderate	Moderate	Moderate
Small-bodied species (5 -30 cm)	Moderate	Moderate	Low	Low	Moderate	Moderate	Low
Medium-bodied (30-150 cm)	Moderate	Moderate	Low	Low	Moderate	High	Low
Large-bodied (150-300 cm)	High	High	Low	Low	Moderate	Very high	Low
Behaviour							
Surface	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Mid-water	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Benthic (including thalweg)	High	Moderate	Low	Low	Moderate	High	Moderate
Migration Flow							
Low (dry season)	Low	Low	Low	High	Moderate	High	Moderate
Moderate (early wet, late wet)	Moderate	Low	Low	Low	Moderate	Moderate	Low
High (wet season)	High	Low	Low	Low	Low	Low	Low
High Biomass	High	High	Low	Low	Moderate	Moderate	Moderate

Key: Low Moderate High Very High

This risk assessment highlights that for upstream passage, large and benthic fish are disadvantaged in the present design, and the design is more effective at low flows than at higher flows. Downstream passage has greater risks overall, again with larger and benthic fish more disadvantaged. Applying all the recommendations reduces most of the risks but leaves two that are very high i.e. i) maintaining drift of larvae through the impoundment and ii) passing large-bodied fish downstream the dam, particularly at the debris screens. These two risks can be mitigated in theory, but both would potentially require a major change in the operations the LPHPP, and an innovative approach to hydropower and fish passage. These measures are discussed in the section on cumulative and cascade effects. If these risks eventuate, they would severely impact the sustainability of the species impacted, affecting populations upstream and downstream, potentially with transboundary implications.

Alignment with the PDG 2009

The current design of the fishpass facilities for the LPHPP does not align with the PDG 2009 in the following ways[4]:

- Alternative fishway options have not been considered and evaluated. The design favours surface-dwelling species and is less effective for benthic species. The entrances at the spillway do not accommodate different flow patterns and zones of fish attraction.
- The proposals for downstream passage do not include options for the drift of larvae through the reservoir or the mortality of fish passing through the trash screens.
- The lock chamber sizes are small and the relationship to fish passing the other dams in the cascade has not been fully explored.
- The limited baseline surveys preclude any assessment of the impacts of the fish passage facilities on local species diversity and biomass.
- Little information is provided on the hydrological and hydraulic conditions in and around the dam site and proposed fish passage facilities.
- No adaptative management programme is envisaged and no contingency funds have been identified should adaptation of the fish passage facilities be required.

Key Concerns

- The planned baseline monitoring should be initiated as soon as possible.
- Greater consideration should be given to the importance of fish of high conservation value and the overall importance of fisheries to livelihoods and food security.
- Ongoing discussions on further improvements should form part of a post prior consultation process, facilitating interaction between all the fish passage and fisheries experts.

[4] When evaluating compliance, due consideration was given to LPHPP being immediately upstream of Xayaburi HPP.

Dam Safety

Why is Dam Safety Important?

Large dams pose significant risks to downstream communities if they fail, causing both economic damage and loss of life. Dams must therefore be built to agreed design standards. This is particularly important in the LPHPP case, as Luang Prabang City is only 25 km downstream, and the Mekong mainstream between the city and dam site and beyond is heavily used by tourist boats.

> *The geological investigation provides a good basis for assessing the foundation conditions for each of the major structures. However, additional investigation will be required.*

Geology and Seismic Studies

The developer has undertaken an investigation of the geology of the dam site and presents a detailed description of the initial ground investigation and geological mapping of the project area. The geological studies have considered the regional faults and fault zones and seismology / seismo-tectonic situation. These studies have found that the project site is within a relatively stable block between main sections of the seismically active Dien Bien Fu Fault Zone.

There were some anomalies found, suggesting that the geology was coincident with the valley bottom of a small tributary. This was further investigated, and the geological maps will need to be updated to include this and any other details found from further studies. Water pressure testing in boreholes found varying values but incidences of high permeability were noted. Further testing should be considered in this regard.

Construction materials will primarily be sourced from quarrying limestone of which five possible outcrop locations were identified. However, only one location was investigated. Karstic features were found within these limestone outcrops, but the developer has verbally indicated that this is not present in the area to be inundated. The reservoir is, therefore, not expected to leak.

The recent earthquake near the Xayaburi Dam has highlighted thorough investigation of the seismo-tectonic situation. The documentation provides a description of the nearest active notes that the nearest active fault is 8.6 km from the project site. The seismic hazard assessment indicates that the LPHPP lies in a moderate to high seismicity region. However, the design standards proposed are substantially higher than the guidance values proposed in the Lao Electric Power Technical Standards (LEPTS 2018).

The earthquake design standards exceed those required by the Lao Electric Power Technical Standards

Flood Design Standards

The Feasibility Report proposes that the infrastructure should be designed for a 1:10,000 year flood event, with the Probable Maximum Flood (PMF) used as a check flood[5]. This is consistent with the PDG 2009 requirements and aligns with the Xayaburi Design Standards. However, the LEPTS 2018 places the Luang Prabang dam in the “Extreme Risk” category and requires that the spillway passes the PMF as the Inflow Design

[5] The Design flood is the flood that will safely pass the structure without any damage. The PMF will safely pass but may cause minor damage.

Flood. It is therefore recommended that the Government of Lao PDR and the developer discuss and agree the standards to be used.

There is no reference to the potential implications of dam failure at the upstream Pak Beng HPP or other upstream dams. However, it is unlikely that these will significantly exceed the PMF at Luang Prabang, but for completeness the developer should demonstrate that this is the case.

Spillway Discharge Capacity

The proposed geometry of the surface and low-level outlet spillways and stilling basins is the same as adopted at Xayaburi, although the number of gates is different. The head differences across the two projects is also slightly different depending on the inflows. The Feasibility Study assessment of spillway capacity for Luang Prabang has been based on the Xayaburi model tests. This is useful as a first approximation for the Luang Prabang spillway capacity but a physical model reproducing the conditions at the Luang Prabang project is required.

The developer has verbally indicated that these tests are underway, but no results have been shared. It is recommended that these results are shared as part of any post prior consultation process. The developer has also verbally indicated that a conservative freeboard has been provided as an additional safety margin.

> *"It is important that the spillway gates remain operational even under extreme conditions. It is therefore recommended that additional backup systems are considered.*

The reliability of gate operation is a key consideration for dam safety and international standards recommend that the model tests are done assuming one gate is not operational. This was done for the feasibility level designs. However, a broader consideration of gate reliability is also required. Loss of grid connection and power supply under extreme weather conditions is possible and must be factored in.

The Feasibility Study report indicates that a standby diesel generator will be provided at the powerhouse. However, configuring the hydraulic pumping sets for the gates such that there is some interconnection and redundancy between gate systems and gates can be opened by adjacent hydraulic units could also be considered. Moreover, in view of the extreme consequences of gate operation failure, the developer may contemplate an additional backup system. Similarly, a robust design for the gates, supporting structures and operating system is required so that the system remains completely undamaged following the Operating Basis Earthquake and fully operational after the Safety Evaluation Earthquake.

The developer should also investigate the speed of gate opening, since failure to respond quickly may cause unacceptable and unsafe water level changes both upstream and downstream. It is not clear how long the current arrangement of radial gates would take to respond, particularly if the primary source of power was not available. The possibility of providing a rapid response facility in the spillway arrangements should therefore be examined. The requirements for opening times, redundancy and security of spillway gate operation are not considered in the Feasibility Study report.

Energy Dissipation and Erosion

The physical model test report does not provide any information on the efficacy of the energy dissipation structures or the potential for erosion in the riverbed downstream. This should be considered since erosion propagating upstream could undermine the stilling basin structure and result in progressive failure of the structure. The geological model suggests that this may be a possibility, and this should also be investigated in the physical model.

Flood Management

> *A cascade flood management system should be developed that includes sediment management fish larval drift considerations, and flood management.*

Effective flood management requires an early warning of inflow flood conditions. There is consequently a need for an upstream hydrometric network and effective communication with upstream projects. The developer has indicated that this is being addressed. The most efficient spillway release strategy can then be devised and included in the operating rules for both the LPHPP and the Xayaburi HPP. However, a cascade flood management plan should be developed with the Government of Lao PDR, which addresses all the HPPs in the cascade.

River Diversion (Coffer Dams)

River diversion will be achieved by constructing the right bank structures (navigation locks, spillways and powerhouse) first, in a single coffer dam and confining the river to the left channel (looking downstream). The cofferdam around the right bank works will be designed for the 100-year flood. Whilst this is a typical figure for flood security during river diversion the probability of the cofferdam overtopping is considerably greater than a failure during the operating phase. Some form of upstream flood forecasting system would therefore be advisable before construction starts so that the works can be safely evacuated if there is a risk of overtopping.

Design Standards

The design standard specified for stability in the Feasibility Study report is based on the US Army Corps of Engineers, which is a standard reference for gravity dam stability. The LEPTS 2004 and 2018 also provide specific requirements for the stability of concrete dams. These requirements are more stringent than the factor of safety of two required by the US Army Corps of Engineers.

The Feasibility Study does not describe how the foundation strength parameters were determined. It is therefore not possible to comment on the adequacy of the designs proposed. The critical section is likely to be the Closure Dam in the left channel. It is probable that the critical case for stability is not the maximum flood condition, and the conditions with the highest differential head should be used to support the design process

A specific loading condition for the powerhouse is the potential for floatation when tailwater levels are high. Pumps are provided to maintain dry, accessible and serviceable conditions at the base of the powerhouse and in the foundation galleries for the spillway and closure dam section. The operation of these pumps will reduce uplift pressures in the structure foundations and enhance stability. The pressure in the foundation drainage system for stability calculations must be based on the tailwater level or the elevation of the gravity exit point from the drainage system, whichever is the highest.

Panel of Experts

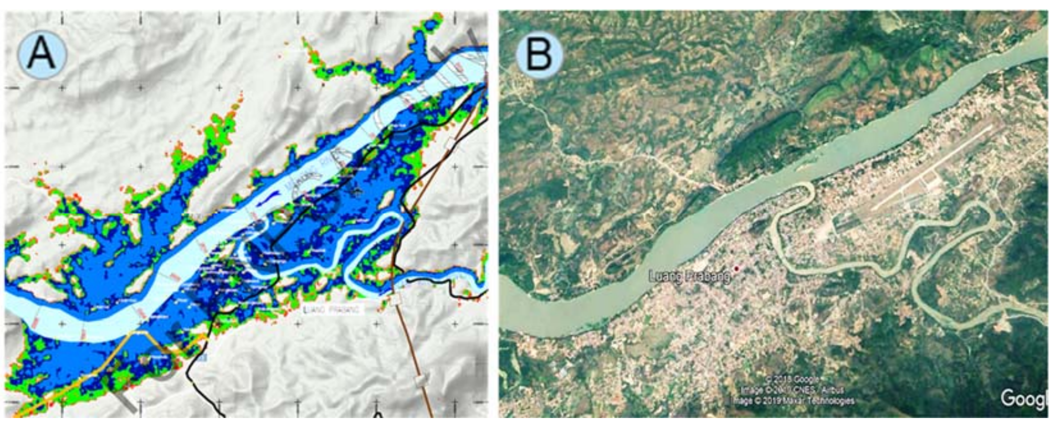
The Feasibility Study report does not refer to the appointment of a Dam Safety Review Panel as is required by the ICOLD and World Bank Operating Policies. These advise that the Panel should be appointed as early as possible in the project development when investigations are in progress and layout decisions are being made. The Terms of Reference for the Panel are often extended beyond dam safety to cover broader issues of project formulation such as construction procedures, river diversion and power generation facilities. It would be beneficial if similar Terms of Reference were adopted for the LPHPP. The LEPTS 2018 does not make any specific reference to the appointment of a Dam Safety Review Panel. However, this is recommended in the PDG 2009.

> *A Panel of Experts should be established as soon as possible, as is recommended by the PDG 2009, ICOLD and World Bank Guidelines.*

Emergency Preparedness Planning

An Emergency Preparedness Plan should be developed before the first impounding when structures are loaded for the first time and much higher levels of monitoring and rapid response are required.

The Feasibility Study report provides a general discussion of the requirements for an Emergency Preparedness Plan, which is appropriate at this stage of the project development. Dam break studies have been undertaken that will form the basis of the Emergency Preparedness Plan. The inundation maps show that the flooded areas downstream are very similar for the 10,000 year flood, the PMF and the dam break event.



The modelled inundation of Luang Prabang City under an extreme 10,000 year flood, and under a dam break scenario is similar

The city of Luang Prabang will be flooded under any of these events. Dam safety, flood management and notifications to downstream communities are matters of extreme importance for any major dam development. The potential to impact a UNESCO World Heritage site further emphasises the need to adopt the very highest standards of dam safety and emergency warning for this project.

The Feasibility Study refers to a "Potential Failure Modes Assessment (PFMA)" but does not present a formal failure modes assessment. This is reasonable at this stage, but a failure modes assessment should be undertaken for the detailed design stage. The output of the assessment will inform the scope of further ground investigation, the development of the Dam Safety Management System, the Emergency Preparedness Plan and the Instrumentation Plan.

Instrumentation

The Feasibility Study provides an initial indication of the instrumentation that will be provided. The final requirements can be determined later in the development of the project when foundation conditions have been fully exposed, and a detailed failure modes assessment has been undertaken. A detailed instrumentation plan is required by World Bank OP 4-37, but not at the Feasibility stage. There is a list of instrumentation in the Feasibility Study report, but this should include additional instruments. The developer has verbally agreed to consider additional instrumentation in this regard.

> *The Feasibility Level design is broadly consistent with the recommendations in the PDG 2009. However, more work is required for the final design. This should be shared as part of a post prior consultation process.*

Alignment with the PDG 2009

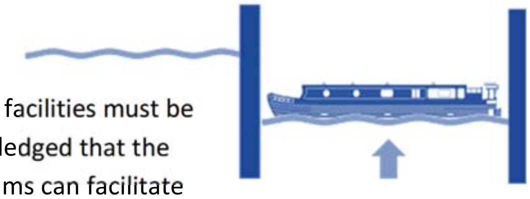
The Dam Safety considerations are broadly in line with the requirements of the PDG 2009 for this stage of the project development. However, key features of the dam safety requirements need to be addressed in the final design stage. It is recommended that these are taken up as part of a post prior consultation process.

Key Concerns

- Agreement on whether the more stringent LEPTS 2018 standards should be followed is required.
- A post prior consultation process should confirm whether the additional studies and instrumentation has been included in the final designs.

Navigation

Why is Navigation Important?



The 1995 Mekong Agreement indicates that navigation facilities must be incorporated into any mainstream project. It is acknowledged that the impounded sections of the river behind hydropower dams can facilitate navigation making it safer, if navigation locks are incorporated into the design of the HPP.

Main features

> *The navigation facilities are like those at Xayaburi and are broadly consistent with the PDG 2009.*

The navigation lock will be located along the right bank and will require extensive excavation works. The developer indicates that this option provides for safer navigation, but that this has the drawback that the navigation facilities lie alongside the spillways potentially posing a danger to navigation when the spillways are in operation. This has been considered as outlined below. The navigation facilities are designed to be operated for 95% of the time and will only be shut down in large floods. The navigation structure is a two-step navigation lock system for 2x500 DWT vessels. The locks are designed to divide the maximum lifting height of 35.5m divided into two equal parts, as recommended by the PDG 2009, with a design like the tandem ship lock at the Xayaburi HPP.

The locks include three miter gates, an upstream, middle and downstream gates. The filling of the chambers of the Navigation Lock is done via a gravity- based feeding system from the headwaters of the plant controlled by bonneted gates. The lockage time for the two-step ship lock is expected to be shorter than 50 minutes.

The drawings indicate the maximum chamber length is in the order of 125 m, which is more than what is recommended in both the PDG 2009 and draft PDG 2019. The bridge over the upper ship lock has enough air clearance for all normal operating conditions.

Navigation During Construction

The Stage 1 coffer dam will restrict the flow in the remaining channel increasing flow speeds and potentially impairing navigation.

The Mekong from Luang Prabang City up to the LPHPP dam site and beyond is heavily used by tourist boats from the town. Construction activities may affect the attractiveness of this stretch river for tourist boats, and this may continue into the operational phase. It is therefore recommended that the developer engages with the boat operators to gauge their perceptions of the proposed HPP, and the use of the navigation lock. It is also recommended that the average number of boats travelling up past the dam site is determined before the main construction activities are started to establish a baseline. The developer has indicated that the Mekong Boat operators were given training in the use of the locks at Xayaburi, and rapidly became accustomed to its use. Similar training is recommended at the LPHPP.

The right bank coffer dam will be in place for some 5 years. During this time the water in the remaining constricted section of the river will be flowing much faster than normal, and special arrangements for navigation will have to be made during this period. The developer has indicated that the smaller boats will be put on a trailer and transported around the construction, following the success of the practice at Xayaburi. However, they are still exploring options for the larger tourist vessels, perhaps including pulling boats.

FILLING AND EMPTYING SYSTEMS

The filling of the chambers of the Navigation Lock is done via a gravity- based feeding system from the headwaters controlled by bonneted gates. The bottom filling system consists of 7 diffusers with 5 openings each. However, the drawings do not indicate baffler beams to avoid strong vertical flows during filling. This may create mushroom shaped upward currents that will shake the vessels and the boats inside the lock chamber. However, the developer has presented the results of the CFD modelling during the site visit, which may address this concern. However, these results should be formally presented.

The developer suggests a single culvert filling system with three gates. However, it is recommended that the culverts in the chamber walls are doubled. This can reduce the current velocity limiting the risk of cavitation and increasing reliability dramatically.

LOCK EQUIPMENT

The Feasibility Study only provides a brief description of the lock equipment (ladders, floating bits, wall armours, line hooks, etc.). The drawings suggest that these are appropriately located, although there is no information on the numbers or exact location of this equipment. However, if this is also copied from the Xayaburi HPP, the design would be considered acceptable.

Both lock chambers are long enough to accommodate the stoppage equipment, although the stoppage equipment just downstream of the middle gate is not needed. Ships entering the lock cannot hit the gates because of the concrete wall which separates the two locks. The third stoppage system, just downstream of the upper miter gate, is therefore not required.

Moreover, there is no detail of the stoppage-system that will be used although the text mentions a cable stoppage. However, these details can be decided in a later stage if there is enough leeway to keep the vessel away from the miter gate.

APPROACH CHANNELS

The approach channels will lie behind two islands that will be left over from the excavation works. However, the upstream island may obstruct the view of the locks and shipping in the resting areas, potentially posing a safety risk.

While reference is made to the PIANC recommendations for the access channels and the three areas in front of the ship lock, the documentation only mentions a single lay-by area, whereas the PIANC guidelines recommend 3 areas. These areas must be linked to the mainland and must include provision of fresh water, waste collection and power supply. The developer has verbally indicated that this is planned.

Ship Dimension Design Standards

The developer refers to European classification systems. These are not applicable to the Mekong, which uses the Chinese ship classification. These indicate that the navigation facilities should accommodate the 500 tonne Chinese self-propelled barge and a push convoy of 2 barges with a pusher. The ship lock chamber dimensions are, nonetheless, consistent with these requirements. However, it is recommended that the updated PIANC guidelines are consulted at the final design stage.

Operation Safety and Maintenance

> *It is recommended that further attention be given to the maintenance of the lock equipment and that spares are kept on site.*

The Feasibility Report deals with the operation of the navigation lock system and proposes keeping the tandem ship lock open on both sides (upstream and downstream) when no navigation is occurring. This will potentially improve fish migration but will reduce the volume of water available for power production.

However, no information on safety and maintenance of the navigation facilities has been provided. It is recommended that a list of mechanical ship lock spare parts is prepared, and spares are kept in stock in order to reduce the outage times for repair and maintenance. The electromechanical equipment of the ship lock should be simple, straightforward, easy to maintain and reliable. An overhead crane over the full length of both lock chambers and ship lock heads should be considered for bringing in spare parts, stop-logs, lifting sunken debris in the chamber, rescue operations, or other emergencies.

Alignment with the PDG 2009

The main features of the navigation facilities are consistent with the PDG 2009. However, the lack of detail on the equipment required needs attention. The recommendations made should be considered in the final design stage.

Key Concerns

- The requirements for maintenance and spare parts need more attention in the final design stage.

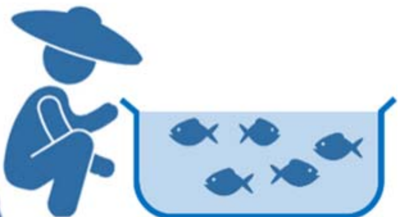
Socio-Economic Issues

Why are Socio-Economic Issues Important?

The generally accepted practice, and Lao PDR legislation requires that all livelihoods that may be affected by the project be restored the same or better level than before the project. A systematic SIA would therefore describe the baseline situation (pre-project), predict the impacts of the project (before mitigation measures are applied), define mitigation measures (following the hierarchy of avoid, minimise, and mitigate) and evaluate the residual impacts after these measures are applied.

The socio-economic baseline

The developer's methodology to determine a baseline involved desk studies, field surveys including household census, and village interviews and meetings. Baseline information for the population living close to and potentially affected by the project is provided for four different groups of Project Affected People (PAP):



- PAP-1 – fully submerged – 6 villages, 581 HH, 2,885 persons
- PAP-2 – partially submerged – 9 villages, 692 HH, 3,855 persons
- PAP-3 – lose farmland – 8 villages, 671 HH, 2,330 persons
- PAP-4 – downstream affected by construction – 3 villages, 189 HH, 904 persons

The total number of PAPs included in the SIA is therefore 9,974 (not all of whom will be directly affected, but who live in villages which will experience different levels of impacts). The main livelihoods for these people are cultivation of rice, complemented by vegetables, fishing, livestock raising, harvesting of timber and non-timber forest products (NTFP), manual labour outside the villages, and activities related to trading, boating and tourism along the river. Average annual household incomes are estimated at LAK 40 million / year, equivalent to approximately USD 4,600 / year or USD 1,000 per capita and year. This is plausible, compared to Laos' 2018 GDP per capita of USD 2,600 / year. Average land holding is estimated at 3.3 ha per household.

Baseline information on health and nutrition is very limited, and there is no baseline information on potentially affected people along access roads, in resettlement areas (future host communities), in the transmission line corridors[6], or further upstream or downstream along the Mekong River.

Expected Impacts and Mitigation Measures

The adverse impacts are generally described qualitatively, not quantitatively. Some of them are differentiated by pre-construction/construction vs. operation phase, and their significance (very high to very low) is determined using the concepts of intensity, extent, and duration. However, the SIA summarizes impacts by broad categories and does not provide the significance for all possible impacts.

While the impacts on PAPs in the 26 villages are described quite comprehensively, the impacts on potentially affected people along access roads, in resettlement areas (future host communities),

[6] The power purchase arrangements, and hence the transmission lines, still must be finalised.

or upstream or downstream along the Mekong River are only described briefly. Consequently, there are no specific mitigation measures identified for these impacts.

The documentation provided describes mitigation measures for impacts on fisheries, sediment, water quality, dam safety, and navigation. These mitigation measures will have indirect social benefits. Based on the identification of potential impacts, the SIA only provides brief principles, recommendations or statements of intent, for several social mitigation approaches. The Social Monitoring and Management Plan (SMMP) contains descriptions of mitigation measures with different levels of detail. For some, there is only a statement of intent. Other measures are described in more detail.

The SMMP also includes institutional responsibilities, implementation schedules, and internal and external monitoring plans. While the Resettlement Action Plan contains more detailed mitigation commitments than the SMMP, specifically for the resettlement-related measures, neither of them contains a budget.

Residual Impacts After Mitigation

Residual impacts that will remain after mitigation are not addressed in the Feasibility Study reports.

Mitigation Measures

Mitigation measures related to the physical and economic displacement of people in the immediate project area are relatively well defined. The Resettlement Action Plan (RAP) describes some objectives, principles and overall outlines of mitigation measures, although there are no budget estimates provided.

Mitigation measures for households, businesses and villages which are not directly displaced, but are further upstream or downstream of the project, or will function as host communities are less well defined. It is uncertain whether the same objectives with regards to livelihoods and living standards apply to these groups, and which mitigation or compensation measures will apply to them. Impacts on different livelihoods based on the river are not likely to be limited to the 26 PAP villages.

Despite a strong dependence of livelihoods along the Lower Mekong Basin on the river and its eco-systems, potential social transboundary impacts which have been the subject of much discussion in the Mekong region over the past years are not covered. It is recommended that the approaches taken in the MRC Council Study and other assessment tools developed by the MRC, which are based on the best available methodologies and good practice, are used.

Residual Impacts

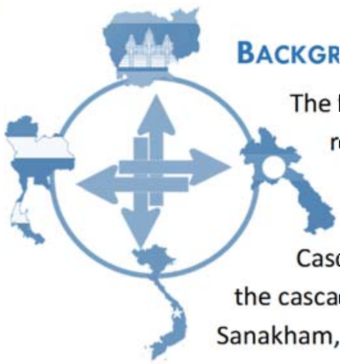
There is no discussion of the anticipated effectiveness of the mitigation measures and any risks that might impact these. The conclusions on residual downstream impacts are vague. General concerns are quoted about the impacts of mainstream dams on nutrition. However, the impacts are downplayed as “not that significant”.

> *The downstream and upstream impacts and mitigation measures should be outlined more consistently and should cover the whole basin.*

KEY CONCERNS

- The Feasibility Study makes very little use of existing, often more recent information at member country and MRC level.
- The baseline information on the locally affected PAPs is up to date with surveys from 2019. However, it has some gaps, especially regarding river-related livelihoods (fishing, different categories of boating, gravel extraction etc.)
- There is no baseline information or mitigation measures on / for populations in the downstream or upstream zones, although it is acknowledged that there could be impacts, for example, on fish migration and therefore nutrition.

CUMULATIVE AND TRANSBOUNDARY IMPACTS

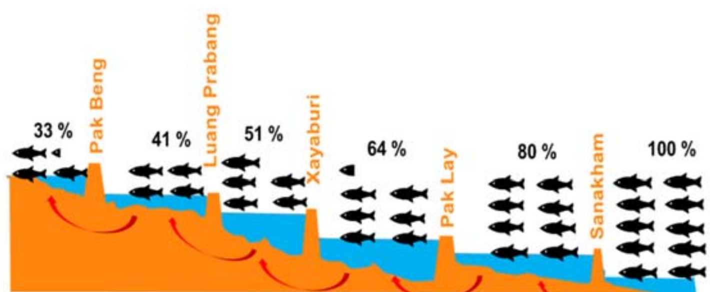


Background

The focus of the prior consultation process is on the notified project, and recommendations are made after reflecting on the impacts the proposed use will have over and above the existing projects, and those that have been notified. However, the LPHPP is the 4th HPP in the upper Lao Cascade to undergo prior consultation. This makes the cumulative impacts of the cascade an increasingly important consideration. This includes the impacts of the Sanakham, Pak Lay, Xayaburi, Luang Prabang, and Pak Beng HPPs in succession. This section considers the cumulative impacts of the full upper Lao Cascade, with an emphasis on the potential transboundary impacts.

Impacts on fisheries

Because no fishpass will be 100% effective, some fish will be lost at each HPP in both the downstream and upstream directions. The situation can be simplified as follows: assuming that of all the fish arriving at the proposed Sanakham HPP, only 80% pass successfully (which is an ambitious target), then at Pak Lay 80% of the remaining fish pass i.e. 64% of those arriving at Sanakham, then at Xayaburi again 80% of the remaining fish, i.e. 51% and so on. Ultimately, only 33% of the fish arriving at Sanakham would make it past Pak Beng, and this with a relatively high efficiency fish pass system in place at each HPP in the cascade. The reverse happens with downstream larval drift. While this is an oversimplification of several factors, it is still illustrative of the cumulative impacts of the full cascade.



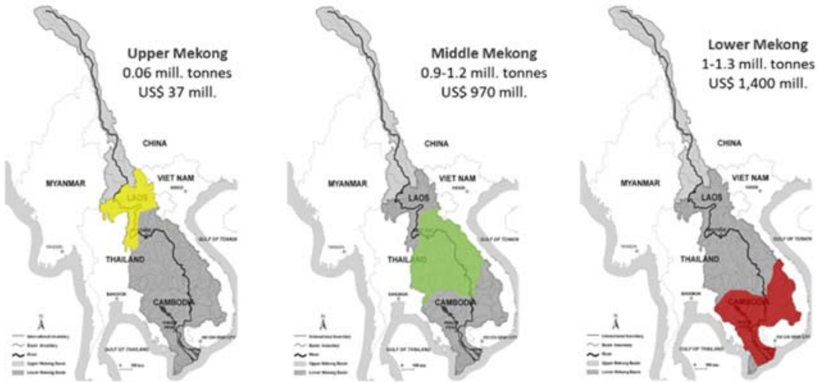
Successive fish pass facilities mean that very few migrating fish will make it past the full cascade

The fisheries impacts are complicated by the fact that fish are migrating upstream to spawn, and this in many cases requires flowing water habitats. If spawning does not occur, or is limited in any way, downstream larval drift and recruitment to downstream fisheries will decline. For this reason, migrating fish species in tropical river systems tend to die out when hydropower is installed. The LPHPP Feasibility Study reports indicate that the flowing water habitat upstream of the Pak Beng reservoir should therefore be preserved. However, the upper Lao Cascade will leave virtually no flowing water habitat from the Sanakham HPP to the Pak Beng HPP backwater at the Khe Phi Dai reef, and very few migrating species are likely to make it past all five reservoirs and HPPs to this area.

Nonetheless, there may be other species that could thrive in the upstream reservoir areas, and some cage fish culture could also compensate for some of the lost capture fisheries – if financial and technical expertise could be provided to support local communities to start these enterprises.

However, much of the upper Zone lies entirely within the Lao PDR, except for that area upstream of the Khe Phi Dai reef.

Most of the capture fisheries in the upper zone is made up of the migratory whitefish species. The Council Study, estimated that 40% of the fisheries in the upper Mekong Zone would be lost due to the upper Lao Cascade. This would have an impact on the local capture fisheries and communities.



The volume and value of capture fisheries is much higher downstream of Vientiane. Impacts of impaired migration are therefore much greater

However, as the total capture fisheries in the LMB is estimated at 2,560,000 tons per year, these losses in the upper zone are a small fraction of the total. The impact of the upper Lao cascade will, however, be felt downstream in the middle and potentially lower fisheries zones through disruption of whitefish migration and loss of spawning habitat.

> *The 40% loss of migratory whitefish species in the upper Zone estimated due to the upper Lao Cascade, makes up less than 1% of the total capture fisheries in the LMB. A smaller proportion of this will be transboundary in nature.*

This will not be the case if HPP are constructed downstream of Vientiane, where the amount and value of the capture fisheries is several orders of magnitude higher. It is therefore recommended that as a better picture of the fishpass efficacy at Xayaburi emerges, additional investigations using the Council Study models should be undertaken.

Sediment Transport

The assessment conducted under the Council Study showed that the upper Lao PDR cascade has a substantial impact on sediment transport, accounting for 15% of the overall sediment trapping in the basin (if with China's mainstream dams), or 24% of the total sediment trapped (if without China's mainstream dams). A similar finding was provided by the modelling exercise in the upper Lao PDR, and by the Delta Study, with bedload transport reduced from over 20 MT/yr to < 5MT/yr due to trapping in the upper Lao Cascade and tributary projects. This is, however, a long-term impact emerging after several decades or more.

Without a deliberate sediment routing regime, coarse sediments will accumulate near the top of the reservoir, moving only a few kilometres downstream in each wet season. The sediment delta would gradually progress down the length of the reservoir taking several decades to reach the dam wall where it can be flushed out. Even then compaction of the sediments over the long time period will make flushing difficult. There may be damage to the turbines after the concession period if sediments accumulate near the powerhouse or are mobilised in higher floods, and expensive dredging may be required.

Hydrology

Transboundary hydrological impacts refer to changes to the annual hydrograph, i.e. reducing and delaying wet season flows, and increasing dry season flows. As a Run-of-River schemes the upper Lao Cascade will have a negligible impact on seasonal flows. The larger storage HPP in China, and on the tributaries have already and will further modify the natural hydrology, delaying the onset of the reverse flow into the Tonle Sap. This will impact on fisheries in this highly productive zone.

Measures to Limit Adverse Transboundary Impacts

There are several measures that could be considered to minimise potential transboundary harm, over and above those already being considered by the developers at each HPP. These largely revolve around lowering the operating level of the reservoir and opening the low-level outlets for a period of time. This creates more natural river conditions and transports coarse and fine-grained sediments through the impoundment. It will also maintain flow speeds greater than 0.3 m/s and will hence reduce the losses of drifting fish larvae.

However, this reduces the power output during the drawdown times, and this affects the financial viability of the HPPs and the viability of the concessionaire model. Some initial work undertaken by the MRC showing that the financial losses could be substantial. This measure therefore requires careful optimisation of sediment transport, downstream fish migration, the loss of power potential, the cost of the power, and the length of the concession period.

It is therefore recommended that these cascade operations are investigated by the Lao Government, the MRC and the HPP operators to identify the optimal balance in line with the commitments made by the MRC Member Countries.

COMMENTS, RECOMMENDATIONS AND WAY FORWARD

COMMENTS

The LPHPP developer has made efforts to address the potential impacts largely by incorporating the lessons learnt at the Xayaburi HPP. There has been a greater effort to align with the provisions of the PDG 2009 and to use the MRC data and Reports, even at this early Feasibility Design stage.

However, the review has nonetheless identified issues in the Feasibility Study documents that should still be addressed. These measures should form part of the Statement and may include measures that:

> *The developer has made considerable efforts to address the potential impacts of the LPHPP, largely by incorporating the lessons from the Xayaburi HPP.*
>
> *However, the technical review suggests that there are some additional measures that could be considered.*

- Place the developer in a better position to assess the potential impacts of the LPHPP using improved hydrological, sediment and ecological data;
- Support the redesign of elements of the infrastructure and operating rules to further avoid, minimise and mitigate potential impacts;
- Assist the assessment of the technical and economic feasibility of the revised designs and operating rules;
- Improve the safety of the dam structure and navigation facilities;
- Further minimise the potential for transboundary impacts; and
- Place the Member States in a better position to address the cumulative impacts of the upper Lao cascade, and other HPP developments throughout the Basin.

RECOMMENDATIONS

While the alignment with the PDG 2009 appears adequate at this stage of the project, there has been too little information provided to make a full assessment. This together with the fact that the additional measures proposed in the technical review need to be further discussed and integrated into the final design and operating rules, it is recommended that a post prior consultation process be undertaken. This would aim at discussing the recommendations made by the Expert Teams with the Government of the Lao PDR and integrating these into the ongoing development of the project.

Given the increasing importance of limiting the potential for transboundary impacts through cooperative management of the cascade, it is recommended that these aspects be addressed by the Government of the Lao PDR, the MRC and the developers. This must address the benefits in terms of sediment transport and fisheries, as well as the disbenefits in terms of reduced power output and lost revenue. The aim should be to determine an optimum balance of these aspects.

There are several options to fund additional measures to avoid, minimise and mitigate impacts. These should be further explored in the MRC's Joint Platform, with the aim of developing a clearer concept on how to enable the uptake of the recommendations resulted from the prior consultation process by the notifying State. Similarly, the parallels between implementing additional measures and the reasonable and equitable use of the Mekong River System could be explored by the Joint Platform.

THE WAY FORWARD

This Summary has been based on the 2nd Draft of the Technical Review Report (TRR) and will be used to support the national and regional stakeholder discussions. Feedback from those discussions will be incorporated, together with any final comments from the Joint Committee Working Group (JCWG) and Member States, into the 3rd draft of the TRR. This will be finalised at the 3rd meeting of the JCWG, and submitted to the Member States on 21 March 2020, in preparation for the Special Session of the JC on 7 April 2020. This will be accompanied by the draft Statement.

The JC will propose any final changes and endorse the TRR for uploading to the MRC Website with other existing documents: http://www.mrcmekong.org/topics/pnpca-prior-consultation/luang-prabang-hydropower-project/.