LAO PEOPLE'S DEMOCRATIC REPUBLIC

PAKLAY HYDROPOWER PROJECT

Environmental and Social Impact Assessment
Environmental Impact Assessment (EIA)
Final - February 2020

POWERCHINA

NCG

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome
ANC	Antenatal care
AP	Affected Persons
ARI	Acute Respiratory Infection
ASEAN	Association of South East Asian Nations
C	Degree Celsius
C/E	Cause / Effect
CSO	Car-sharing Organizations
CDR	Crude Death Rate
CFCs	Chlorofluorocarbons
CHAS	Center for HIV, AIDS and STI
CITES	Convention on International Trade in Endangered Species (of wild fauna and flora)
CIA	Cumulative Impact Assessment
CMC	Child Mortality Rate
CO^2	Carbon Dioxide
CPI	Consumer's Price Index
CU5	Children under 5 years ol
DTL	Discipline Team Leader
E &SC	Environmental and Social Culture
ECARS	Environment Components / Activities at Risks
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
EMMP	Environmental Monitoring and Management Plan
FDI	Foreign Direct Investment
FM	Families
FS	Feasibility Study
GEF	Global Environment Facility
GHG	Green House Gas
GOL	Government of Lao People's Democratic Republic
GDP	Gross Domestic Product
GHGs	Green House Gases
GIS	Geographic Information Systems
GWP	Global Warming Potential
Ha	Hectare
HC	Health Center
HH	Households
HIV	Human Immunodeficiency Virus
HPP	Hydro-electric Power Project
IEE	Initial Environmental Examination
IMR	Infant Mortality Rate
IP	In Patients

IPCC	Intergovernmental Panel of Climate Change
IUCN	International Union for Conservation of Nature
km	Kilometers
km^2	Square kilometers
kpm	Kip per person per month
LB	Left Bank (Mekong River)
Lao PDR	Lao People's Democratic Republic
LMB	Lower Mekong River Basin
LNTA	Lao National Tourism Authority
MA95	(1995) Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin
PLHPP	Mekong Paklay Hydroelectric Power Project
MIC III	Multiple Indicator Cluster Survey III
MMT	Million Metric Tons
MOH	Ministry of Health
MONRE	Ministry of Natural Resource and Environment
MOU	Memorandum of Understanding
MRC	Mekong River Commission
masl	meters above sea level
MUSD	Million United State Dollars
MW	Megawatt (1 million watts of power)
NBCA	National Biodiversity Conservation Area
NCG	National Consulting Group
NCHS	National Center for Health Statistics
NGO	Non-Governmental Organization
NPA	National Protected Areas
NTFP	Non-Timber Forest Products
NMRC	National Mekong River Commission
NSC	National Statistical Center
OP	Out Patients
PAP	Potentially Affected People
PCR	Physical Cultural Resources
PMF	Probable Maximum Flood
RAP	Resettlement Action Plan
RB	Right Bank
ROR	Run of River
SAP	Social Action Plan
SIA	Social Impact Assessment
SMMP	Social Monitoring and Management Plan
PL	Paklay
SSC	Suspended Sediment Concentration
STI	Sexually Transmitted Infection
TAT	Tourism Authority of Thailand

TB	Tuberculosis
TL	Team Leader
TCE	Tons CO_2 Equivalent
TOR	Terms of Reference
TWh	Terawatt Hour [(1012) watts]
UCQ	Upstream, Construction/Quarry
UMRB	Upper Mekong River Basin
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
VEC	Valued Ecosystem Components
WB	World Bank
WHO	World Health Organization

1 INTRODUCTION

This Environmental Impact Assessment (EIA) of Paklay Hydroelectric Power Project (PLHPP) contains analysis and assessment of environmental and social characteristics that are potentially affected by the implementation of the project.

The PLHPP would be located on the Mekong River and it is one of the Run-of-River hydro projects currently at the feasibility stage in the Lao People's Democratic Republic (Lao PDR); the aim of these hydropower dams is to stimulate the country's economic development by selling electricity to Thailand and through other positive benefits.

The GOL, CEIEC and Sinohydro Corporation Ltd have entered into a Memorandum of Understanding ("MOU") dated 11th June 2007 (hereinafter referred to as the "MOU") in order to undertake the development of Paklay 770 MW hydroelectric power project and its associated structures and facilities to located on the mainstream Mekong River (hereinafter referred to as the "Project"). With the consent of the GOL and CEIEC, Sinohydro Corporation Ltd transferred its rights and obligations under the MOU to Sinohydro Resources Ltd, a company incorporated under the laws of People's Republic of China, which is an affiliate of Sinohydro Corporation Ltd, by entering into a Novation Agreement on 31 January 2014. Sinohydro Resources Ltd then changed its name into Powerchina Resources Ltd on 24 April, 2015

1.1 Required reports for the PLHPP.

For the scope of work PLHPP 9 reports will be required:

1. Execuitve Summary
2. Environmental Impact Assessment (EIA)
3. Environmental Management and Monitoring Plan (EMMP)
4. Social Impact Assessment (SIA)
5. Social Management and Monitoring Plan (SMMP)
6. Health Impact Assessement (HIA)
7. Resettlement Action Plan (RAP)
8. Access Road IEE
9. Transboundary Environmental and Social Impact Assessment & Cummulative Impact Assessment (TBESIA & CIA)
10. Transmission Line will be studied in later stage once the PPA set out the connection

Note that ethnic minority groups are either living in mainstream Lao communities in the project area or sufficient numbers are not significantly affected by the development of the project. Therefore, an Ethnic Minority Development Plan (EMDP) will not be required; this has been confirmed in discussions with MONRE by the National Consulting Group.

2 PROJECT DESCRIPTION

2.1 Project location

Located on the middle Mekong River in Laos, Paklay Hydropower Station is the fourth hydropower station (from upstream to downstream) of the 11 Hydropower Stations planned for the main stream of Mekong River. Xaiyaburi Hydropower Station is located upstream of it while Sanakham Hydropower Station is located downstream. The dam site of Paklay Hydropower Station is located at 1829km (to the estuary) on the main stream of Mekong River, about 31km upstream from Paklay County and about 241km from Vientiane, the capital city of Laos. The control drainage area at the dam site is about 278,400 km^2 for the geographical location of Paklay Hydropower Station.

As a famous international river in Southeast Asia, Mekong River, known as Lancang River within the Chinese territory, is originated from the north piedmont of Tanggula Mountains in China, passes Qinghai, Tibet and Yunan Provinces (autonomous regions) and leaves China at Mengla County, Xishuangbanna Prefecture, Yunnan Province, from where it is called Mekong River, passes Myanmar, Thailand, Laos and Cambodia from north to south and converges in the South China Sea in Ho Chi Minh City, Vietnam.

With a drop of about 480m, Mekong River has a total length of about 2720km and a control drainage area of 621,000 km^2. The mean annual discharge at estuary is 15062m^3/s and annual runoff is 475 billion m^3. According to statistics of relevant data, the reserve of waterpower resources of Mekong River is about 58,000MW in theory, of which the exploitable waterpower resources are about 37,000MW. The exploitable waterpower resources of Mekong River mainly concentrates in Laos and Cambodia, accounting for 51% and 33% respectively, as well as in other countries (Myanmar, Thailand and Vietnam) accounting for 16%. At present, the exploited waterpower resources of Mekong River accounts for only 1% of the total.

In accordance with the *Study on Development of Run-of-River Hydroelectric Projects on Mekong River Main Stream* released by Mekong River Commission Secretariat in 1994, 11 hydropower stations are planned on the main stream of Mekong River, including five hydropower stations in Laos, namely, Pak Beng, Luang Prabang, Sayaburi, Paklay and Sanakham.

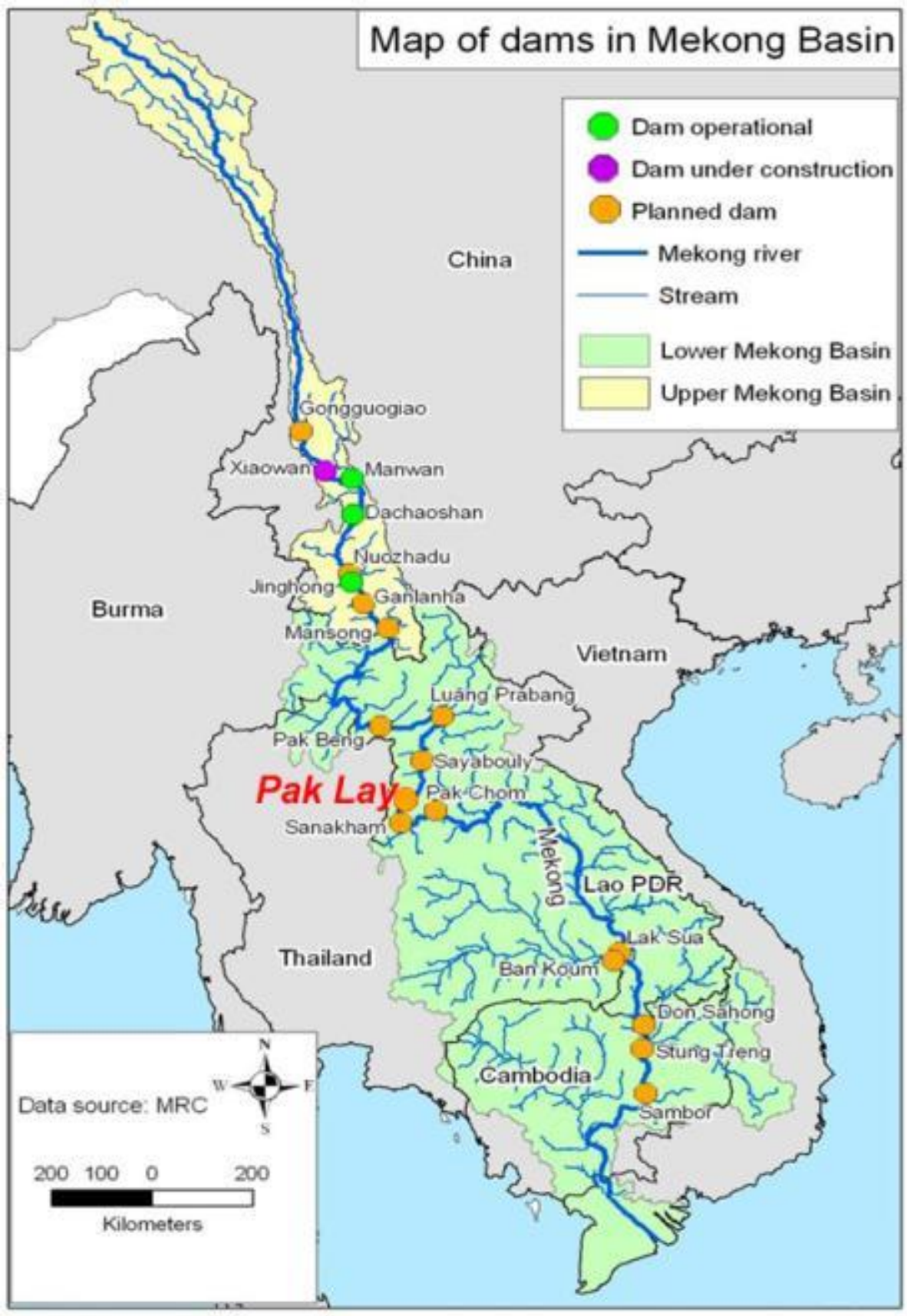


Figure 1: PLHPP dam site and other Mekong River dam location

2.2 Project concept

The dam would be a Run-of-River type dam. This means that the very large reservoir of water usually associated with hydropower dams will not be present. There will instead be a *backwater* area on the upstream side of the dam which will normally be at the depth of 240 meters above sea level (masl). The dam would be constructed and operated on a Build-Operate-Transfer (BOT) basis by Powerchina Resources Ltd. and China National Electronics Import & Export Corporation.. The project would be transferred to the GOL at the end of concession period.

2.3 Need for the project

Lao PDR is on the United Nations Development Programme (UNDP) list of least developed nations and also on its list of Landlocked Developing Countries. Many people in Laos are living below the poverty line. Some relevant statistics include the following:

Percent of population living on less than $1.25 a day 33.9 (2008)
Percent of population living below the national poverty line 27.6 (2007)
Under-5 mortality rate per 1,000 live births 59.0 (2009)

SOURCE: UNDP (2011)

The government of Lao PDR has repeatedly stated its plan to get off the list of least developed nations by the year 2020. One integral part of this plan is to invest in Hydropower to bring in much needed income to the country as stated in the county's National Growth and Poverty Eradication Strategy (NGPES).

It has been calculated that less than 2% of the country's hydropower potential has been developed EPD (2011). The demand for electricity is rising both in Lao PDR and especially, abroad. Most of the electricity produced by the Paklay Hydroelectric Power Project would be sold to Thailand with the rest being used in Laos.

Another issue is that much of the energy used in Laos still comes from fuelwood (about 90%); the country wishes to remove its dependency from forest use and logging because it is not sustainable and can cause unwanted impacts on the environment. Many of the people using fuelwood live in the countryside and only 8% have electricity (Paklay IEE 2009).

One of the biggest issues worldwide is climate Change. It has been calculated that a properly constructed and operated Run-of-River dam can have a positive net affect on climate change (see the climate change Annex of this document for more information). Of course, generating electricity using Hydropower does not involve the burning of fossil fuels so no greenhouse gases are released to the atmosphere. Thailand plans to buy electricity from Lao PDR in the future as the Electricity Generating Authority of Thailand (EGAT) has stated in it Power Development Plan (PDP 2010); Thailand also wishes to reduce Greenhouse Gas Emission in its Power Sector (PDP 2010).

2.4 The power of sector for Lao PDR

The Lao powersector is under process of development, which aims at realizingthecountry's electrification program, and at thesametimeexport of electricity to the neighboringcountries. Around ten percent of the total houses across thecountry will have to be electrified by theyear 2020. Thepowersector has thepotential to play a pivot a role in achievingthesocialandeconomic development objectives of the Government by expandingthe availability of lowcost, reliableelectricity within thecountryandearningrevenue from exportsales to theregion. The Government's Policy facilitatestheseobjectives by encouraging optimal use of thecountry's natural resources, promoting efficiency in power sector institutions and creating an environment conducive to responsible infrastructure investment, both publicandprivate.

Lao PDR (Laos) is land-locked mountainous country, which has fewoptions to diversify its energysources. The Lao Government has theambition to realizethedevelopment of electricpowerfacilities as a highlyappropriatemethod of achieving sustainable socialandeconomicdevelopment through electrification program as well as source of income. Laos' nationalbordersincorporate a significantpart of the Mekong River basin. Its maintributariescontribute around 35% of total inflows of the Mekong River. Asthecountryinterceptsmonsoons from two directions - the Gulf of Thailand andthe Gulf of Tonkin - precipitation is considerably favorablefor hydropower development. Thistrendpresents an opportunityfor Laos to develop hydropower plants to meet its domestic electrification needsandalso to exportelectricity to neighboring countries where demand for electric power has beensteadily increasing.

Hydropower is seen as a cost-effective energysource in Laos which has a theoretical hydroelectric potential of about 26,500MW includingthe mainstream Mekong River. Of thiscapacity, about 18,000MW is technically exploitable, with 12,500MW found in themajor Mekong sub-basins andtheremainder in minor Mekong or non-Mekong basins. Around one-fifth of thecountry's hydropower potential has beendeveloped over thepast 30 years, but under thepresentgovernmentpolicytherate of development will accelerate to supplyelectricity to therapidlygrowingeconomies of theregion.

Coal development is at its nascent stage. Renewable energy such as wind and solar is currently experimented and is not developed on a commercial basis. Oil and gas have no prospect for development in theterritory of Laos. Assuch, the

Table 1: Highlights of Power Sector in Lao PDR.

Project Stage	No. Of Projects	Installed Capacity (MW)	Power Generation (Gwh/Year)
MOU	55	10,806	47,625
PDA	38	11,791	60,934
CONSTRUCTION	21	3,224.5	-

Source: Department of Energy Managmeent,MEM 2019

2.5 Project proponents

Approved by the State Council, Power Construction Corporation of China (POWERCHINA) is a wholly State-owned company founded on Sept 29, 2011 on the basis of 14 provincial, municipal, and district electric power survey and design, engineering, and equipment manufacturing enterprises formerly affiliated to Sinohydro Group Ltd, Hydro China Corporation, State Grid Corporation of China, and China Southern Power Grid Co Ltd.

POWERCHINA is a large comprehensive construction group that offers solutions to the entire chain of the global energy and power, water resource and environment, infrastructure, and real estate industries. Its main businesses cover energy and power, water conservancy, railways and subways, roads, airports, buildings, water environmental governance, city infrastructure, large civic engineering and construction, as well as investment, planning, and design, project contracting, equipment manufacturing, and operation of projects. It highlights a core competence in hydro power projects and industry chain integration. Authorized by relevant national ministries and commissions, POWERCHINA also works in the national planning and review of hydropower, wind power, solar power, and other clean energy and new energy sources.

In 2018, POWERCHINA achieved the business revenue of 404.9 billion yuan ($59.93 billion), with profits reaching 13.8 billion yuan. By the end of 2018, the assets totaled 852.9 billion yuan. It ranked 182nd among Fortune Global 500 in the year 2018 and 41st among Top 500 Enterprises of China; placing sixth on the list of the world's 250 largest global contractors and placing second among top 150 engineering design companies worldwide according to ENR. For six consecutive years, it has been evaluated as a Grade A enterprise by the State-owned Assets Supervision and Administration Commission of the State Council.

POWERCHINA now has eight national research and development (R&D) institutions, 82 provincial R&D institutions, eight academicians' workstations, and six postdoctoral workstations. Eighty-six of its member companies and subsidiaries have been identified as high-tech enterprises. In addition, POWERCHINA has won 110 national science and technology awards, 2,293 provincial and ministerial-level scientific and technological progress awards, and owns 12,136 patents (including 1,890 invention patents).

As of 2018, POWERCHINA has won 88 items of the China Construction Engineering Luban Prize, 49 National Quality Engineering Golden Awards, 167 National Quality Engineering Awards, 25 Tien-yow Jeme Civil Engineering Prizes, 33 China Quality Water Engineering Awards, and 150 National Quality Engineering and Consulting Awards.

Address: POWERCHINA RESOURCES LTD.
No. 428, Unit 39 Ban Phonthan,
Saysettha District Vientiane Capital, Lao PDR
Telephone: (00856) - 21- 419075
Fax: (00856) - 21- 419075

National Consulting Group (NCG) is a firm of ESIA studies of hydropower projects and some other infrastructure development projects in Lao PDR.

Address: National Consulting Group (NCG)
No. 012 Kaysone Road, BanPhonexay,
Xaysettha District, Vientiane Capital, Lao PDR
Tel: (856-21) 264389, 264390;
Fax: (856-21) 261882, 413533

2.6 Project history and planning

Since 1963, the Mekong River Commission (MRC) has carried out a great deal of drainage area planning for the Mekong River. In 1970, the commission put forward the Drainage Area Guiding and Planning report in which 7 hydro projects were proposed in the Mekong mainstream which would be spread over 2,400 km from Hekou, China to Chiang Saen, Thailand. The 7 cascaded power stations would have had a total installed capacity of 23,300 MW, total reservoir capacity of 258.9 billion m^3, and an effective storage of 136 billion m^3.None of them were realized for they were designed with high dams and large reservoirs, inflicting significant inundation loss and impact on environment and society.

In 1994, under the sponsorship of United Nations Development Program and the government of France, the Secretariat of the Mekong River Commission called out a research team staffed by experts from the member countries to review hydropower planning of the Mekong mainstream and prepare a Study Report for Run-of-River(ROR) Type Hydraulic Engineering Developments on the Mainstream. In this report, called *Mekong Mainstream Run-of-River Hydropower*, the high dams with large reservoirs were altered into ROR type dams; the report recommended a cascade of 11 ROR dams including Pak Beng, Luang Prabang, Xayaboury, Paklay, Chiangkhan, Pamong, Ban Koum, Dong Sahong, Stung Treng, Sambor and Tonle Sap with a total installed capacity of 14,810 MW.

See the table below for the major technical indexes of the 1994 Mekong River **ROR Type Hydropower Planning Proposal**.

Table 2: Mekong River ROR Type Hydropower Planning Proposal

Item	Location	Distance from Estuary	Catchment Area of Dam Site	Mean Annual Discharge at Dam	Normal Pool Level	Installed Capacity	Mean Annual Energy Output	Annual Operation Hours of Installed
Unit	**1**	km	10^3 km^2	m^3/s	m	MW	10^9 kWh	h
PakBeng	Laos	2188	218	3170	340	960	5.67	4610
Luang Prabang	Laos	2036	230	3810	320	1410	7.38	5234
Sayaburi (Xaiyabury)	Laos	1930	272	3990	270	1285	7.37	4754
Paklay	Laos	1818	283	4030	240	770	6.46	4894
Chiangkhan (Sanakham)	Laos	1772	292	4160	220	660	3.21	5632
Pamong	Border between Laos and	1651	295.5	4310	207.5	2030	8.87	4369
BanKoum	Border between Laos and	928	419	8520	120	2330	10.23	4391
Don Sabong	Border between Laos and Cambodia	719	553	10310	70~72	240	1.64	6833
Stung Treng	Cambodia	670	635	13710	55	980	4.87	4969
Sambor	Cambodia	560	646	13950	40	3300	14.87	4506
Tonle Sap	Cambodia	362	710	13820	10	140	0.31	2214
Total						14,105.00	70.88	52,406.00

At the end of 2008, the government of Laos entrusted CNR in France to conduct a re-check and justification on five cascades in Laos, namely, Pak Beng, Luang Prabang, Xayaboury, Paklay and Sanakham. In September 2009, CNR put forward the final "Optimization of Mekong Mainstream Hydropower" and the recommended normal pool level of the Paklay dam was 240.0 masl

In September 2009, CNR Corporation submitted the final report on their cascade level optimization study, moving the dam site of Chiang Khan Hydropower Station from Stake No. 1772km to 1737km and proposing recommended scheme for level optimization of the cascade power stations. The results hereof are shown in the table below.

Table 3: Results of the Cascade Level Optimization Scheme Recommended by CNR Corporation.

Project	Developer	Results of 1994 Planning	CNR Recommended Scheme
Pak Beng	Datang International Power Generation Co,. Ltd	340m	337.5m~340m
Luang Prabang	Petro Vietnam Power Corporation (Vietnam)	320m	310m~312.5m
Sayaburi	CH.Kanchang (Thailand)	270m	275m
Paklay	Sinohydro Corporation and CEIEC (China National Electronics Imp. & Exp. Corp.)	240m	240m~245m
Sanakham	Datang International Power Generation Co,. Ltd	220m	217.5m~220m

On June 11, 2007, the joint venture of Sinohydro Corporation Limited and China National Electronics Import-Export Corporation (referred to as "joint venture") signed an investment and development memo (MOU) for BOT items of PAKLAY Hydropower Station with the Lao government. In November, 2007, the joint venture officially entrusted Hydrochina Zhongnan to carry out the feasibility study on the project of Paklay Hydropower Station.

In November, 2007, Hydrochina Zhongnan began to move in the site to carry out field survey and investigation. In May, 2008, we finished the field survey and investigation as well as field experiment of this stage.

On August 26, 2009, the Lao government gave a notice to the joint venture by letters requiring that the normal pool level of the Paklay Hydropower Station should not be higher than 240.00m. On March 25, 2010, the joint venture made it clear by letters that the feasibility work is carried out based on normal pool level 240.00m as basic water level and required that relevant results of comparison with a normal pool level of 245.00m should be provided at the same time.

In July, 2010, Hydrochina Zhongnan completed the feasibility study on Paklay Hydropower Station as required above and submitted to the joint venture the relevant results of the following recommended dam sites.

On April 28, 2011, the joint venture held the *Technical Review Meeting about Feasibility study Report on Laos Paklay Hydropower Station* in Beijing, in which technical review of the feasibility report submitted by Hydrochina Zhongnan in July, 2011 was carried out. The main conclusion and comments of the review are as follows:

a)The report has reached the design depth of feasibility stage. The design is generally rational and feasible.

b)It is required to give up the lower dam site scheme which has better economic indicators and choose the upper dam site as the recommended one. The report compared the schemes for lower and upper dam sites from two aspects, i.e. technical and kinetic energy economic indicators, which shows that the lower dam site scheme has larger installed capacity, larger mean annual energy output and better construction conditions than the upper dam site scheme. Thus the lower dam site scheme should be preferably selected. However, the relocated population of the lower dam site scheme is about 10,000 ranking the first among the five hydropower stations planned for Mekong River Basin (in Laos) and has aroused the attention of the Lao government. Considering that the relocation problem concerns the local people's livelihood and social stability and that the various uncertainties will increases investment risks, the lower dam site scheme which brings more economic benefits has to be abandoned to select the upper dam site one.

Based on comments in the meeting, Hydrochina Zhongnan Engineering Corporation carried out exploration and feasibility study again for the upper dam site.

On November 29, 2011, the surveying team entered the site and carried out topographic surveying of the road leading to the upper dam site (along the Nanpeng River reach). On January 10, 2012, field surveying was completed. Technicians in geology, drilling, geophysical prospecting and testing disciplines arrived at Paklay one after another on February 24, 2012 to carry out exploration again for the upper dam site and on May 10, all the field work was completed.

In December 2012, the feasibility report in which the upper dam site was recommended, and corresponding attached drawings (draft for review) were submitted to the joint venture.

In April 2014, the feasibility study report of the Paklay HPP successfully passed the review conducted by China Renewable Energy Engineering Institute.

In August 2014, the feasibility study report (approved draft) of the Paklay HPP was submitted to the joint venture.

In July 2015, the feasibility study report of the Paklay HPP successfully passed the interim review conducted by the Ministry of Energy and Mines of Lao PDR.

In September 2015, the joint venture arranged for the Ministry of Energy and Mines of Lao PDR, and CNR — the third review organization appointed by the Government of Laos (experts from Brazil, engaged by CNR, would be responsible for the review of water quality and fish way) to conduct site survey for the Paklay HPP, and held a kick-off meeting on the third review of the feasibility study report of the Paklay HPP.

In December 2015, CNR — the third review organization, submitted the *Report on Interim Review for Feasibility Study Report of Paklay Hydropower Project* (draft).

In January 2016, the joint venture arranged for the Ministry of Energy and Mines of Lao PDR, CNR — the third review organization (including experts from Brazil employed by CNR to be responsible for review of water quality and fish way), and POWERCHINA Zhongnan Engineering Corporation Limited to hold an interim review meeting in Vientiane.

In March 2016, experts from Brazil submitted the *Report on Interim Review for Water Quality and Fish Way of the Paklay Hydropower Project*, and a compliance checklist.

On April 25~30, 2016, the joint venture arranged for POWERCHINA Zhongnan Engineering Corporation Limited and CNR to conduct technical exchange after interim review. On May 20, CNR submitted the *Report on Technical Exchange of Feasibility Study Report of Paklay Hydropower Project* and an adjusted compliance checklist.

In May ~ July 2016, POWERCHINA Zhongnan Engineering Corporation Limited and experts from Brazil conducted 3 written exchanges concerning issues mentioned in the *Report on Technical Exchange of Feasibility Study Report of Paklay Hydropower Project* and the compliance checklist.

The feasibility study report (revision) was revised according to the *Report on Interim Review for Feasibility Study Report of Paklay Hydropower Project*, the *Report on Technical Exchange of Feasibility Study Report of Paklay Hydropower Project*, the *Report on Interim Review for Water Quality and Fish Way of the Paklay Hydropower Project*, opinions of 3 written exchanges, the adjusted compliance checklist, and technical requirements specified in relevant standards and regulations. In this feasibility study, the 240.00m normal pool level is taken as the basic water level and feasibility study for downstream Sanakham Hydropower Station is also considered. So the influence of backwater jacking of the reservoir of the downstream Sanakham Hydropower Station is considered for tailwater level of Paklay Hydropower Station. Reservoir inundation results in the report were provided by NORCONSULT. For environmental impact assessment of the Project, please refer to relevant reports submitted by NORCONSULT (on August 1, 2011, the joint venture and National Consulting Group (NCG) signed the consulting service contract of ESIA, to complete environmental and social impact assessment of upper and lower dam sites respectively based on the normal pool level of 240 m a.s.l. At present, the final environmental impact assessment report has been submitted to the Ministry of Natural Resources and Environment of Lao PDR for approval process).

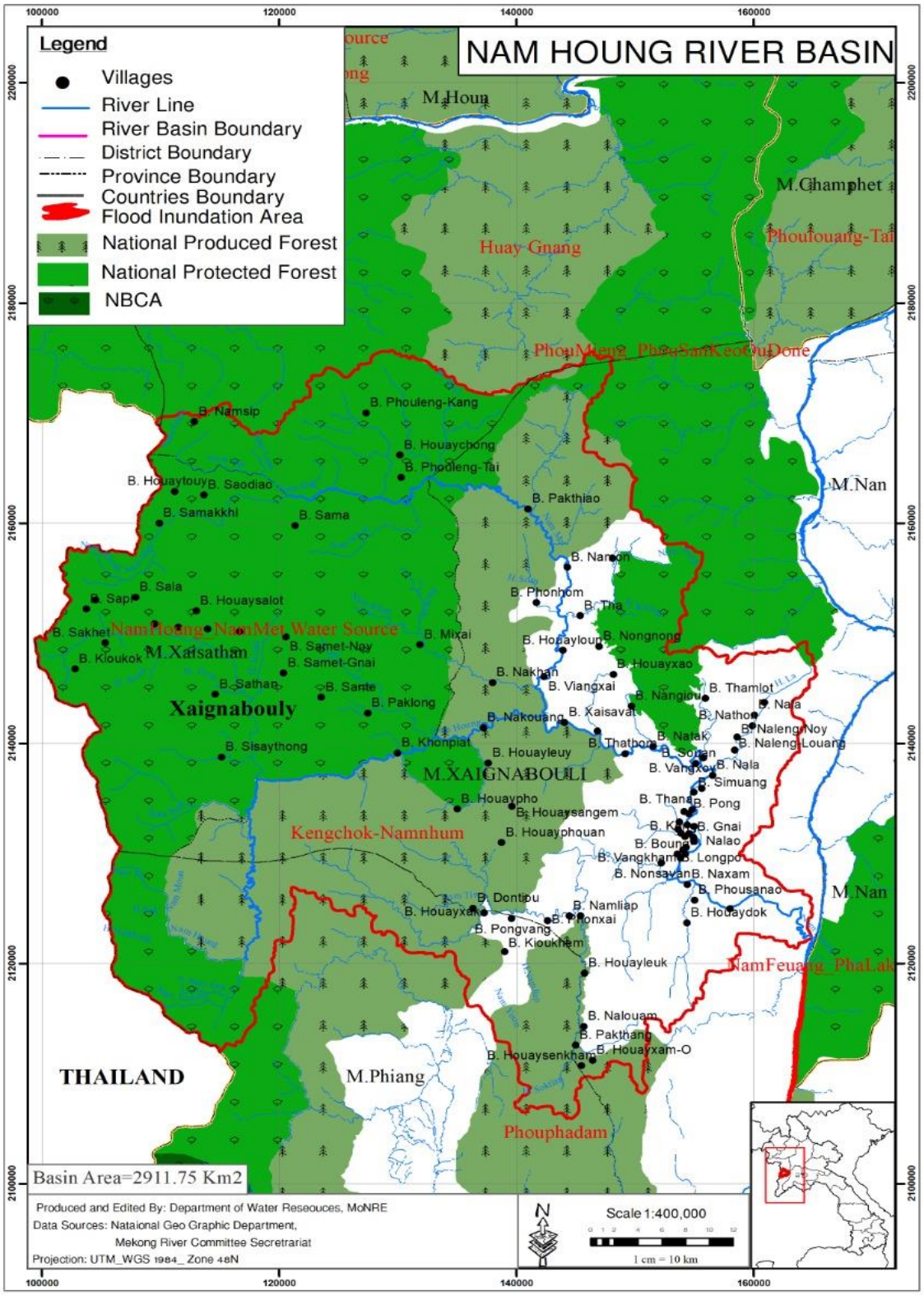
2.6.1 Inundated Area

The project will inundate an area of 5,951 ha (more than 40.86% is water body) and 1427.46 of inundation area is located on the 3 type forest (National protection forest and Production forest) while the total catchment of the project area is 278,400 km^2.

There are 10 tributaries listed for the Mekong River between Xayabury dam and Paklay dam, the backwater from the Paklaydam will intrude to them. Among them, there are 4 tributaries on Xayabury province side and 6 tributaries on Vientiane province side.The information and the detail map for the upstream tributaries are as follows.

Potential Flooding Length of the Tributaries of Paklay Project

No.	Name of Tributaries	Length (m)	Basin Area (km^2)	Flooding Area (ha)	Location
1	Nam Houng	60	2911.75	0.5	Xayabury Province
2	Nam Poui	180	1690.56	1.5	Xayabury Province
3	Nam Fueng	170	823.3	1.2	Vientiane Province
4	Nam Met	215	310.82	3	Vientiane Province
5	Nam Nan	260	199.93	5	Vientiane Province
6	Nam Gnam	940	314.78	9	Xayabury Province
7	Nam PouGhai	2600	72.64	18	Vientiane Province
8	Nam Piri	3000	72.80	17	Vientiane Province
9	Nam HouayNonsavath	4200	169.81	20	Vientiane Province
10	Nam Pa	4000m	182.01	50	Xayabury Province


NAM HOUNG RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
M.Houn
M.Champhet
Phoufouang-Tai
Huay Gnang
PhouMeng_PhaSamKeoOuDone
B. Namsip
B. Houaytouy
B. Saodiao
B. Samakkhi
B. Houaychong
B. Phouleng-Kang
B. Phouleng-Tai
B. Sama
B. Pakthiao
M.Nan
B. Sala
B. Houaysalot
B. Sakhet
NamHoung_NamMet Water Source
B. Samet-Noy
B. Samet-Gnai
M.Xaisatham
B. Kioukok
B. Sathan
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Xaignabouly
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B. Khonpiat
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B. Houaypho
B. Houaysangem
Kengchok-Namnhum
B. Houayphouan
B. Dontiou
B. Houayxai
B. Namliap
B. Phonxai
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B. Thathom
B. Natak
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B. Nalenq-Louang
B. Vangxou
B. Nala
B. Simuang
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B. Nonsavan
B. Naxam
B. Phousanao
B. Houaydok
M.Nan
NamFeuang_PhaLak
Basin Area=2911.75 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
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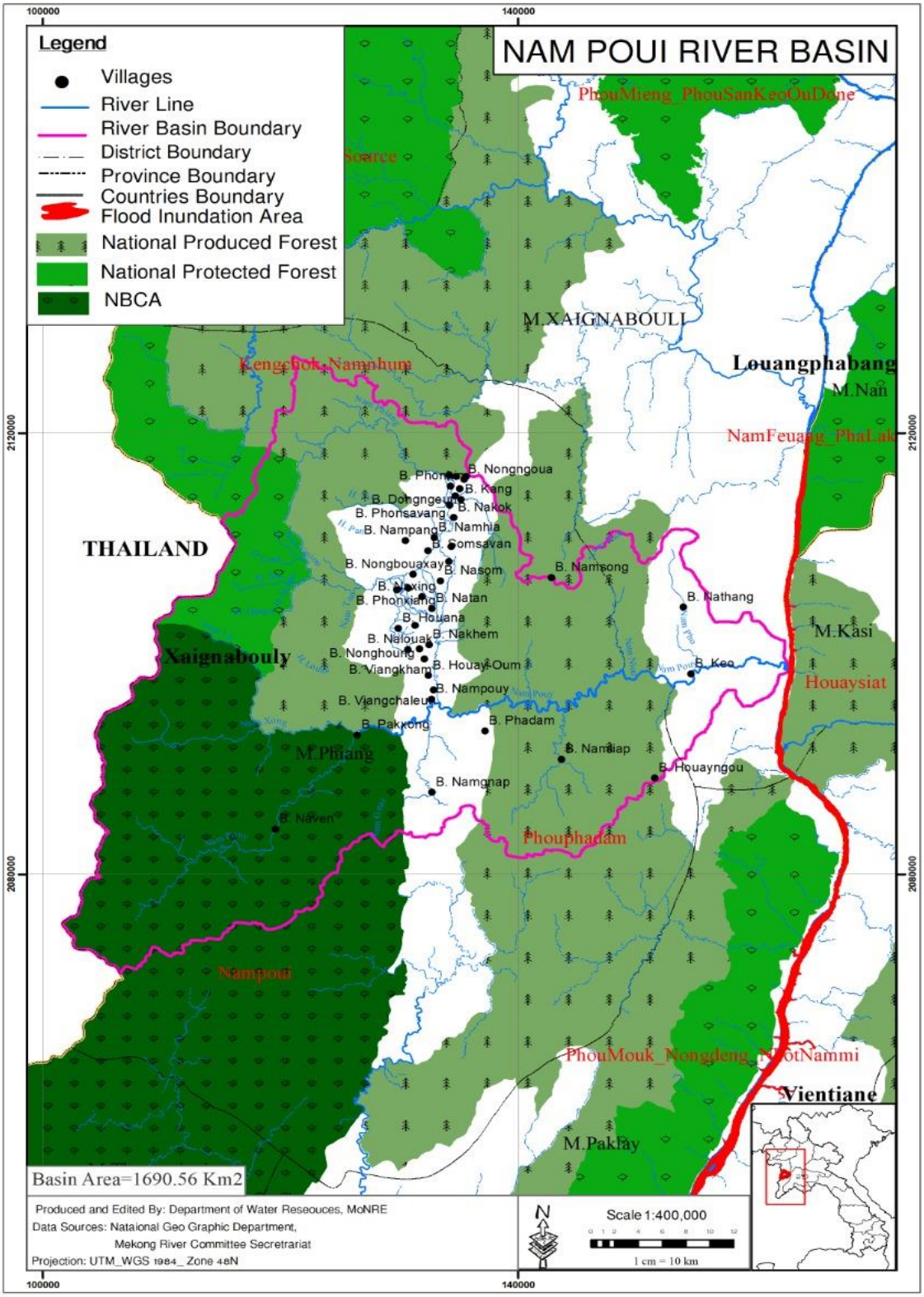
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Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
PhouMieng_PhouSanKeoOuDone
Source
M.XAIGNABOULI
Louangphabang
M.Nan
Kengchok_Namnhum
NamFeuang_PhaLak
THAILAND
Xaignabouly
M.Phiang
M.Kasi
Houaysiat
Phouphadam
Nampoui
PhouMouk_Nongdeng_NotNammi
Vientiane
M.Paklay
B. Nongngoua
B. Kang
B. Nakok
B. Namhia
B. Somsavan
B. Nasom
B. Namsong
B. Nathang
B. Natan
B. Nakhem
B. Houay-Oum
B. Nampouy
B. Phadam
B. Namlap
B. Houayngou
B. Namgnap
B. Naven
B. Keo
Basin Area=1690.56 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
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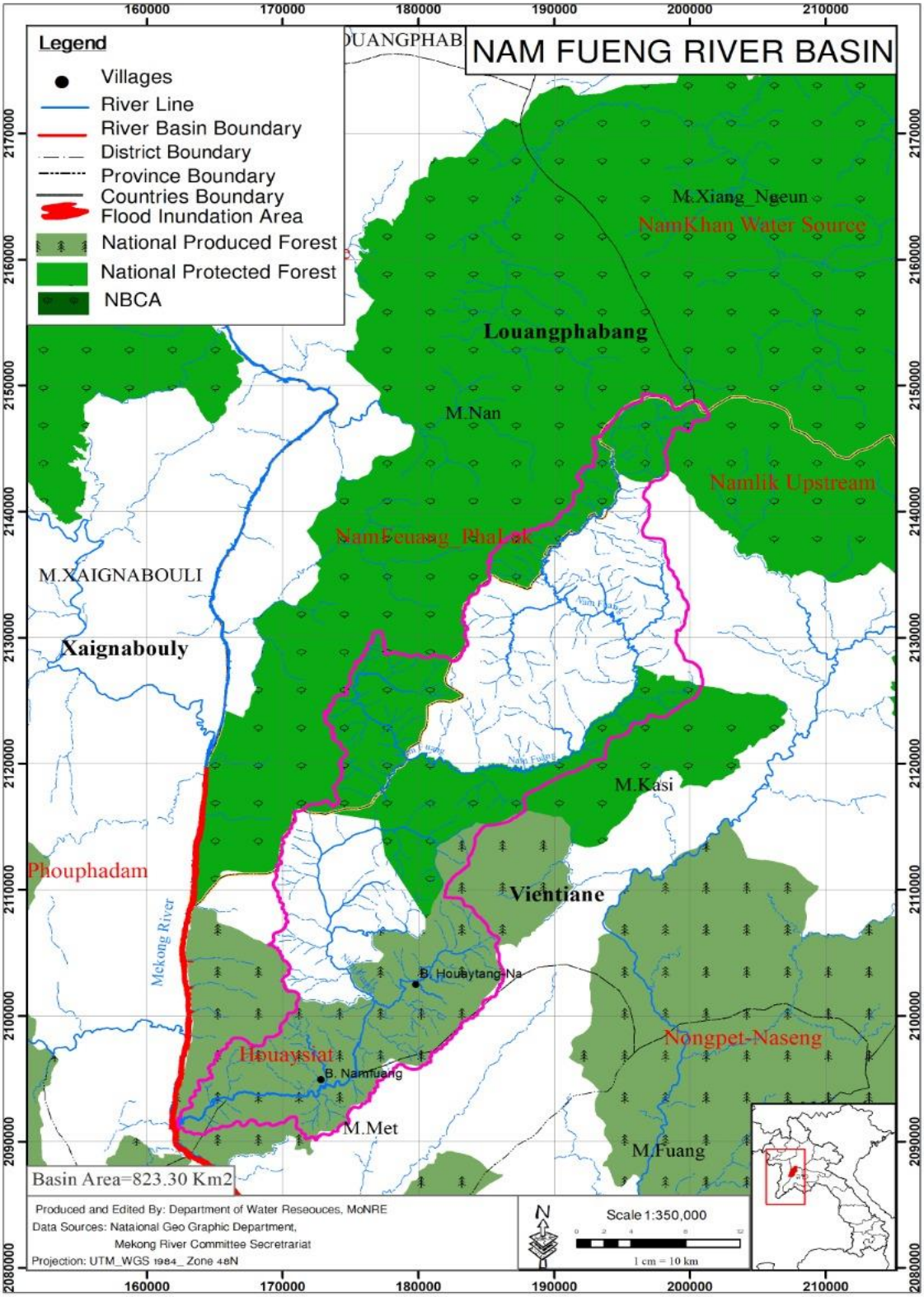
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Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
M.Xiang_Ngeun
NamKhan Water Source
Louangphabang
M.Nan
Namlik Upstream
NamFeuang_Phalak
M.XAIGNABOULI
Xaignabouly
M.Kasi
Phouphadam
Vientiane
Mekong River
B. Houaytang-Na
Houaysiat
B. Namfuang
Nongpet-Naseng
M.Met
M.Fuang
Basin Area=823.30 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
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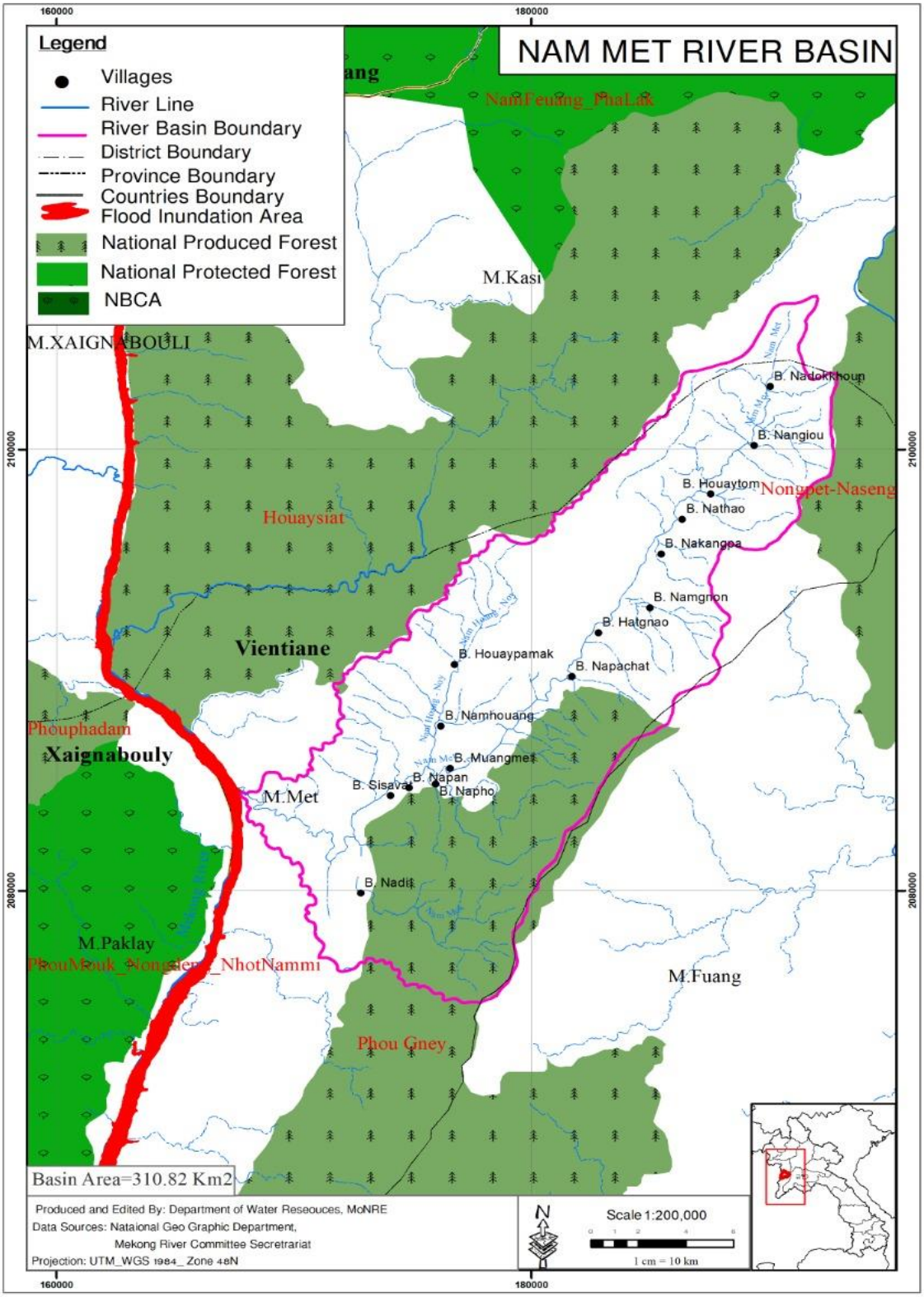
NAM MET RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
NamFeuang_PhaLak
M.Kasi
M.XAIGNABOULI
B. Nadokkhoun
B. Nangiou
B. Houaytom
Nongpet-Naseng
B. Nathao
B. Nakangpa
B. Namgnon
B. Hatgnao
Houaysiat
Vientiane
B. Houaypamak
B. Napachat
B. Namhouang
Phouphadam
Xaignabouly
B. Muangmet
B. Napan
B. Napho
B. Sisavat
M.Met
B. Nadi
M.Paklay
PhouMouk_NongSeng_NhotNammi
M.Fuang
Phou Gney
Basin Area=310.82 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
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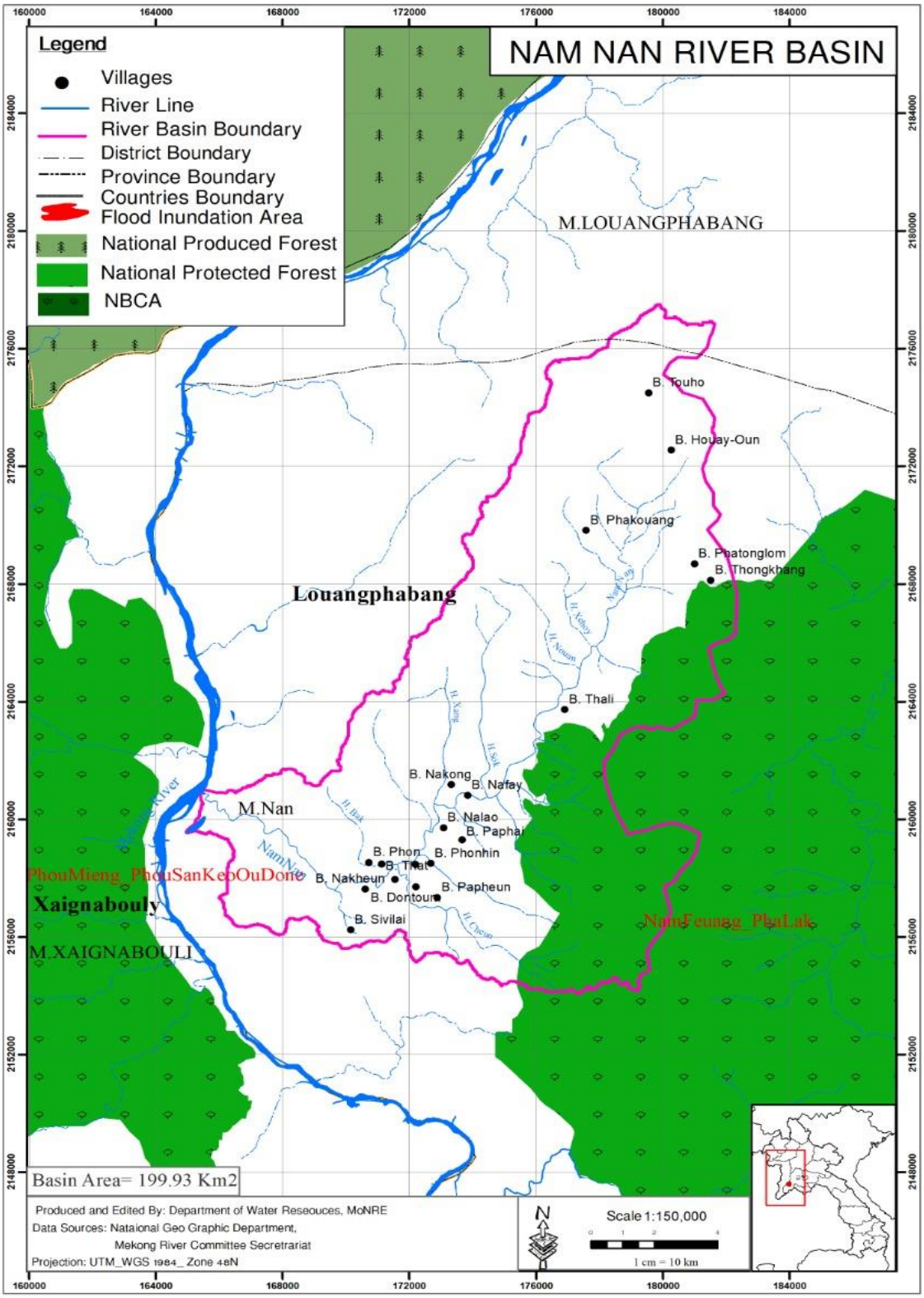
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Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
M.LOUANGPHABANG
B. Touho
B. Houay-Oun
B. Phakouang
B. Phatonglom
B. Thongkhang
Louangphabang
B. Thali
B. Nakong
B. Nafay
M.Nan
B. Nalao
B. Paphai
B. Phon
B. Phonhin
B. That
B. Nakheun
B. Papheun
B. Dontoum
B. Sivilai
PhouMieng_PhouSanKeoOuDone
Xaignabouly
M.XAIGNABOULI
NamFeuang_PhuLuk
Basin Area= 199.93 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
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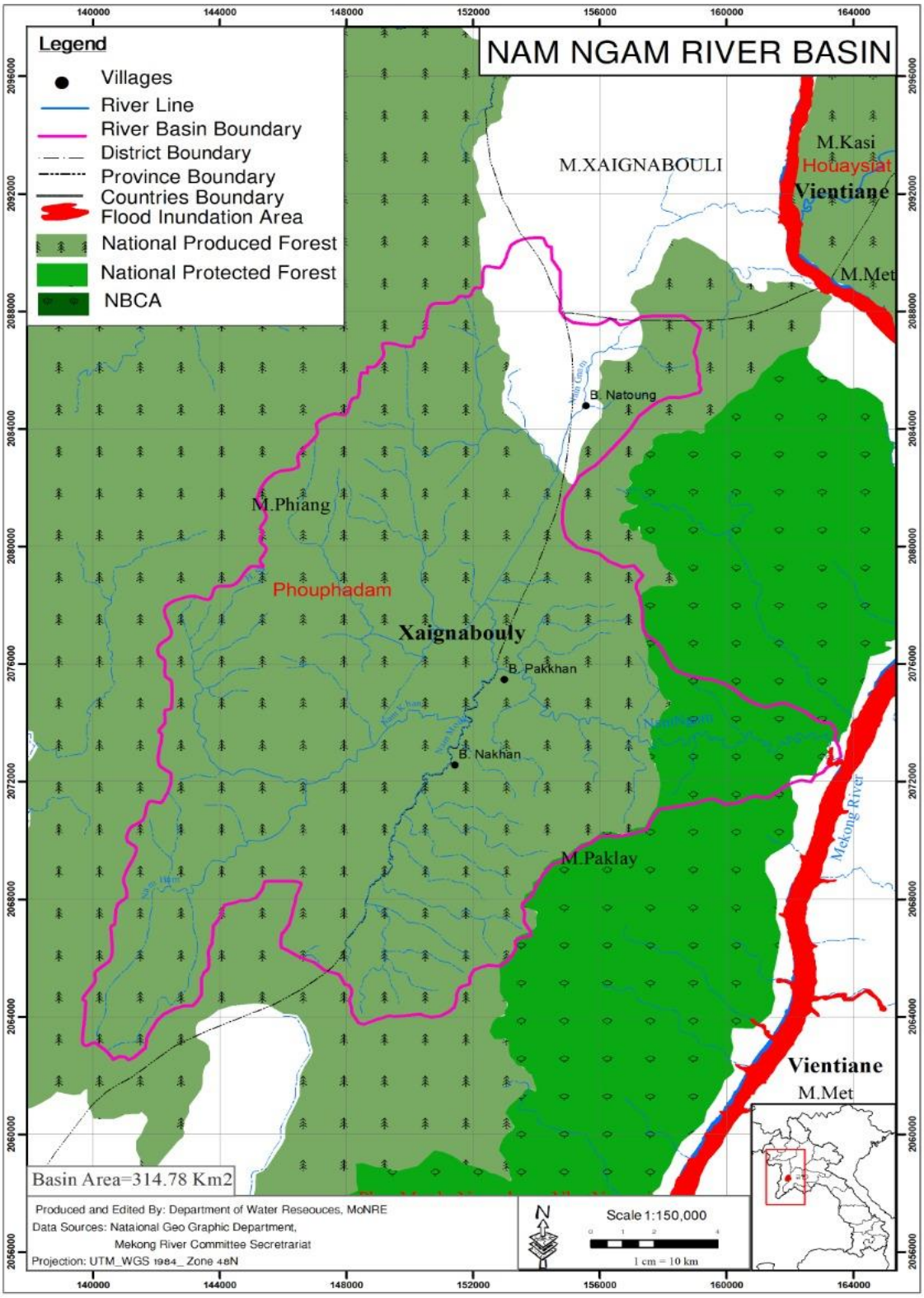
1 cm = 10 km


NAM NGAM RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
M.XAIGNABOULI
M.Kasi
Houaysiat
Vientiane
M.Met
B. Natoung
M.Phiang
Phouphadam
Xaignabouly
B. Pakkhan
B. Nakhan
M.Paklay
Mekong River
Vientiane
M.Met
Basin Area=314.78 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
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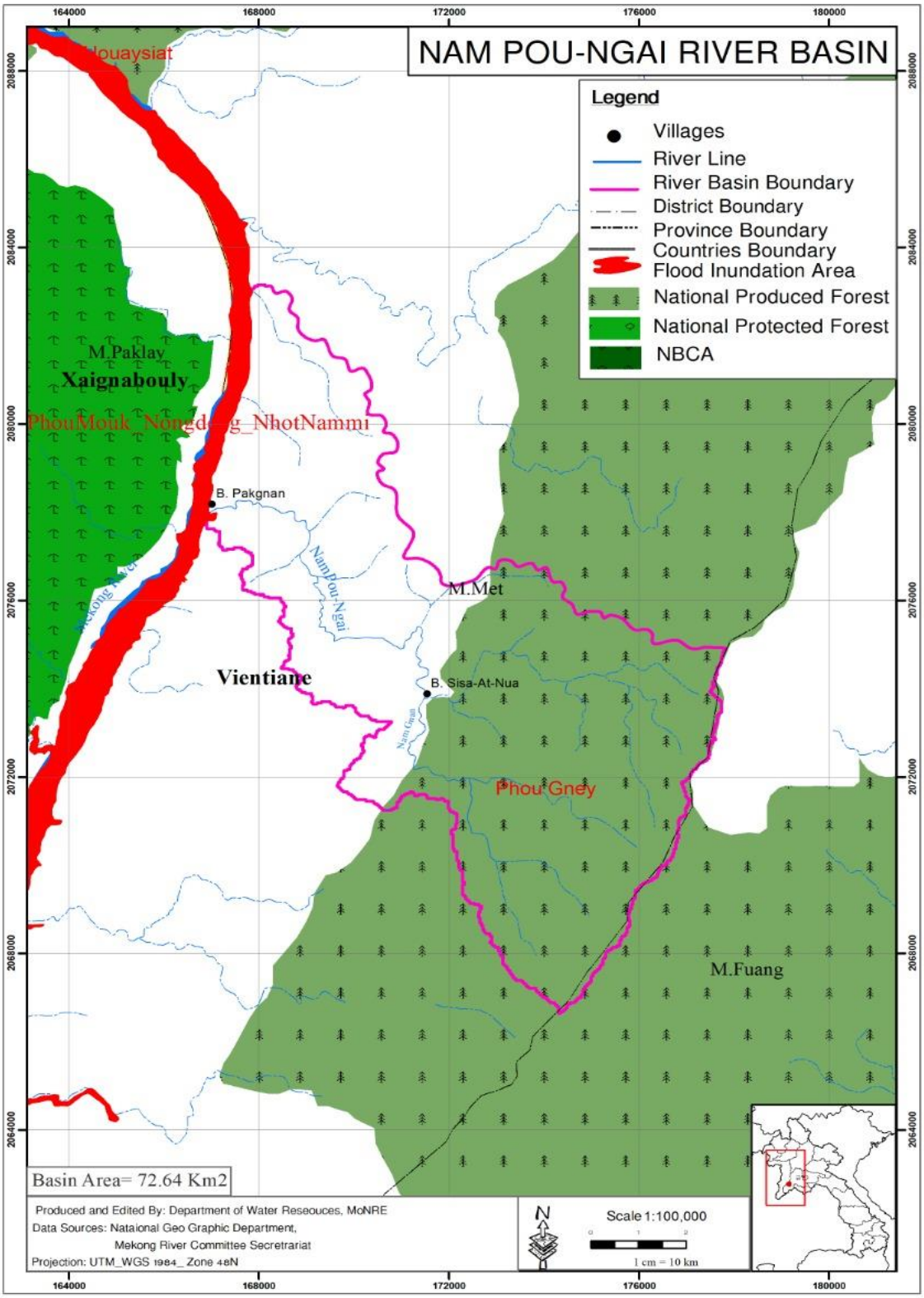
NAM POU-NGAI RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
M.Paklay
Xaignabouly
PhouMouk_Nongdaeng_NhotNammi
B. Pakgnan
Mekong River
NamPou-Ngai
M.Met
Vientiane
B. Sisa-At-Nua
Nam Ngai
Phou Gney
M.Fuang
Basin Area= 72.64 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
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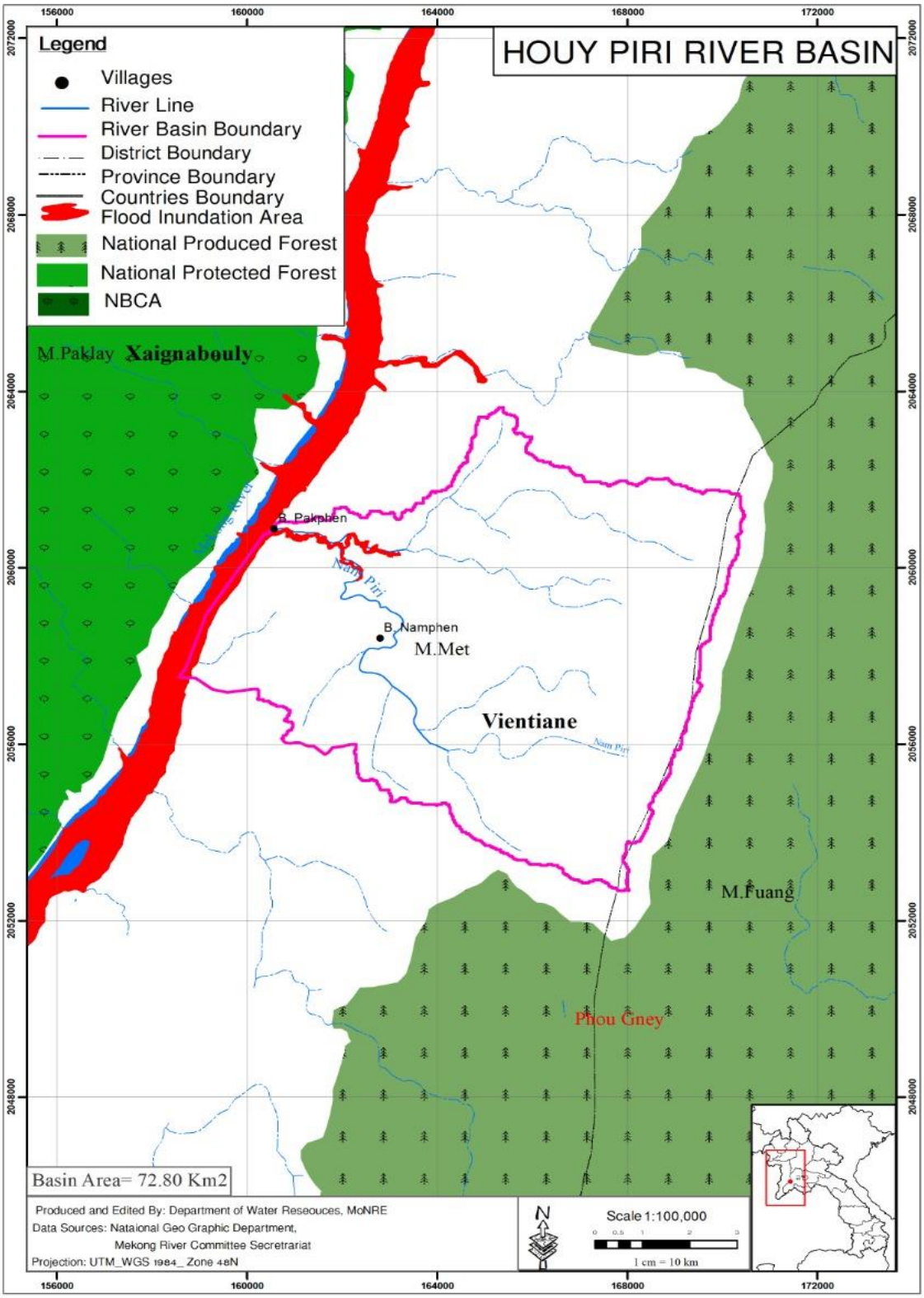
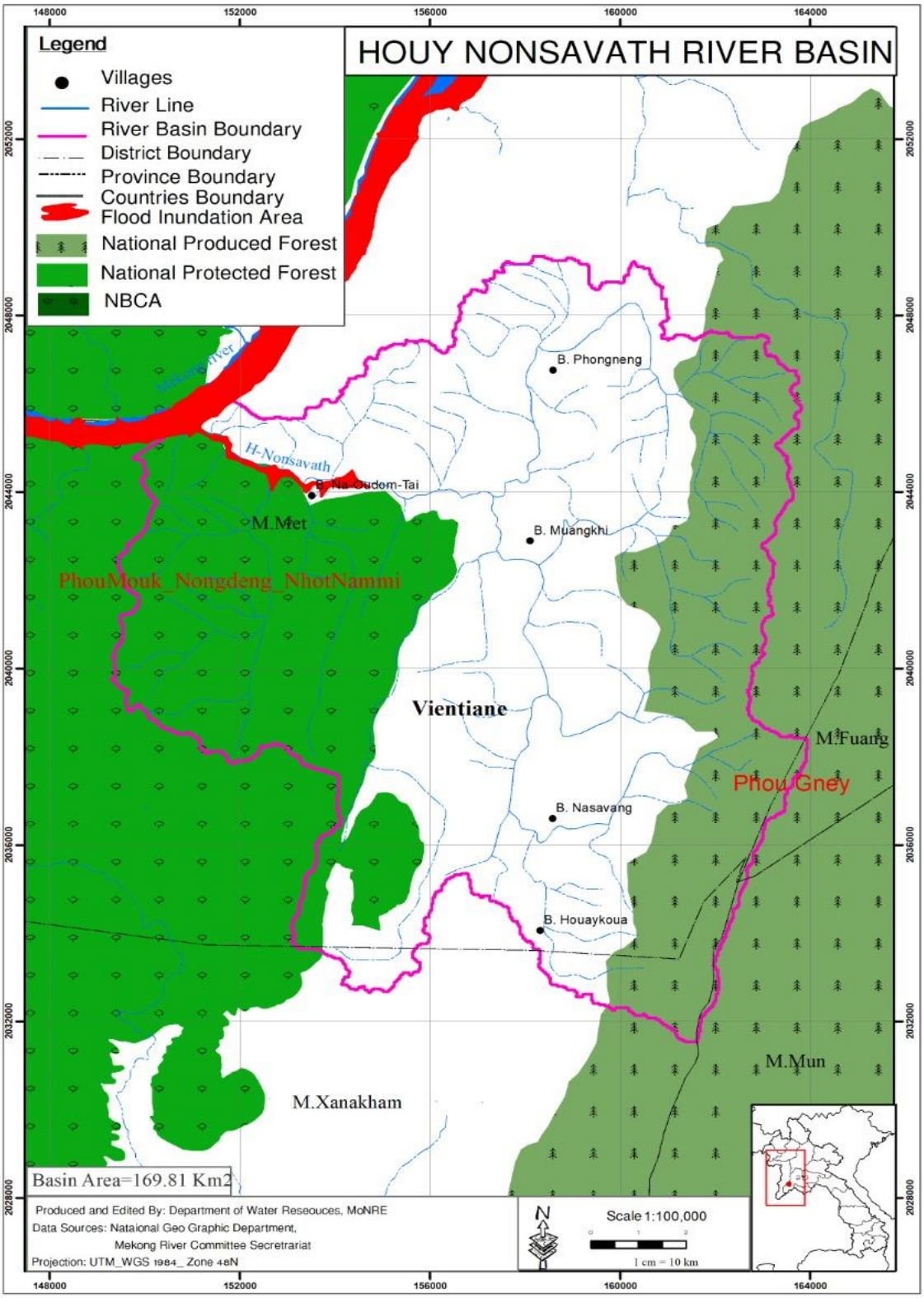


Fig. 9: Catchment of Piri


HOUY NONSAVATH RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
B. Phongneng
H-Nonsavath
B. Na Oudom-Tai
M.Met
B. Muangkhi
PhouMouk_Nougdeng_NhotNammi
Vientiane
M.Fuang
Phou Gney
B. Nasavang
B. Houaykoua
M.Mun
M.Xanakham
Basin Area=169.81 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
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Scale 1:100,000
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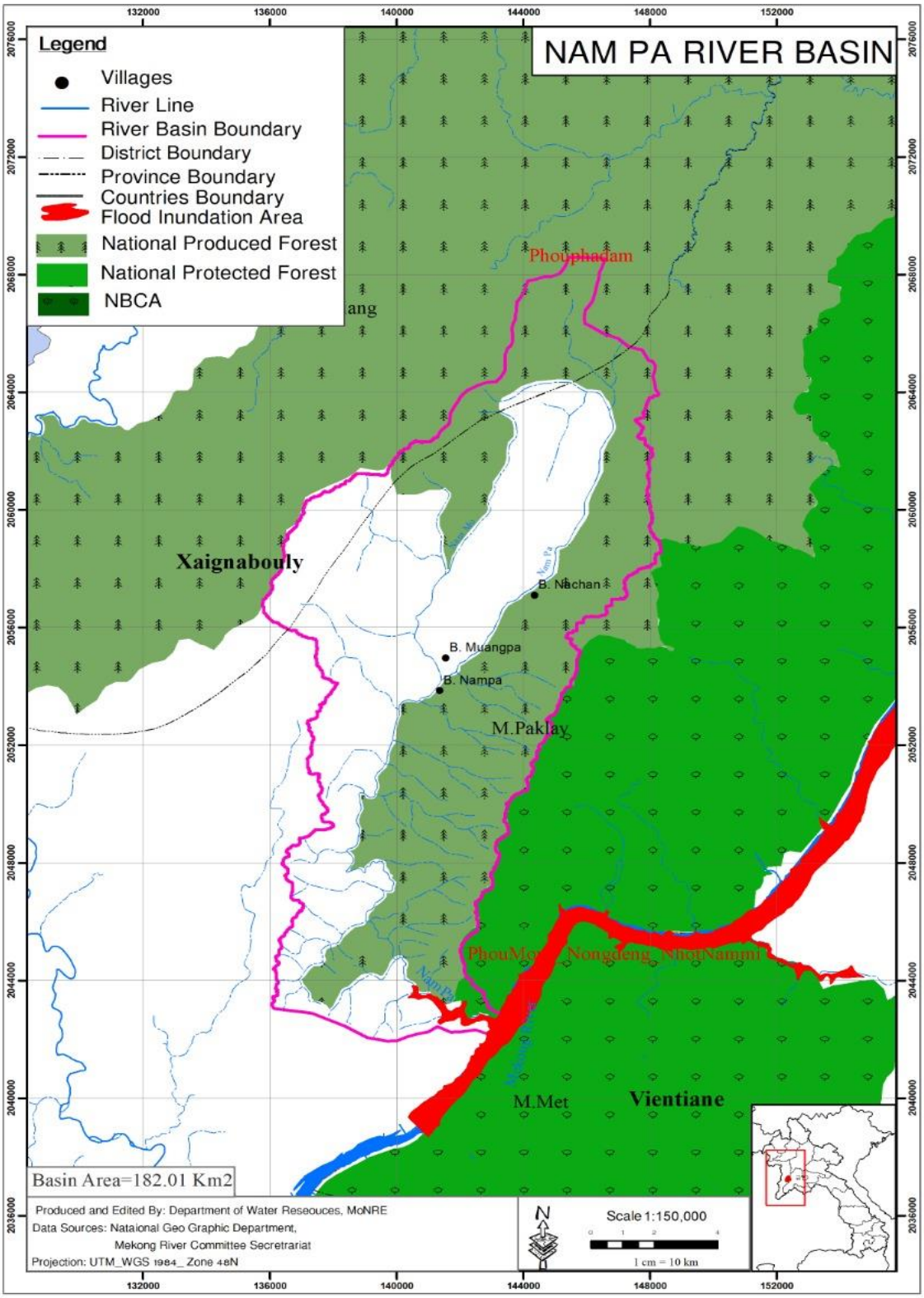

NAM PA RIVER BASIN
Legend
Villages
River Line
River Basin Boundary
District Boundary
Province Boundary
Countries Boundary
Flood Inundation Area
National Produced Forest
National Protected Forest
NBCA
Phouphadam
Xaignabouly
B. Nachan
B. Muangpa
B. Nampa
M.Paklay
Nongdeng
M.Met
Vientiane
Basin Area=182.01 Km2
Produced and Edited By: Department of Water Reseouces, MoNRE
Data Sources: Nataional Geo Graphic Department,
Mekong River Committee Secretrariat
Projection: UTM_WGS 1984_ Zone 48N
N
Scale 1:150,000
1 cm = 10 km

2.7 Project component and features

2.7.1 Overview

The dam has the following characteristics:

- The normal pool level is 240.00 m, and the minimum pool level is 239.00 m.
- Bulb unit and water retaining type powerhouse are applied for the unit. Itsinstalled capacity is 770MW, and capacity per unit is 55MW. And there are 14 units.
- This project has low waterhead and high flood discharge.
- Fish pass to be installed according to MRC's regulations.
- Single-stage ship lock is used for navigation structure, with the effectivedimension of 120.00m×12.00m×4.00m (effective length × effective width × water depth onsill). Fish way is not involved in the selection of dam axis.
- Run of River dam design.

2.7.2 Summary of dam components

- Normal concrete gravity dam.
- Power House on right side.
- Generator set is a bulb generator set and uses a water retaining powerhouse.
- Installed capacity is 770MW.
- Independent capacity is 55MW.
- Number of Generators is 14.
- Overflow dam will be on the middle left.
- Ship lock on left bank.

2.7.3 Access road anf bridges

Presently, there is no road that directly leads to the upper dam site, so construction of a 6.5km outward road and extension of a 11.5km outward road are required so as to connect it with the nearest national road (Road number 4). There is no bridge over Mekong River within the upper dam site. At present, a ferry approximately 13km downstream from the Upper Dam Site is the main facility for both banks to cross the river. This could not meet the transport requirements of left and right banks when the Paklay Hydroelectric Power Project is under construction. It is required to build a bridge about 1.1km downstream from the upper dam site for the purpose of transportation between the two banks. The right bank of the upper dam site has a flat landform; it has favorable conditions in the site for layout of a construction road. The left bank is relatively steep, and the condition in the site for layout of construction road is average. Approximately 16.5km of construction road has been laid in the site in total (including the road to the aggregate processing system).

2.7.4 Project layout and main structures

The valley of the upper dam site is broader and wider, and the river course is U-shaped insequent valley. The main river course is located on the left side of river course. When in normal pool level, the width of water surface is about 230m, and lots of reef flat on the right side and in the middle of riverbed emerge. When the normal pool level is 240.00m, the width of water surface is about 790.00m.

The main river channel at the dam site is on the left bank. The overburden in the river channel is thick and is around 17.2m. Considering that the foundation base of the powerhouse is relatively low, quantities of earth-rock excavation and concrete used can be reduced if the powerhouse is arranged within the scope of the main river channel on the left bank; In the meanwhile, since the whole river course 800m downstream of the dam site is main river course, it is feasible to arrange the navigation lock on the reef flat on the right bank, so that the navigation lock can be easily connected with the downstream main river course via the downstream approach channel. After comprehensive consideration of the layout condition of construction diversion, scheme for layout of hydroproject of the upper dam site at this phase is: powerhouse is arranged on the left bank, navigation lock is arranged on the right bank, and overflow dam is arranged at the right in the middle.

The dam is a normal concrete gravity dam, with the crest elevation of 245.20m, and length of 931.50m. The layout from the left to the right is: non-overflow section on the left bank, water retaining type powerhouse section, non-overflow dam between powerhouse and dam, overflow section (stilling basin is arranged downstream), navigation lock dam section and overflow section on the right bank.

The total length of the water release structure is 243.50m and 12-hole open type spillweir is adopted. Energy dissipation by underflow should be adopted. The length of the stilling basin is 90.00m with 3.00m thick base slab. Slotted flip bucket is arranged at the tail part of the stilling basin. Concrete protection section is connected after the bucket.

The powerhouse is water retaining powerhouse which is installed with 14 bulb hydraulic generator units with capacity per unit of 55MW and total installed capacity of 770MW. The length of the powerhouse is 397.00m in total. Dimension of the main powerhouse is 397.00m×22.50m×52.44m (length × width × height). Spacing between units is 21.50m. Total width of powerhouse section along the water flow direction is 83.05m. Elevation of installed units is 208.50m. Water retaining type intake should be arranged on the upstream side of the generator hall, while on the downstream side of the generator hall is usually arranged with auxiliary powerhouse ①. Erection bay ① is arranged on the left side of the generator hall, and erection bay ② is arranged between unit ⑪ and unit ⑫. Erection bay ① is 52.00m long with floor elevation of 228.50m. Central control building is arranged 26m downstream of the erection bay ① on the right side, and turnaround loop is arranged 26m on the left side. Powerhouse access road leads to the site horizontally from the downstream and connected with the turnaround, via which direct access to the floor of erection bay ① is provided. Erection bay ② is 39.00m long. Blower room is arranged at the upstream side of the erection bay ② and auxiliary powerhouse ② is arranged on the downstream side.

Navigation lock should be arranged on reef flat on the right bank. The water retaining front is 42.00m wide. The navigation lock can be smoothly connected with the downstream main waterway via the downstream approach channel.

2.8 Construction diversion

2.8.1 Diversion Method

At the dam site of Paklay Hydropower Project, the river valley is wide, and theriverway is U-shaped longitudinal valley in general. The left bank is deep riverway whilethe right side is beach. When the water level is 217.80m, the water surface is about230m wide; at the normal pool level of 240.00m, the water surface is about 788.00m wide.

The recommended hydraulic structures layout (from left to right) for the Project is:left-bank non-overflow section + river-bed powerhouse monolith + overflow section + shiplock section + right-bank non-overflow section. According to the hydraulic structureslayout characteristics and the upstream and downstream topographical and geologicalconditions of the dam site, it is recommended to adopt phase diversion method. In the firstphase, the right-bank beach, construction ship lock, flood discharge gate and right-banknon-overflow section shall be fenced; in the second phase, the left-bank deep riverway, 14units for construction and left-bank non-overflow section shall be fenced.

2.8.2 Diversion Procedure

According to the master construction schedule, the project construction is divided intotwo phases, and the diversion procedure is as follows:

a) Construction in First Phase

1) Excavation of the right-bank slope will be started from July of the 1st year,and filling of Phase I longitudinal concrete cofferdam and the upstream and downstreamearth-rock cofferdam shall be started from December. By the end of February in the 2ndyear, the flow on right-bank beach will be cut off, and the left-bank main river bed is foroverflowing and navigation.

2) From December of the 1st year to November of the 3rd year, Phase I upstream and downstream cofferdams and longitudinal cofferdam shall be used for waterretaining, the left-bank main river bed shall be used for diversion and temporary navigationduring construction. During the period (from December of the 1st year to November of the3rd year), the right-bank ship lock, 14 flood discharge gates, two-bottom-orifice section,Phase II longitudinal cofferdam, etc. shall be constructed.

3) By the end of November in the 3rd year, the metal structures of ship lockshall be installed and the normal navigation conditions shall be met. The 14 flooddischarge radial gates and bottom outlet gate shall be installed, and the conditions forreservoir impoundment shall be met.

b) Construction in Second Phase

1) In November of the 3rd year, Phase I upstream and downstream cofferdamsand the longitudinal cofferdam section in the powerhouse section shall be dismantled;filling of Phase II upstream and downstream cofferdams will be started from December,and the Project will enter the second phase of construction. In the middle ten daysof December, closure of the left-bank main river bed shall be conducted, the right-bank 14flood discharge gates shall be used for overflowing, and the right-bank permanent shiplock shall be used for temporary navigation.

2) From December of the 3rd year to May of the 5th year, Phase II upstream anddownstream cofferdams and longitudinal cofferdam shall be used for water retaining, theright-bank 14 flood discharge gates shall be used for discharging, and the permanent shiplock shall be used for temporary navigation. During the period, the left-bank powerhousesection with 14 units and left-bank non-overflow section shall be conducted.

3) In March of the 4th year, Phase II upstream and downstream cofferdamanti-seepage treatment shall be completed, and the impounding and water retainingconditions of the cofferdam shall be met.

4) At the end of March in the 4th year, the right-bank flood dischargegate will be closed for impounding. After impoundment has been conducted for 17d,the water level will be above the temporary navigation water level of 236.50m, andthe water amount and water level will both meet the conditions for temporarynavigation during construction. By gate adjustment in later period, the conditions forfirst unit debugging and power generation can be met after the water lever is above239.00m.

5) By the end of May in the 5th year, Phase II upstream and downstreamcofferdams and part of longitudinal cofferdam shall be dismantled to the specifiedelevation. The units shall be

installed and debugged under the condition of waterretaining with powerhouse water intake and tailrace gate. At the end of June in the 6th year,the first-batch unit (2 sets) will have the conditions for power generation. At the end ofMarch in the 8th year, the last-batch unit (2 sets) will have the conditions for powergeneration. The power generation construction period of the first batch (2 sets) is 5 yearsand the total construction period is 6 years and 9 months.

2.8.3 Diversion Standard and Flow Selection

a) Diversion Standard and Flow in First Phase

According to the provisions in Specification for Construction Planning ofHydropower Engineering, for a Grade 4 diversion structure, when the earth-rock cofferdamis adopted, the design return period of flood is 20~10 years; when the concrete cofferdamis adopted, the design return period of flood is 10~5 years. According to the constructioncharacteristics of hydraulic structures layout and master construction schedule, in the firstphase of the Project, the construction scheme with the earth-rock cofferdam for waterretaining throughout the year shall be adopted. As the water level before cofferdam of the20-year return flood retaining standard is only about 0.90m higher than that of the 10-yearreturn flood retaining standard, the cofferdam scale of both standards is basically the same,and compared with the 10-year return flood retaining standard, the 20-year return floodretaining standard is improved a lot. Therefore, the upper limit of the diversion standard inthe first phase shall be adopted, and the 20-year return flood shall be adopted with the peakdischarge of 23,000m3/s.

b) Diversion Standard and Flow in Second Phase

The construction in the second phase is mainly in the powerhouse with 14 units onthe left main river course, and the construction is relatively simple. According to theconstruction characteristics of hydraulic structures layout and master construction schedule,in the second phase of the Project, the construction scheme with the earth-rock cofferdamfor water retaining throughout the year shall be adopted. As the water level beforecofferdam of the 20-year return flood retaining standard is only about 1.00m higher thanthat of the 10-year return flood retaining standard, the diversion standard is the same withthat for the first phase. The upper limit of the diversion standard shall be adopted, that is,the 20-year return flood shall be adopted with the peak discharge of 23,000m3/s. Duringinstallation of units, water intake and tailrace gate will be adopted for retaining the waterduring the flood season. The flood control standard is for flood appearing once 100 yearsduring the whole year and the peak discharge is 27,200 m3/s.

c) Other Diversion Design Standards and Flow

①Final gap-closing design standard of right-side beach in the first phase: accordingto the master construction schedule, the dry season in the first phase will be in February ofthe 2nd year, and the 10-year return flood in February shall be adopted as the finalgap-closing standard with the average monthly discharge of 1890m3/s.

②Final closure design standard of left-side main river bed in the second phase:according to the master construction schedule, the closure in the second phase will bein December of the 3rd year, and the 10-year return flood in December shall be adopted asthe closure standard with the average monthly discharge of 3190m3/s.

③Design standard of gate closing and impounding: According to the masterconstruction schedule, gate closing and impounding of the Project is proposed to be inMarch of the 4th year. The 10-year return flood in March shall be adopted as the designstandard of gate closing with the monthly average discharge of 1360m3/s.

2.8.4 Temporary Navigation During Construction

Thetemporary navigation scheme during construction of the Project is: in the first phase,

theship lock, 14 flood discharge gates and 2-bottom-orifice section on the right beach will beconstructed, and the left main river bed will be used for overflowing and navigation; in thesecond phase, the powerhouse with 14 units in the left main river bed will be constructed,before Phase II closure, the navigation conditions of the right-bank permanent ship lockshall be met, during Phase II construction, the permanent ship lock will be used fortemporary navigation.

2.9 Quarry and Borrow pits

Quarry

The selected artificial aggregate area is Dajiang Quarry Area.Dajiang Quarry Area is located in the region adjacent to river at upper dam site and onthe left bank of Mekong River. It is about 2km away from the river bank and about 13kmaway from lower dam site, accessible via a tractor road. Its elevation is 300.0m~650.0mand area is 150,000 m^2. The area is south-west corner of a limestone mountain, with steepterrain and many precipitous cliffs. Its lithology is grey calcipulverite of crumb andmassive structures, with hard rock, relatively integrate rock mass and small overburdenamount of unavailable layer in mining. Calculated based on parallel section method,reserve of available layer is greater than 8 million m^3, meeting demand of the project foraggregates. Identification of mineral composition shows that major components of calcipulverite are calcite and a few quartzes, and partly contain a few huntites. Test resultsobtained with three methods show that the sample of tested rock in the area is non-alkalireactive aggregate.

Borrow Pits

The borrow area is located at terrace I on the right bank at lower dam axis at upperdam site, distributed in strip form along the river and classified as Class I area. The borrow area is 40m~90m wide and about 2000m long, its distribution elevation is 230.00m~237.00m and its area is about 152,100 m^2, grossreserves are about 533,000 m^3.

2.10 Fish passage

a)Fish resources and fish pass requirements

Mekong River basin is the second largest biodiversity basin following the Amazon Basin. According to Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin proposed by MRC (Mekong River Commission) in Aug. 2009 and relevant data, 40% ~ 70% fishes in Mekong River multiply depending on long distance migration. Migratory fishes to the upstream are mainly adult fishes of cyprinidae and grouper with body length of 20 cm ~ 100 cm; target fishes to the downstream include fish roe, young fish with body length of only a few millimeters and adult fish.

b)Fish way operating water level

Normal pool level of the hydropower station, i.e. 240.00m is taken as the highest upstream operating water level, and minimum pool level of the hydropower station, i.e. 239.00m is taken as the lowest; tail water level at full capacity of the hydropower station, i.e. 224.24m is taken as the highest downstream operating water level, and downstream cascade minimum pool level, i.e. 219.00m is taken as the lowest. The maximum operating water level difference of the fish pass structure is 21.00m.(See Page 5-188 to 5-199, details of Fish Pass Structure could be found in the section of Project Layout and Main Structure in FS approved in March 2017 as attached in this Report).

c)Type and layout of fish way

The fish pass structure is bilateral vertical slot fishway arranged along the left bank slope of the powerhouse with a total length of 1017m. The fish can swim upstream and downstream via the fishway. Under normal operation, the fishway water discharge is about 8.5m^3/s including quotative discharge of the fishway of 3.885m^3/s and quotative discharge of the make-up system of 4.785m^3/s. The fishway has a net width of 6m, depth of 3m and vertical slot width of 0.7m. A single pond is 5m long and level difference between adjacent ponds is 0.14m. A horizontal section of 10m-long rest pond is provided every 10 ponds. The upstream inlet of the fishway is arranged about 100m in front of the left-bank dam. Since the surface flow rate is low, obvious flow variations are created by the fishway quotative discharge exerting the fish luring effects. The downstream inlet is arranged on the bank about 280m below the tail water of the hydropower station. At the downstream outlet of the make-up system, a 15m-wide artificial waterfall is arranged to create the fish luring effects through the waterfall sounds and water flow .Between piles F. 0+613.834 ~ F. 0+670.567 in the middle section of the fishway is a large nature-imitating ecological rest pond where the fish can prey and feed themselves.

2.11 Dam safety

1) Flood Design

According to provisions of Classification & Design Safety Standard of Hydroproject(DL5180-2003), for structures such as concrete water retaining structure, water releasestructure and water retaining type powerhouse, design standard of flood control for normalapplication is based on 500-year return period and that for special application is based on2000-year return period For energy dissipation and anti-scour structures, design standard offlood control for

normal application is designed as 50-year return period. Flood controlstandard for downstream lead wall and retaining wall should be kept consistent with that ofthe energy dissipation and anti-scour structures.

2) Earthquake Safety

According to LAO PDR: Natural Hazard Risks published in March, 2011 byOCHA-ROAP and World Map of Active Tectonics, Nuclear Power Plants, Major Damsand Seismic Intensity, and with reference to Thailand Natural Disaster Profile (the upper& lower dam sites are 45km and 35km respectively west of the borders of Laos & Thailand)published in January, 2005 by Thailand's Ministry of Energy & Mining, the basic seismicintensity of the dam sites is determined as VI degree. After comprehensive considerationand analysis combined with the materials such as seismotectonic characteristics described above, the peak ground acceleration (PGA) of the dam site with 50-year exceedanceprobability of 10% is temporarily determined as 0.8m/s^2; In addition, there is no activefault distributed within 5km of the two dam sites, earthquake magnitude "M" within thearea is less than 5. According to Technical Specification for Regional Structure StabilityInvestigation of Hydropower & Water Conservancy Engineering, the regional structure isgood in stability.

According to (DL5073-2000) Specifications for Seismic Design of Hydroproject, theseismic intensity of the permanent water retaining structures of the Project is designed as 6degree.

3) Monitoring of the project during operation (by the proponent)

a) Monitoring Design Purpose

1) Conduct monitoring to each important structure and each key part to master the pattern change, to find out the abnormality timely and to take remedial measures to avoid accidents and ensure the project safety.

2) Check the correctness of the design proposal and the construction process to underlie the optimization of the design proposal, the improvement of the construction process and the determination of the design parameters.

3) Monitor and master the change tendency and stability process of the rock mass of the geotechnical works to make timely evaluation to its stability and safety degree

4) Provide measured data for feedback analysis and accumulate data for safety evaluation and scientific study of the project.

b) Monitoring System and Its Composition

Safety monitoring system of Paklay Hydropower Station mainly consists of various sensors, detecting units (monitoring-floor equipment) arranged at each observation station and equipment in the monitoring center. Main monitoring items include:

a)Deformation monitoring includes: horizontal displacement monitoring, vertical displacement and slope monitoring, dam body deflection monitoring, dam foundation deformation monitoring, structural and construction joints monitoring etc.

b)Seepage flow monitoring includes: foundation uplift pressure monitoring, seepage pressure monitoring, monitoring of seepage flow around the dam, overall leakage monitoring etc.

c)Stress-strain and temperature monitoring includes: concrete stress-strain monitoring, temperature monitoring of dam body and dam foundation, reinforcement stress monitoring, stress monitoring of prestressed anchor cable etc.

d)Slope monitoring includes: surface and internal horizontal displacement monitoring, surface and internal vertical displacement monitoring, underground water level monitoring, anchor stress monitoring, anchor cable stress monitoring etc.

e)Other monitoring includes: environmental variables, silting monitoring, seismic monitoring etc.

c) Safety Monitoring Design

According to design characteristics of hydroproject structures of the Project and combining specific situations of the Project scale, structure level etc. 8 monitoring sections are provided for water retaining dam and powerhouse, 2 for ship lock sluice chamber, 1 for dam abutment slope on the right bank and 3 for dam abutment slope on the left bank.

- Dam horizontal displacement and deflection monitoring: monitoring is carried out by adopting plummet + tension wire system, accompanied by artificial measurement (horizontal displacement monitoring network measurement).
- Dam vertical displacement and slope monitoring: automatic monitoring technical scheme of hydrostatic leveling + bimetal bench mark is adopted, accompanied by artificial measurement (leveling).
- Ship lock deformation monitoring: horizontal displacement monitoring is performed by adopting collimation line + direct and inverted plumb line system. The surface vertical displacement monitoring is performed by means of geometric leveling.
- Slope deformation monitoring: fourteen and six horizontal displacement monitoring points are set respectively on the slope berms on the left and right banks. Horizontal displacement observation is performed by adopting the combined method of triangulation and trilateration, taking monitoring network as working standard; slope vertical displacement measuring point and intersection measuring point are arranged at the same level. Vertical displacement observation is performed by adopting third order leveling method or trigonometric leveling by electro-optical distance measurement combined with third order leveling method.

- Stress-strain monitoring of dam concrete: strain gauge group and non-stress meter are provided inside the concrete at dam heel and dam toe.
- Slope supporting structure monitoring: one monitoring section is provided respectively for each dam abutment slope on the left and right banks. Anchor stress monitoring and anchor cable stress monitoring etc. are included.
- Temperature monitoring: some concrete thermometers have been provided according to monitoring requirements of ordinary concrete temperature field; one group of dam surface temperature measuring points have been arranged at one place on the

overflow surface at spillway affected by sunshine. Three thermometers are arranged in the characteristics of temperature gradient change.

- Joint surface and structural joint monitoring: an amount of joint meter has been provided at joint surface of concrete and bedrock at steeper part; joint meters have been provided in groups at expansion joints near monitoring sections.

- Bedrock deformation monitoring: Bedrock displacement meter is arranged at dam heel and dam toe on determined horizontal monitoring section. One group of thermometers are provided on the pull rod (in the vertical borehole) of bedrock displacement meter so that temperature correction can be performed to bedrock displacement meter and temperature variation in dam foundation can be observed.
- Prestressed pier monitoring: two intermediate piers and one abutment pier are selected for monitoring in order to perform monitoring on stressed state of prestressed pier. Monitoring items mainly include: tensioning control tonnage monitoring, prestress loss and stress variation monitoring.
- Longitudinal and transverse joints monitoring during powerhouse construction: to provide relevant parameter data for joint grouting construction and to monitor the state and variation after joint grouting, an amount of joint meter, reinforcement meter and thermometer have been provided on and near those joints.

- Uplift pressure monitoring: a piezometer tube is provided at each dam section along the dam longitudinal foundation gallery. Besides, one group of piezometer tubes (3 - 5 tubes for each group) are provided at different dam sections along horizontal foundation gallery, forming vertical and horizontal uplift pressure monitoring sections.
- Seepage discharge monitoring: six sets of measuring weir plant are temporarily considered to be provided at inlet of drainage sump and where the flow is concentrated at each dam section.
- Monitoring of seepage flow around the dam (underground water level): ten holes for seepage flow around the dam (underground water level) are respectively provided for dam abutments on the left and right banks for long-term monitoring of seepage flow around the dam.

- Environmental Variable Monitoring:A group of 6 surface thermometers are provided on concrete surfaces on upstream side of the A8-A8 monitoring section of the left non-overflow section to monitor reservoir water temperature Water level monitoring pipes are embedded at suitable part at upstream and downstream sides of concrete dam. A set of special water level automatic monitoring devices are provided. Special small-scale meteorological station is provided at suitable part of dam abutment to monitor environment variables, such as temperature, precipitation, humidity. Observation sections are arranged at suitable positions in front of the dam and at downstream to periodically or as required observe silting in front of the dam and downstream scouring and silting.

3 Objectives of the ESIA

3.1 Objectives

According to Lao PDR Law and regulations, Environmental and Social Impact Assessments are required for all HPP projects over 50,000 kW. At 770 MW the PLHPP will require a full ESIA.

The objectives of this ESIA are to:

- Examine existing information on the proposed PLHPP.
- Identify and review existing environmental and social information related to the potential effects of the PLHPP
- Identify and outline the existing National and International legal framework and guidelines related to the project and its environmental and social effects
- Identify information gaps and an appropriate study area
- Acquire additional project information and conduct baseline field studies to fill data gaps
- Report on the existing environmental and social context in the project area .
- Assess the significance of project-related, physical, biological and social issues
- Identify additional mitigation not included in project design
- Prepare an E&S mitigation and monitoring plan
- Identify and outline the existing National and International legal framework and guidelines related to the project and its environmental and social effects.

3.2 Approach in Conducting the ESIA

This section provides an overview of the Principal Activities and Tasks carried out during the ESIA process. The ESIA comprised 4 distinct phases:

- Phase 1 – Preparation;
- Phase 2 – Biophysical and Social Data Collection and Analysis;
- Phase 3 – Environmental Impact Analysis, Assessment, and Mitigation;
- Phase 4 – Drafting and Reporting.

Phase 1 – Preparation

- ***Task 1.1 - Developed Detailed Work Plan and Schedule***

  The Team Leader (TL) developed the detailed spread sheet / work plan and schedule for the ESIA. These documents described the Key activities / tasks, deliverables and the milestones for the EIA.

- ***Task 1.2 - Briefed Study Team***

  The TL briefed the Biophysical and Social Discipline Team Leaders (DTL) on the TOR for the environmental work, the available project information, the initial work plan and schedule. The experts also are from various expertise sector and universities in Laos and Thaland and Some concerns GoL Organisations like Living Aquatic Resources Research Center (LARReC)

- ***Task 1.3- Initial Reconnaissance of Projected Affected Area***

  Team leaders conducted an initial reconnaissance of the project and reservoir area. The objective was to obtain first-hand knowledge, plan logistics and prepare an initial impact identification matrix.

- ***Task 1.4 -Acquired Guidelines and Establish Paklay HPP Library***

  Relevant National and International guidelines and examples of current good practice for ESIA were acquired and made available to the discipline specialists for use in their work.

- ***Task 1.5A - Reviewed Project Specifics***

  Relevant existing documentation on the project was acquired and data gaps were identified. This provided the background for the identification of project components / activities with potentially significant impacts.

- ***Task 1.5B - Compiled Initial Project Information***

  Environmentally relevant information on construction and operation of the project was compiled from the feasibility study.

- ***Task 1.6 - Multidisciplinary / Stakeholder Scoping and Consultation***

  Discipline Team Leaders (DTL) conducted additional project and discipline specific scoping sessions with their respective teams and stakeholders and discipline TORs, work plans, methodologies and schedules were developed. Participatory Stakeholder Consultation was also conducted to verify the validity of the proposed scope and approach to the ESIA. Feedback obtained from participants was used to adjust the scope, approach and focus of the ESIA to meet National and International guidelines.

- ***Task 1.7 - Secondary Data Collection and Documentation***

Under the direction of the DTLs, specialists identified, acquired, reviewed, analysed and assessed the existing (secondary) information relevant to the environmental description and impact assessment. On the basis of this information they identified critical data gaps and began drafting discipline specific sections of the environmental description.

- ***Task 1.8 Initial GIS Data Entry***

  GIS was a keystone of the ESIA and allowed the creation of base maps that accurately illustrated the physical relationship between key components of the project and the physical, biological and social features / resources potentially affected by implementation.

- ***Task 1.9 - Acquired Copies of Existing Information for Project Library***

  Discipline specialists facilitated acquisition of existing information acquired during their research. These copies were made available in the project library for use by other members of the study team.

- ***Task 1.10 - Procured Necessary Equipment***

  DTL and specialists identified specific needs for equipment and logistical support. The NCC Management Team prepared formal requests for access to information in the hands of Agencies and NGO's, and provided equipment and support.

- ***Task 1.11 - Draft and Final Inception Reports***

  Draft and final Inception reports were submitted at the end of Phase 1 of the ESIA.

Phase 2 – Bio Physical & Social Data Collection And Analysis

- ***Task 2.1 Primary Field Data Collection***

  Based on; the project description provided in the Feasibility Study (FS), review of the existing information, the initial reconnaissance, and the discipline work plans, specialists conducted field studies to obtain additional (primary) information needed to: 1) fill information gaps, 2) prepare a focused description of the physical, biological and social environments of the potentially affected / study area, 3) assess project impacts, and 4) develop environmental management and monitoring plans.

- ***Task 2.2 - GIS Data Entry Completed***

  The creation of the GIS data base and the capability to produce maps illustrating the physical relationship between key components of the project and physical, biological and social features / resources was a key activity during Phase 2 of the ESIA. This facilitated identification and quantification of impact magnitude and assessment of impact significance in Phase 3 of the ESIA.

- ***Task 2.3 - Prepared Draft "Environmentally Relevant" Project Description***

Based on information provided by the Feasibility Study (FS) the designated NCC specialist prepared the first draft of the "Environmentally Relevant" project description which focused primarily on the aspects of the project that were expected to have potentially significant environmental or social effects or impacts.

- ***Task 2.4 - Describe Cause Effect Relationships & Confirm VECs & ECARs***

Following preparation of the initial impact identification matrix (activity #1.4) and the draft "Environmentally Relevant" project description, a brief description of each of the potential cause / effect relationships between specific project components / activities and potentially affected Valued Ecosystem Components (VECs) and Environmental Components at Risk (ECARs) were prepared. The output of this work was used to set the stage for the assessment of project impacts in the assessment phase (3) of the ESIA.

- ***Task 2.5 - Draft and Final Interim Reports***

The Draft Interim report provided an overview of the progress and results to that point in the study and an outline of upcoming Tasks and the anticipated schedule for their completion.

Phase 3 - Environmental & Social Impact Analysis, Assessment & Mitigation for the EIA, SIA, EMMP, HIA, RAP, SMMP, TBESIA&CIA.

- ***Task 3.1 - Impact Assessment Workshop***

Prior to the Environmental and Social Impact Analysis and Assessment Phase of the ESIA the team leader conducted an Impact Assessment Workshop with the NCG management team and DTLs. The workshop reviewed the Impact Assessment Framework designed to ensure a thoughtful, systematic, and rigorous approach to the identification and analysis of project effects and the assessment of Impact significance.

- ***Task 3.2 - Impact Assessment***

Following the workshop the DTLs worked with their respective specialists to assess the significance of project impacts in their discipline areas. This entailed final Identification of potential concerns on the Cause / Effect Impact Matrix, Prediction of the probable Magnitude of anticipated Effects, Evaluation of the probable Importance of the predicted Effects and the Assessment of the Significance of anticipated impacts.

- ***Task 3.3 - Identify and Cost Monitoring and Mitigation***

In parallel with the assessment of project impacts, cost effective and feasible Mitigation and Monitoring Measures were recommended and described in relation to the impact for which they are required. Monitoring protocols for specific parameters were also identified, described and costs were estimated. Recommended mitigation and monitoring measures were

integrated within the Environmental and Social Mitigation and Monitoring Plan (ESMMP).

Phase 4 - Reporting

- ***Task 4.1 - Drafting Discipline Specialist Sections of the ESIA***

  The Discipline Team leaders worked with the discipline specialists to develop the final Table of Contents for each of the specific reports. Under the direction of the Discipline Team Leaders each discipline specialist prepared a draft of a specific section or sections of one or more of the EIA - EMMP-SIA-SMMP-RAP-HIA-TBESIA&CIA reports.

- ***Task 4.2 - Review and Revise Draft Reports***

  The Discipline Team leaders reviewed the draft sections / reports prepared by the discipline specialists and worked with the discipline specialists to revise them as necessary. The Discipline Team Leaders or Team Leader were responsible for the final content, quality and timely delivery of one or more of the reports.

- ***Task 4.3 - Final Review Formatting and Printing Draft Final Reports***

  This task will be carried out by NCC Project management staff with the support of the Team Leader and Discipline Team Leaders as required.

Phase 5 - Public Consultation

- ***Tasks 5.1, 5.3, & 5.4 - Village Provincial and National Consultations***

  In addition to the consultations that took place early in the ESIA with the Potentially Affected people (PAP) more formal consultations will be held to inform PAP and other village, provincial and National stakeholders of the progress and results of the ESIA, and to receive their comments on the draft reports. These comments will be addressed in the final versions of the reports before they are submitted in final form to the government for approval.

Overall ESIA Project Management (PM)

- ***Task PM. 1 - Weekly Project Management Meetings and Reporting***

  These meetings were held to ensure the ESIA was managed, conducted and documented in a systematic, comprehensive, effective and clear manner. At each meeting the team presented and discussed the status of the tasks being conducted during the current Phase of the Environmental Assessment work. Following this meeting the weekly status report was issued.

4 POLICY AND LEGISLATIVE/REGULATORY FRAMEWORK

4.1 Environmental Legislation

Lao PDR is one of the 10 countries in ASEAN that has advance environmental laws and regulations. Key organizations and agencies involved in the EIA process include the Government of Lao PDR (GOL); the Prime Minister's Office (PMO); the Ministry of Natural Resources and Environment (MONRE) especially the Department of Environment and the Department of EIA; the Ministry of Agriculture and Forestry (MAF) especially the Department of Forestry; the Ministry of Energy and Mines (MEM) especially the Department of Mines; the Ministry of Finance; the National Land Management Authority especially the Department of Land Development and Planning; the Ministry of Culture, the Ministry of Health, the Provincial Administration, District administration and Village administration of the project location.

Since the establishment of Lao PDR in 1975 and adopted a new constitution in August 1991, a number of laws and regulations were on boarded. The main ones related to ESIA are as follows:

- **The Lao Environmental Protection Law (2012)**

Article 1 Purpose (revised): The Environmental Protection Law defines principles, regulations and measures related to environmental management, monitoring of protection, control, preservation and rehabilitation, with quality, of mitigating impacts and pollution created by anthropogenic loads or by nature, aiming to provide balance between social and natural environment, to sustain and to protect natural resources and public health; and contribution into the national socio-economic development and reduction of global warming.

Article 5 Environmental Protection Policy(s) (new): The State promotes protection and rehabilitation of social and natural environment through dissemination of regulations and environmental information, building of awareness and knowledge, training and conducting campaigns for individuals and organizations, both domestic and international, to recognize importance of social and natural environment in daily livelihoods and in strictly implement the environmental protection regulations, methods and measures.

The State encourages investments into clean production and technology, green economy, and environmental protection via policies, particularly provisions of credits, technical assistance, information, and exemptions or reduction of duties-taxes based on regulations.

Article 7 Commitment in Environmental Protection (revised): Persons, households, legal entities and organizations have commitments of protecting, improving, rehabilitating, controlling, monitoring and inspecting the environment based on regulations to avoid creating impacts on the environment, causing degradation and polluting that exceeds the Pollution Control Standard and the National Environmental Quality Standard, aiming to ensure good quality of the environment and sustainable development.

Article 22 Environmental Impact Assessment (revised): Environment Impact Assessment (EIA) shall be a process of addressing an issue in order to anticipate impacts that may affect the environment, society and nature, derived from investment projects or activities, along with considerations related to climate change in Lao PDR, and development of reports. Apart from reporting, there shall be development of Environmental Social Management and Monitoring Plans.
Both the report and the plan shall be approved by MONRE prior to functioning investment projects and activities.

The process of assessing impacts from the investment project and the activity on the environment, society and nature, shall comply with the specific regulations.

b) The Lao Amended Forestry Law (No. 64/NA-June.2019)

The Amended Forestry Law, No 64/NA (June. 2019): determines basic principles, regulations and measures on sustainable management, preservation, development, utilization and inspection of forest resources and forestland. At the same time it promotes regeneration of forest and tree planting, and increase of forest resources in the Lao PDR with aiming to maintain the balance of nature, making forest and forestland a stable source of living and use of people, ensuring sustainable preservation of water sources, prevention of soil erosion and maintenance of soil quality, conserving plant and tree species, wildlife species as well as environment and contributing to the national socio-economic development.

c) The Lao Wildlife and Aquatics Law (No. 07/NA-Dec.2007)

Wildlife and Aquatics Law, No 07/NA (Dec. 2007) The Wildlife and Aquatic law determines principles, regulations and measures on wildlife and aquatic life in nature to promote the sustainable regeneration and utilization of wildlife and aquatic, without any harmful impact on natural resources or habitats and to restrict anthropogenic pressure on decreasing species and the extinction of wildlife and aquatic, by encouraging people as a whole to understand and recognise the significance, with enhancing the conscientious love, care and treatment of animals. To engage in managing, monitoring, conserving, protecting, developing and utilizing wildlife and aquatic in sustainable manner. To guarantee plenteousness and richness of ecological natural equilibrium systems, to contribute in upgrading the condition of livelihoods for multi-ethnic people, which has the potential to develop and realise the national social-economic goals.

d) **The Water and Water Resources Law (No.010/NA - 11 May 2017)**

The amended law defines principles, regulations and measures relating to the management, prevention, development and use of water and water resources to ensure they are effective and sustainable in response to the living conditions of people, agriculture, industry production, and regional and international integration. It also aims to contribute to national safeguarding, construction and development.

e) <u>The Lao Amended Land Law (No. 04/NA-Oct.2003)</u>

The GoL grants rights to individuals, families or organizations pursuant to the Land Law (2003). These grants are either temporary "right to use" grants for up to five years or as thirty year "leases". The National Land Management Authority (NLMA), in conjunction with the Prime minister's office (PMO), has the responsibility for land titling, registration and leasing of land. The MAF manages the use of the land. **Decree 37/PM** specifies that the MAF provincial office shall determine which parts of the resettlement area shall be used for what purpose. Subsequently, the land will be surveyed by the Department of Land Development and Planning (NLMA) which can grant a thirty years lease on land for housing and agricultural development.

4.2 Decree on the Assessment of Environment Impacts no. 21/GO, dated 31 January 2019

This decree defines the principles, regulations, and measures for the management and monitoring the environmental impact assessment in order to ensure that the activity is implemented properly, transparently and uniformly. This decree aims to prevent, reduce and solve negative environmental impacts; to ensure the reasonable compensation; to allocate the settlement and occupation, and rehabilitate the lives of affected people; to enhance the management and utilization of natural resources to progress in the most effective manner; and to contribute to the national social-economic development.

This decree can be used in all investment projects identified in the guideline of the ESIA process and approved agreement that declared a list of investment project whether the project must conduct the IEE or ESIA.

- *Category 1:* Investment projects which are small or create less impacts on environment and society, but require initial environmental examination;

- *Category 2:* Large - sized investment projects which are complicated or create substantial impacts on environment and society but require environmental impact assessment.

4.3 Hydropower Environmental & Social Sustainability

The 2005 National Policy on Environment and Social Sustainability of the Hydropower Sector in Lao PDR – An important GOL's environmental policy improvement was found on the new national policy on Environment and Social Sustainability of the Hydropower Sector in Lao PDR which was recently adopted in June 2005. It applies to all large hydropower dams (installed capacity more than 50 MW or inundated area more than 10,000 hectares) that constructed after 1990.

This policy employed the development principle based on Nam Theun 2 Hydropower Project with the integrated approaches to river basin where cumulated impacts and mitigation with appropriate institutional and financing mechanism were mentioned.

4.4 Law on Resettlement and Vocation (No. 45/NA,c dated 15June2018)

This Law sets out principles, rules and measures regarding the supervision, inspection and monitoring of resettlement and vocation in order to enhance its efficiency, effectiveness, compliance, and to be consistent with locality condition and development to ensure Lao multi-ethnic persons who live in resettlement and vocational area have place to stay, place to earn a living and sustainable vocation which aim to solve illegal relocation problem, reduce poverty, improve livelihood of Lao multi-ethnic persons physically and mentally, develop social discipline, become development village and agglomerate big villages into small town in rural areas therefore contribute to national socio-economic development as well as to safeguard national defense and security.

Resettlement and Vocation:

Resettlement is an arrangement of place to live and to earn a living for persons in urban and rural areas who have displaced or migrated from their original residence to a new residence, to ensure the balance and consistency with the development.

Vocation is to build facility and capacity to make a living for persons in urban and rural areas who displaced or migrated from their original residence to a new residence, to ensure that they have stable sources of income, have a better livelihood and are graduated from poverty.

4.5 Ethnic Groups

The 1991 Constitution defined Lao PDR as a Multi-Ethnic State with "Equality among all ethnic groups" as described under Article 8 of the Constitution below:

The State pursues the policy of promoting Unity and Equality among all ethnic groups. All ethnic groups have the rights to protect, preserve and promote the fine customs and cultures of their own tribes and the nation. All Acts of creating Division and Discrimination among ethnic groups are forbidden. The State implements every measure to gradually develop and upgrade the economic and social level of all ethnic groups".

The 1992 ethnic policy, in the Resolution of the Central Politic Bureau of the Party concerning Ethnic Affairs in the new era, focuses on gradually improving the living conditions of the ethnic groups, while promoting their ethnic identity and cultural heritage.

4.6 Cultural & Archaeology

Relevant policy, legal and regulatory framework for archaeology and cultural heritage included Cultural and Natural Heritage in Lao People's Democratic Republic (Lao PDR) is controlled by the following laws and regulations:

- The national Heritage Laws of Lao PDR on the preservation of culture, historical and natural heritage. Complete set of regulations concerning the management of culture, historical and natural heritage was agreed from National Assembly Number 08/NA on dated 09 November 2005.
- The Decree of the President of the Lao People's Democratic Republic on

the preservation of culture, historical and natural heritage. Complete set of regulations concerning the management of cultural, historical and natural heritage.

- Constitution. Article 19: The management of national heritage is a State study.
- Penal Code. Article 103: Sanction to law offenders in particular in the cases of damage and destruction of cultural sites, export and trade of antiquities.
- Law on the protection of environment. Article 16: Developers must abide by laws and regulations concerning the material culture sites that might be affected by their development projects.
- The Ministry of Information, Culture and Tourism , on behalf of the council of Ministers implements the National policy on culture and cultural heritage. It is represented at provincial and district level by the Office of Information and Culture of province and district, respectively. Laws and regulations on cultural heritage are enforced under the guidance and control of Ministry of Information and Culture. Lawsuits are filed by Ministry of Information and Culture and transmitted to courts for trials and sanctions against offenders.

4.7 Tourism

Key issues of the 2005 Law on Tourism related to Paklay tourism aspect are as follows:

Article 1: Purposes - The Law on tourism sets the principles, procedures and measures on the establishment, activity and administration of tourism aiming to promote and develop the cultural, historical and eco-tourisms in extending, sustainable ways, transforming to modern tourism industry and contributing the national protection and development, to promotion of mutual understanding, peace, friendship and to cooperate in international development, tourism's services.

4.8 Other Lao Laws/Policies Relevant to ESIA

- **Land Law (2003)**

The objectives of the Land Law are to determine the regime on the management, protection and use of land in order to ensure efficiency and conformity with [land-use] objectives1 and with laws and regulations[,] and to contribute to national socio-economic development as well as to the protection of the environment and national borders of the Lao People's Democratic Republic.

- **Road Law (1999)**

Environmental protection is required during road activities. National and provincial authorities of the Ministry of Communications, Transport, Post and Construction are responsible for environmental protection on road projects. Reasonable compensation must be paid to individuals whose land is expropriated for road rights-of-way, relocation of replacement structures, and loss of trees and crops.

- **The Amended Forestry Law, No 64/NA (June 2019)**

Determines basic principles, regulations and measures on sustainable management, preservation, development, utilization and inspection of forest resources and forest land, promotion of regeneration and tree planting, and increase of forest resources in the Lao People's Democratic Republic aiming for maintaining the balance of nature, making forest and Forestland a stable source of living and use of people,

ensuring sustainable preservation of water sources, prevention of soil erosion and maintenance of soil quality, conserving plant and tree species, wildlife species as well as environment and contributing to the national socio-economic development.

- **Prime Minister Decision No. 81/MP (2008) on Endorsement of the Prohibited and Controlled Species List of Wildlife and Aquatic Animals**

  With reference to the Article 22 of the Wildlife and Aquatics Law of the Lao PDR, the Prime Minister' Decision has endorsed the prohibited species namely List-1 which include 44 species of mammals, 9 species of reptiles, 36 species of birds, 6 species of aquatics and 1 species of amphibian. While the Decision has also set the controlled species namely List-2 which include 15 species of mammals, 13 species of reptiles, 22 species of birds, 9 species of aquatics and 7 species of insects.

- **MAF Decision No. 0070/MAF (2008) on endorsement of General or Common Species List of Wildlife and Aquatics**

  With reference to the Article 22 of the Wildlife and Aquatics Law of the Lao PDR, the Ministry of Agriculture and Forestry (MAF) has also issued the decision No. 0070/MAF to endorse the general or common species list of wildlife and aquatics namely List-3 which include 6 species of mammals, 8 species of reptiles, 5 species of birds, 18 species of aquatics, 3 species of amphibians and 5 species of insects.

- **MAF Regulation No. 0360/MAF on Management of National Biodiversity Conservation Areas (NBCAs)**

  MAF' Regulation Nº 0360/MAF on Management of National Biodiversity Conservation Areas, Aquatic Animals and Wildlife provides guidelines on NBCA establishment and zoning and also on restricted activities and development fund establishment and the rights and duties of state agencies in NBCA management.

4.9 LAW ON HYGIENE, DISEASE PREVENTION AND HEALTH PROMOTION No. 73 /NA, dated 22 No2019)

This Law determines the principles, rules and measures relating to the organization and activities on hygiene disease prevention and health promotion in order to maintain the good health, quality of life and longevity of the citizens, aiming at reduction of the rates of morbidity and mortality; prevention of diseases of all types; internal, regional and international integrations; and access to networks of hygiene, disease prevention and health promotion for reaching international standards and contribution into the national protection and development.

- Decree of Prime Minister, No:54/MP, 23/03/2006 on the Declaration of use and Implementation of National Policy on HIA

4.10 Law Electricity (Amended) No.19/NA, dated 09May2017

The Law on Electricity determines the principles, rules and measures on the organization, operation, management and inspection of electrical activities for the high effectiveness of electricity generation and business operation with the aims to use the natural resource potentials in economical and sustainable manner, to encourage the implementation of the national socio-economic development plan and to improve the living conditions of the multi-ethnic people.

Electricity is a type of energy which is comprised of electricity power, electricity current, voltage and frequency produced by the sources from natural resources, such as: hydropower, wind power, solar energy, fuel, lignite, biomass energy, thermal, gas, Palm oils and nucleus energy and others.

4.11 Regional Agreement

The regional agreement is found on *"The Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (1995)"* This agreement was signed on 5 April 2005 by four Mekong riparian countries, namely, the Kingdom of Cambodia, the Lao People's Democratic Republic, the Kingdom of Thailand and the Socialist Republic of Viet Nam.

The agreement has set a new mandate for organization to cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin. Signatories to this treaty agree that transfer of the Mekong River and tributary water outside the Mekong River Basin can occur only by consensus among the four country members. The member countries therefore agree to coordinate in water project planning and monitoring of the basin waters.

Also important is to start a process of reasonable and equitable use of the Mekong River System in each country to develop procedures for water utilization. The Mekong River Commission (MRC) is supporting a joint basin-wide planning process with the four countries called The Basin Development Plan, which is the basis of its Integrated Water Resources Development Program. The MRC has included the following topics: fishery management, the promotion of safe navigation, irrigated agriculture, watershed management, environmental monitoring, flood management and exploring hydropower alternatives. The agreement outlinesthree sets of procedures:

Procedures for Notification, prior to Consultation and Agreement, requires member countries to alert each other on planned river development that could significantly affect their neighbors, and to provide information regarding the developments, including technical specifications and environmental assessments.

1) Procedures for Water Use Monitoring which can provide a legal basis for a water use monitoring system to be established in the lower Mekong Basin.
2) Procedures for the Maintenance of Flows on the Mainstream.

These agreed procedures provide a definition of water use, covering uses of the Mekong that may have a significant impact on water quality and hydrological regimes on the mainstream of the Mekong.

5 ENVIRONMENTAL BASELINE CONDITION

5.1 Supplement Site Survey for Collecting Environmental Information

According to the changes of project design and comments from CNR and Instituto Áqua Viva - Brazil, NCG carried out the supplement site survey for information updating and checking from November 2015 to March 2017. Although the design has revised, many basic conditions were still the same as the last survey. So the aim of supplement site survey was to update the changed information and confirm new impacts. The supplement site survey included new data and policies collection, reviewing for impacts, more public participation, consulting with local government.

5.2 Global Environmental Study

5.2.1 Global Baseline

In 2007, the Worldwatch Institute reported a story relating to the global environment and it is summarized below:

a) **General**

The global number of population was 6.6 billion and would be growing year by year. While the ecosystem services upon which life depends are being stretched to the limit due to record levels of consumption:

- In 2006, the world used 3.9 billion tons of oil. Fossil fuel usage in 2005 produced 7.6 billion tons of carbon emissions, and atmospheric concentrations of carbon dioxide reached 380 parts per million.
- More wood was removed from forests in 2005 than ever before.
- Steel production grew 10 percent to a record 1.24 billion tons in 2006, while primary aluminum output increased to a record 33 million tons. Aluminum production accounted for roughly 3 percent of global electricity use.
- Meat production hit a record 276 million tons (43 kg per person) in 2006.
- Meat consumption is one of several factors driving soybean demand. Rapid South American expansion of soybean plantations could displace 22 million hectares of tropical forest and savanna in the next 20 years.
- The rise in global seafood consumption comes even as many fish species become scarcer: in 2004, 156 million tons of seafood was eaten, an average of three times as much seafood per person higher than in 1950.

The expanding world population's appetite for everything from everyday items such as eggs to major consumer goods such as automobiles is helping to drive climate change, which is endangering organisms on the land and in the sea:

- The warming climate is undermining biodiversity by accelerating habitat loss, altering the timing of animal migrations and plant flowerings, and shifting some species towards the poles and to higher altitudes.
- The oceans have absorbed about half of the carbon dioxide emitted by humans in the last 200 years. Climate change is altering fish migration routes, pushing up sea levels, intensifying coastal erosion, raising ocean acidity, and interfering with currents that move vital nutrients upward from the deep sea.

- Despite a relatively calm hurricane season in the U.S. in 2006, the world experienced more weather-related disasters than in any of the previous three years. Nearly 100 million people were affected.

The global vital signs have been addressed in sub section b) to h) below.

b) Food and Agriculture

- For the second year in a row, the world produced over 2 billion tons of grain (more than at any other time in history). (p. 22)
- Since 1997, wild fish harvests have fallen 13 percent. Yet total fish production continues to growto 132.5 million tons in 2003bolstered by a surging aquaculture industry. (p. 26)
- World exports of pesticides reached a record $15.9 billion in 2004. Pesticide use has risen dramatically worldwide, from 0.49 kilograms per hectare in 1961 to 2 kilograms per hectare in 2004. (p. 28)

c) Energy and Climate

- Oil use grew 1.3 percent in 2005, to 3.8 billion tons (83.3 million barrels a day). (p. 32)
- In 2005, the average atmospheric carbon dioxide concentration reached 379.6 parts per million by volume, an increase of 0.6 percent over the record high in 2004. (p. 42)
- The average global temperature in 2005 was 14.6 degrees Celsius, making it the warmest year ever recorded on Earth's surface. The five warmest years since recordkeeping began in 1880 have all occurred since 1998. (p. 43)
- Economic damages from weather-related disasters hit an unprecedented $204 billion in 2005, nearly doubling the previous record of $112 set in 1998. (p. 44)
- Global wind power capacity jumped 24 percent in 2005, to nearly 60,000 megawatts. The growth in wind power capacity was nearly four times the growth in nuclear power capacity. (p. 36)
- In 2005, worldwide production of photovoltaic cells jumped 45 percent to nearly 1,730 megawatts, six times the level in 2000. (p. 38)
- Production of fuel ethanol, the world's leading bio-fuel, increased 19 percent to 36.5 billion liters in 2005. (p. 40)

d) Economic Trends

- In purchasing-power-parity terms, the global economy reached another new peak, with the gross world product hitting $59.6 trillion in 2005. (p. 52)
- Global advertising spending increased 2.4 percent to a record $570 billion in 2005. Nearly half of this spending was in the United States, with $56.6 billion alone going to the production and distribution of 41.5 billion pieces of mail advertisements. (p. 54)
- In 2005, steel production reached a new record of 1,129 million tons while aluminum production reached a record 31.2 million tons. (p. 56, 58)
- Round-wood production hit a new record of 3,402 million cubic meters in 2004. (p. 60)

- In 2004, nearly 1,800 transnational corporations or their affiliates filed corporate responsibility reports, up from virtually none in the early 1990s. While this reflects growing transparency and commitment to social and environmental principles, 97.5 percent of the nearly 70,000 TNCs worldwide still do not file such reports. (p. 122)

e) Transportation and Communications Trends

- The world reached a new record in vehicle production, with 64.1 million cars and light trucks being manufactured in 2005. (p. 64)
- Air travel hit new records as well: in 2004, 1.9 billion passengers traveled 3.4 trillion kilometers. Yet only 5 percent of the world's population has ever flown. (p. 68)
- Total membership in car-sharing organizations (CSOs) hit 330,000 in 2005, 2.5 times the number in 2001. Total vehicles used by CSOs reached 10,570. According to studies, sharing a car reduces the need for 4–10 privately owned cars in Europe and 6–23 cars in North America. (p. 118)

f) Conflict and Peace

- The number of wars and armed conflicts worldwide declined to 39 in 2005, the lowest figure since the peak in the early 1990s. Yet at the same time, global military expenditures hit $1.02 trillion, the highest spending since the early 1990s. (p. 82, 84)

g) Health and Society

- World population added 74 million more people in 2005, reaching a record 6.45 billion. (p. 74)
- Five million more people were infected by HIV in 2005, while 3 million people died from AIDS-related illnesses. (p. 76)
- Infant mortality rates fell 7 percent over the last five years, from 61.5 deaths per 1,000 live births in 1995–2000 to 57 deaths per 1,000 live births in 2000–2005. (p. 78)
- Over half of the world's 7,000 languages are endangered, and more than 500 are nearly extinct. (p. 112)
- One billion individuals, or one in every three urbanites, live in "slums," areas where people cannot secure one or more of life's basic necessities: clean water, sanitation, sufficient living space, durable housing, or secure tenure. (p. 114)
- As of 2002, 1.1 billion people lack access to an improved water supply, and some 2.6 billion are thought to lack access to improved sanitation facilities. (p. 116)
- Obesity now afflicts more than 300 million people, increasing their chances of contracting cardiovascular disease, diabetes, certain cancers, and other ailments. (p. 120)

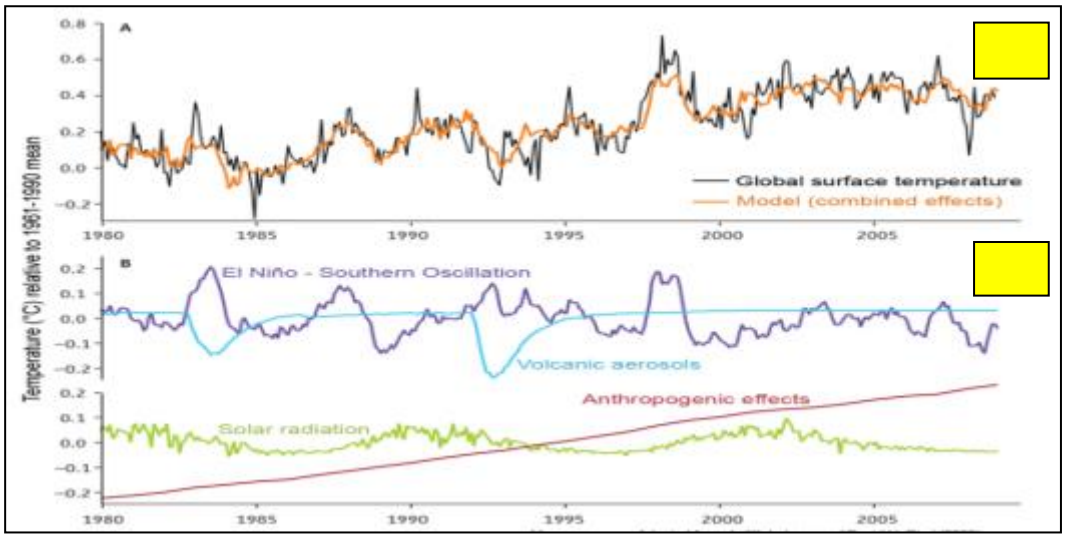
h) Environment Trends

- Humanity overdrew the natural capital it depends on by 23 percent in 2002. (p. 92)
- Between 2000 and 2005, global forested area shrunk by more than 36 million hectares (just under 1 percent of the total forested area). (p. 102)
- As of late 2005, an estimated 20 percent of the world's coral reefs had been "effectively destroyed," while 50 percent are threatened in the short or long term. (p. 94)
- Twenty percent of the world's mangrove forests have been destroyed over the past 25 years. (p. 100)
- Twelve percent of all bird species were categorized as "threatened" in 2005. (p. 96)
- Three percent of all plant species are currently threatened with extinction. (p. 98)

5.2.2 Global Temperature Change and Paklay HPP Climate Change Study

5.2.2.1 Global Temperature Change

The key global environmental issue is concerned with global temperature change. The temperature of the air near the surface has been measured by land, sea and satellite instruments, very accurately since the 1970s and fairly accurately since the late 19th century (see figure below). Four main influences are known, and combining these gives quite a good match to the observations (orange curve in A). The known influences are: irregular "El Niño" fluctuations in the upwelling of deep cold waters in the tropical Pacific Ocean, which cool or warm the air for a few years (purple curve in B); sulfate smog particles emitted in volcanic eruptions, such as El Chichón in 1982 and Pinatubo in 1991, which bring temporary cooling (blue curve); a quasi-regular cycle in the Sun's activity that changes the radiation received at Earth (green curve); and human ("anthropogenic") changes — primarily emission of carbon dioxide from fossil fuels, but also other greenhouse gases and pollution such as smoke, and land-use changes such as deforestation (red curve).



Source: http://www.aip.org

Figure 2: Global Temperature Change

5.2.2.2 Paklay HPP Climate Change Study

(a) Introduction

The PLHPP has conducted specific study on climate change in relation to the project development.

Carbon dioxide (CO_2) accounts for more than half of the warming affect of climate change, while CFCs contribute about a quarter and methane and nitrous oxide the remainder. Released CO_2 reaches the upper layer of the atmosphere and acts as a greenhouse gas. CO_2 and other gases such as oxides of sulphur and oxides of Nitrogen allow sun rays to enter the earth but prevent the outgoing radiation.

Information on Green House Gas (GHG) emissions among countries in the LMB, ASEAN, and other part of the world showed that the LMB countries produced very small GHG compared to those produced in Europe, USA, and China. The LMB GHG emission is 568 (see Table below) TCE while Europe, USA, and in China are as high as 5047 TCE, 6,963 TCE, and 7,219, respectively. Therefore, the LMB countries produced emissions only about 3% of Europe, USA, and China.

Table 4: GHG Emission Statistic

Country/ Region	GHG Emissions (TCE)	GHG Emissions per capita (TCE/person)	GHG Emission Intensity (TCE/year2000international MUSD)
LMB:	568.3		
Cambodia	*22.7*	*1.6*	*1,131.6*
Lao PDR	*17.4*	*3.1*	*1,691.1*
Thailand	*351.3*	*5.6*	*788.7*
Vietnam	*176.9*	*2.1*	*993.2*
ASEAN	1,609.4	2.9	747.0
China	7,219.2	5.5	1,353.6
Europe	5,047.7	10.3	378.4
USA	6,963.8	23.5	561.7
Russia	1,960.0	13.7	1,151.4
WORLD	37,766.8	5.8	672.3

Source: MRC, Note: MUSD = Million US Dollars, TCE=Tons CO_2 Equivalent

(b) Greenhouse Gas

The APEC Energy Demand and Supply Outlook 2006 mentioned that Thailand's total CO_2 emissions from the energy sector are projected to increase from 193 million tons of CO_2 in 2002 to 734 million tons of CO_2 in 2030. The electricity sector will be the major contributor accounting for 40 percent of total CO_2 emissions in 2030, or 294 million tons CO_2. Thailand has agreement to import hydropower electricity from Lao PDR in the amount of 7,000 MW by 2020. The Paklay HPP is expected to sell electricity produced to Thailand.

In this regard, we have to address global issues that related to global warming. The climate change specialist has calculated the net emissions based on a "benefit transfer approach" with assumptions as below:

- The forest biomass proxy (that is 259 ton/ ha) estimates of *all* forest types and state of the standing forest in the project area;
- As generally employed, 0.5 is used to estimate the carbon content in forest biomass, by weight;
- We assume that 40% of the forest biomass is harvested for the dam construction, hence 60% remains un-harvested to decay;
- Assume zero under-ground biomass, invariably justified by the remaining 60% above-ground above—thus no methane emissions;
- Estimated biomass for this type of forest according to source is 259 tons/ ha;
- Estimated inundated land for hydropower project is 451.29 ha;
- Only 13.8% of the standing forest is lost to flooding.
- For methane emissions, it is estimated at approximately 13.8% of the forest to be affected by dam construction and 40% harvested in Paklay HPP that:

Forest biomass being cleared = 0.4 x 0.138 x 259 tons/ ha x 2,943 ha

= 42,075.48 tons biomass

With an estimated 50% of the biomass being carbon, the total carbon emissions are 21,037.74 tons carbon dioxide emitted. This is a rather small amount to be released compared to the amount of avoided emissions calculated above.

The above figure is small compared to the nearly 52 million tons of carbon dioxide avoided. In sum, the avoided emissions coming from hydro-generated electricity of the Paklay HPP modestly estimated far out-weigh the emissions considered from biomass clearing activity alone. The more efficient biomass harvesting, will be the less methane emission that will subsequently follow. In light of this project, nonetheless, it is not clear what the extent of methane emissions will be produced by the dam flooding, hence, the *real total net* emissions could be under-estimated.

These positive results obtained from the current calculation can also be enhanced with careful and efficient biomass clearing, already called for by the Lao PDR government in its guideline. Such timber benefit from biomass clearing could be cash benefits used to finance local projects, including for instance, reforestation in the dam areas. The Paklay HPP will not generate significant negative impacts contributing to climate change. A carefully designed, managed and operational project will, and could, contribute positively to enhancing the climate change in the long run. The well managed Paklay dam could enhance the local microclimate by creating a larger body of water to enhance moisture, and thus cooler environment.

(c) Depletion of Fossil Fuel

The PLHPP planned to export electricity to Thailand where Thailand's power generation is mostly based on fossil fuels with natural gas and lignite that contributes more than 50% of total electricity generation. The economy's electricity generation is projected increasing annually at 5.5 percent, from 111 TWh in 2002 to 504 TWh in 2030, less than half the growth rate of 14.1 percent observed before the financial crisis in 1997.

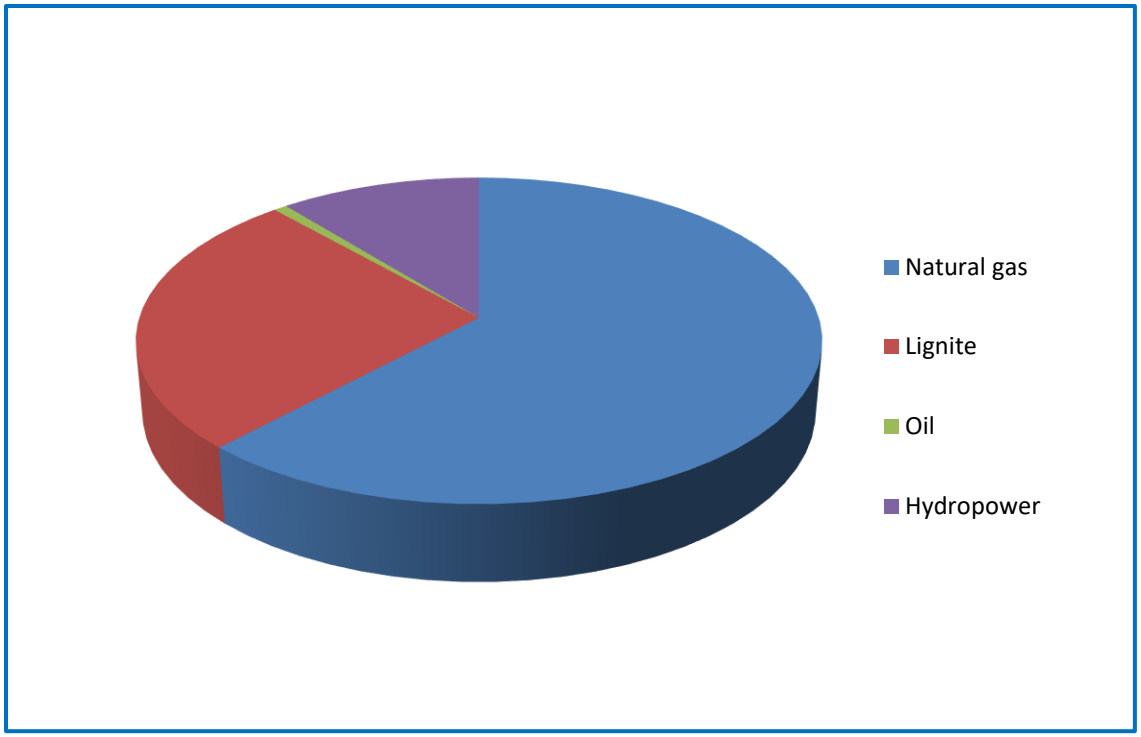


Figure 3: Thai Natural Gas and Lignite Use for Power Generation

The growth of energy consumption was fuelled by robust consumption for natural gas for electricity generation and to a lesser extent, for industries, at a rate of 8.0 percent. More than 40% percent of Thailand's electricity is generated through natural gas, reflecting the economy's heavy dependence on natural gas for electricity generation.

One way to support the reduction of global warming is to use renewable energy, import of hydropower electricity from neighboring countries are considered as acceptable alternative to help global climate change

5.3 Regional Environmental Issues

5.3.1 Environmental Concerns in Asia and the Pacific

Six Major Environmental Problems of Asiawere posted by the United Nations (2009 - un.org/intradoc/groups/public/documents); they include: urban excess, deforestation, overfishing, global warming, air pollution, and limited safe water supplies, as elaborated below.

a) Urban Access

Environmental problems arise from the urban by-products of transport, industrial activities, and the overcrowding of human habitation. Economic policies have encouraged mass migration of labor to urban industries. The shift from rural to urban Asia will accelerate in the coming century, aggravating urban crowding and increasing the risk of social and political conflict. Asia's urban profile increased from 27% (0.7 billion people) in 1980 to 38% (1.4 billion) in 2000 and will rise to 50% (2.3 billion) in 2020.

To date, governments have stimulated urban migration by maintaining low food costs, which reduce rural incomes and increase the flight to the cities. About a third of the people in the Third World's cities live in desperately overcrowded slums and squatter settlements, with many people unemployed, uneducated, undernourished and chronically ill. Conditions will worsen as their numbers swell and transport, communication, health and sanitation systems break down. One solution to urban excesses is to divert industry and its induced labor migration away from the mega cities towards surrounding areas. This requires significant infrastructure investment, however, and establishes competing centers of political power.

b) Deforestation/Desertification

Asian food security is threatened by deforestation and desertification. More than a third of the arable land in Asia is at risk. Nearly 75% of Southeast Asia's original forest cover has been destroyed at an annual loss rate that is about the size of the country of Switzerland.

The loss of forests and agricultural land is due both to exploitation for profit and an ignorance of good practices. Isolated, rogue regimes such as Burma exploit timber, oil, and mineral resources to support their governments. Poor farmers across Asia use improper irrigation and fertilization practices, resulting in increased salinity and toxic soils.

Regardless of motive and method, the loss of workable land hurts not only the harvester, but also has broad consequences for his neighbors in terms of erosion, downstream flooding, and pollution.

c) Water

As the demand for water grows with population and the economy, water supplies will be increasingly polluted from untreated sewage, from industrial discharges, and from salt-water intrusion of overexploited water tables.

Water disputes have affected international relations for years. Although an agreement was reached in 1996, India and Bangladesh have disagreed on the sharing of the waters of the Ganges for more than 20 years. Greater numbers of international disputes will arise and be more difficult to resolve as populations increase and economies grow, thereby placing a greater demand on scarce resources.

A domestic resource allocation problem that is common to the Pacific Islands soon will prevail over Asia: high-use agriculture will compete with populations for scarce water supplies. While more than 80% of the water consumed in Asia is used for agricultural purposes, 60 to 75% is lost to evaporation before reaching the crops. A technological solution may be to encourage the use of water-efficient drip irrigation techniques, which are employed in less than 1% of all irrigated areas.

d) Overfishing

Fish are a key source of food for virtually all Asian states, providing one of the largest sources of animal protein to the world's fastest growing commodity market. The world's largest tuna fishery crosses the jurisdiction of at least 21 countries—as well as extensive high-seas areas of the Pacific Ocean—and involves harvesting by fishing vessels from 26 different nations.
Across the Pacific and in many coastal and riparian parts of Asia, fishing is a significant part of the economic base, providing food, employment, revenue, and foreign exchange earnings. World fisheries are being overfished as marine catches have increased from 17 million metric tons (MMT) in 1950 to a peak of 87.1 MMT in 1996. As a result, there has been a steady increase in the frequency of clashes and incidents at sea caused by foreign fishing trawlers illegally encroaching into Exclusive Economic Zones and territorial seas.

Aquaculture production is a growing part of the fisheries sector. In 1996, 20% of all global fisheries production was from aquaculture. Asia dominates world aquaculture for fish, shrimp and shellfish, with China producing 68% of the global total. If done in an environmentally friendly manner, aquaculture can be a positive contributor to the world food supply.

To protect fisheries and insure sustainability, cooperative resource management schemes such as fishing quotas need to be established and enforced. Militaries, coast guards, law enforcement, and courts should cooperate to reduce the possibility of disputes, collisions, and pollution, such as negligent oil spills.

e) Global Warming

Carbon dioxide, chlorofluorocarbons (CFCs), methane, and nitrous oxide act like a glass in a greenhouse, letting the sun's rays in but trapping heat that would otherwise be released back into space. Carbon dioxide accounts for more than half of the warming affect, while CFCs contribute about a quarter and methane and nitrous oxide causes the remainder. Temperatures have increased .3 to .6 degrees C over the last century, consistent with the rise in greenhouse gases as predicted in recently developed computer models. Climate models predict that temperatures will be 1 to 3 degrees C higher in 2100.

f) Air Pollution

Air pollution from vehicles, power plants, incinerators and industry is a major problem in Asia. Outdated pollution control technology and the use of high polluting fuels compound this problem.

The developed countries have dramatically reduced the amount of pollutant emissions in the last 20 years through the implementation of new technologies. Widespread use of these proven technologies in developing and advanced Asian economies, coupled with cleaner burning fuels such as unleaded gasoline, natural gas and low sulfur coal can reduce total emissions regardless of rising energy consumption. Implications for Cooperation Since trade has a significant effect on environmental conditions, the World Trade Organization is making efforts to address these problems in a multilateral forum. Also, the APEC forum is discussing environmental policy, technologies, sustainability, and education and information.

Countries are increasingly participating in global and regional conventions on atmosphere and oceans, protection of wildlife and habitat, and the handling of hazardous substances. The United Nations and the World Bank are providing aid through the Global Environment Facility (GEF) for countries suffering from spillover pollution of neighboring countries.

- Fledgling regional organizations are developing a dialog for resolving contentious issues by discussing environmental management; nature conservation; industrial, marine, and urban settings; and education, training, and information.
- Among these organizations are ASEAN, the South Asia Cooperative Environment Program, the South Pacific Regional Environment Program, and the LMB Development Environment Program. The latter organization links economic cooperation and development in Laos, Vietnam and Thailand, addresses food and power production, flood control, and navigation in the lower Mekong River basin.

5.3.2 Environmental Issues in Lower Mekong Basis (LMB)

Below is the selected information related to environmental condition of the Lower Mekong Basin (LMB) that can provide the ESIA a perspective of the sub-regional environmental situation as foreground for baseline study for the PLHPP. The information was extracted from a report entitled the State of Lower Mekong Basin prepared by Mekong River Commission - MRC (2010).

a) **Population Increase**

It was recorded that in the last 8 years the total number of population in the LMB has increased on the average of 8% from 55 million in 2003 to about 60 million in 2009. The highest population increase was found in Cambodia where the population growth was 25% followed by Vietnam (10%), Lao PDR (6%) and

Thailand was remained the same. It is known that the way-of-life of riparian people is closely linked to the Mekong River and its tributaries.

b) **Forest and Wetland Resource**

As pressured by the growth of population and economic development, the quality of forest and wetland resources are declining. For terrestrial forest, was converted to secondary forest or the so called re-growth, and also to monoculture plantation expansion. In the last few years, the LMB has 54 million ha of forest or accounted for 43% of total basin area. The Figure below shows that forest coverage of all countries in the LMB have decreased except for Vietnam.

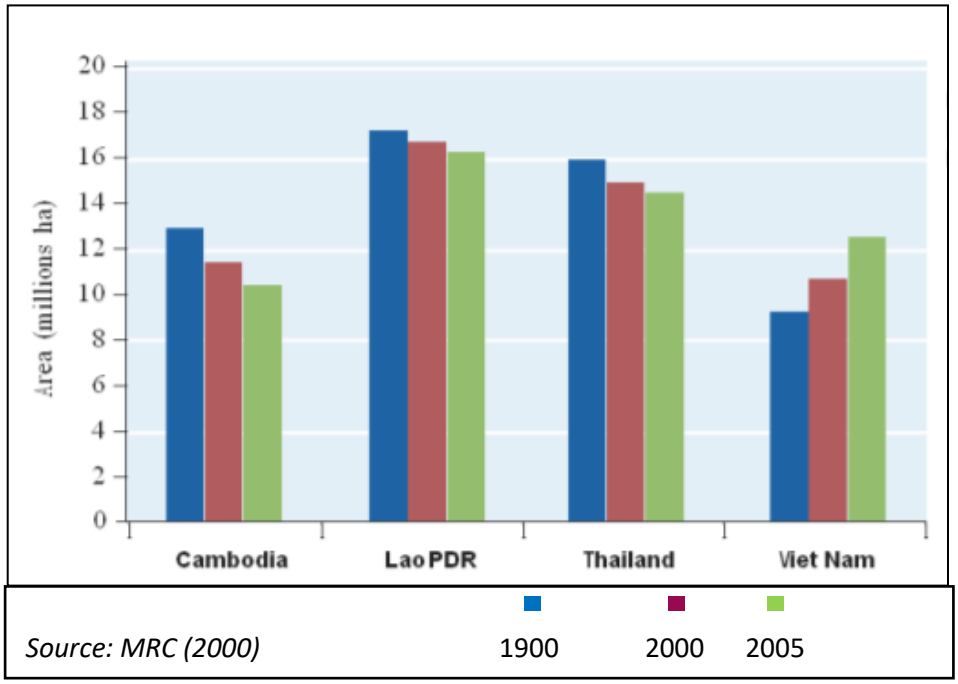


Figure 4: Decrease of Forest in the Lower Mekong Basin

The loss of wetlands in the LMB has been widespread. In the Mekong Delta for example, less than two per cent of the area's original inland wetlands remain. Many of the pressures on wetlands in the delta – population growth, poverty and agriculture and upstream infrastructure development are common threats to wetlands throughout the Mekong Basin. In the delta vast areas of natural wetlands have been converted to other uses. In recent decades, land development in Thailand for example has accelerated with the construction of many reservoirs for irrigation, flood control and hydropower. The area of wetlands reclaimed for cultivation has increased greatly, combined with intensive, often unsustainable, human use of those small wetlands which remain.

Other concerns including deforestation, agriculture, mining, and road construction all increase the amount of silt and sediment in rivers and wetlands. Too much silt can clog up the gills of fish, suffocate freshly laid eggs, affect nursery grounds of juvenile fish and reduce the amount of light penetrating the water – reducing plant survival. Degradation of seasonally inundated forests along the banks, channels and

islands of the Mekong mainstream and its tributaries has significant impacts– not least because forest fruits, flowers, leaves, bark and roots are important food items for various species of fish of economic importance that feed in the flooded areas in the rainy season.

In sum, the biodiversity, water quality, flood protection, fisheries, and a range of livelihoods in the basin are at risk from endangered wetlands and increasing deforestation.

c) Water Quality of the Mekong River

The MRC's continuous water quality monitoring indicatesthat water of the Mekong was in a normal range except some areas near urban center or with intensive agriculture or aquaculture; however, the trends also show that these areas are experiencing a decline of water quality.

In addition, chemicals used in livestock farming and aquaculture, such as antibiotics for catfish (*Pangasius*) and shrimp farming may pose a threat to aquatic organisms. Though little is known about the effects of these chemicals on the environment, caution is needed as they can result in antibiotic resistant bacteria and may accumulate inspecies used for human consumption.

For the aquatic environment, the use of agrochemicals, especially pesticides, poses a threat to organisms. Agrochemicals are most intensively used in the Mekong Delta, where farmers may have as many as three crops of rice per year. Also, the use of pesticides in orchards and on vegetables is high, where large quantities are suspected to end up in the aquatic environment. Many pesticides with high toxicity to aquatic organisms and humans, are still being used.

d) Fishery and Aquatic Environment

In general, the months of April and May are the most important of fishing months followed by March, June and July. However, fishing activities are found throughout the year.

Plankton and benthic fauna were generally low in number and also poor in species diversity because the river bottom was affected seasonally by strong currents during the wet season and by low water during dry season.

Transformation of the habitat from a river with rapids into to standing ecosystem due to impoundment will not occur for Mekong Pak Beng HPP due to the run-of-river design. Fish species which live in running water habitat will not be negatively impacted to the new conditions. There are number of species which appear in schools such as Henicorhynchus spp. Cirrhinus spp. with a short life span and a fast rate of reproduction; normally their abundance in the catch appears to follow the level of floods from the upstream.

The creation of a barrage without any reservoir stagnant effects will improve the overall natural fish production capacity of the Mekong River in the project area, especially in the dry season; based on the information of the water quality and the existing aquatic organisms, species diversity and their quantities, a positive impact

on fish biomass will occur for species that do not have long distance migration patterns. The increasing volume and regulation of the water level would be a benefit for many aquatic living organisms. After impoundment, fisheries activities would have to be adapted to using new fishing methods and gear.

As the upstream pond will be created with different flow condition, the following impact may occur to aquatic biodiversity.

Loss of habitats with rapids / riffles and deep pools throughout the entire river stretch from the dam to the upper reservoir backwater area. Considerable reduction in spawning / production areas and dry season habitat for rheophilic Mekong species (require flowing water) and certain more sedentary type fish species. Fish production of some real riverine species over the impounded area will be less than under pre-impoundment conditions over one calendar cycle.

The fish species composition of the upstream pond will be different to that of the pre-impoundment riverine species population. Some species that are able to adapt to the reservoir conditions may develop to the point where they dominate the fish population including the possibility of the proliferation of predatory species which may impact on non-predatory fish populations.

Impact on spawning and recruitment to reservoir fish populations. Certain riverine species will adapt to reservoir conditions

e) **Climate Change**

The LMB may at risk from the impact of climate change from the findings and predictions of the Intergovernmental Panel of Climate Change (IPCC):

- There has been a basin wide temperature increase of 0.79˚C with greater increases for colder catchments in the north of the basin; the range of temperature increase wasfrom 0.68 to 0.81˚C.

- There has been an annual precipitation increase of 200 mm equivalent to 13.5 per cent ranging from -3 to 360 mm; the increase was pre-dominantly from increased wet season precipitation.

- There has been an increase in dry season precipitation in northern catchments and a decrease in southern catchments, including most of the LMB

- There has been an increase in total annual runoff of 21 per cent, which will maintain or improve annual water availability in all catchments, however pockets of high levels of water stress are remaining during the dry season in some areas, such as northeast Thailand and Tonle Sap Great Lake

- There has been an increase in flooding in all parts of the basin, with the greatest impact in downstream catchments on the mainstream of the Mekong River.

The above prediction showed that temperatures as well as annual rainfall runoff will increase and that the sea level will rise which would affect the residents and environment of the LMB.The predicted changes in rainfall and temperature may cause the level of the Mekong River to increase in both the rainyand dry seasons. Key impacts anticipated to occur due to these changes include increased water availability during the dry season, which may be beneficial to agriculture, but there would also be an increase in the risk of flood during the rainy season.

Possible social issues are an increase in people's vulnerability to poverty and food insecurity in the basin by the increasing risk of extreme weather events such as drought and flooding.

f) Sediment Transport and Trans-boundary Issue

There are two major sources of regional sediment production, which between them produce 90 per cent of the total. The first is the upper basin in China with an estimated production of 60 x 106 tons per year (based on the post 1993 data sampled at Chiang Saen),which is about half of the regional total and sourced from less than 20 per cent of the overall basin area. The second major source terrain is the Central Highlands, with the Se Kong, Se San and Sre Prok tributaries delivering considerable loads to the Mekong mainstream. Elsewhere, tributary sediment contributions are relatively low with erosion rates just 5–10 per cent of those in the two principal source areas.

The Mekong River transports large amounts of sediment, much of which originates in the upper part of the basin. This process helps to redistribute nutrients within the basin and is very important for areas of high productivity, such as the Tonle Sap Great Lake. In this sense, trans-boundary transportation of nutrients along the river has, so far, been regarded as a benefit rather than a cause of pollution.Concerns on sediment issues have received considerable attention in recent years, reflecting a growing realization of the potential consequences of reduced sediment transport due to trapping behind dams.

The MRC indicated no strong evidence for trans-boundary pollution within the Mekong Basin between Lao PDR and Thailand, Lao PDR and Cambodia, and Cambodia and Viet Nam, although elevated nitrogen levels in the upper part of the river indicate some trans-boundary transmission of pollutants from the Upper Mekong Basin into the LMB.

5.4 Environmental Condition in Lao PDR

5.4.1 Overview

Lao PDR is located in the LMB and is one the committee of the MRC. Statistics in 2010 indicated Lao PDR has an area of 236,800 km^2 with the population of 6.8 million. The population density is low (approximately 25 persons/km^2) but the growth of population is moderately high (2.5%). There are 3 main ethnicities in the country (Lao Loum, Lao Theung, and Lao Soung) with 49 ethnic groups. Main religion is Buddhism. The country still has low average income of about 2 US $ per person per day. The Lao environmental resources including forest, water and wetland are considered one of a high bio-diversity in Southeast Asia; however, the

environmental resources are at risk to be degraded rapidly from uncontrolled illegal exploitation and encroachment to these resources. The following sub-sections summarize and update environmental condition in the country based on recent report on environmental monitor.

Figure 5: Map of Protected Area in Lao PDR

5.4.2 Natural Resources Degradation

Compared to other Asian countries, Lao PDR has more area of forest cover. In 1940, forests were estimated to cover 17 million ha, approximately 70% of the land area. Recent surveys suggest that this Figure is being reduced by an average of 53,000 ha per annum, with a 2004 cover of 41.5 %. Laos also has biodiversity-rich, however, despite relatively poor information, it is known that over-harvesting and wildlife trade are by

far the greatest threats to biodiversity, placing much of it at risk of local extirpation domestic and increasing foreign demand. As part of its efforts to conserve its biodiversity, Lao PDR currently has 24 National Protected Areas (NPAs) and two Corridors, covering almost 3.5 million ha, or 15 % of the country .If the area under provincial and district protection is added, the area increases to 5.3 million ha, or 22.6 % of the land area. The protected areas in Lao PDR are among the most remote areas in the country.

However, human use of these areas is rising as a result of increased population growth in traditional communities, migration, and settlement. In addition, both protected areas and the land around them face increasing degradation as a result of expanding agricultural frontiers, illegal hunting, illegal logging, and uncontrolled burning.

Because of Mekong River and a number of its tributaries in the country give higher hydropower potential compared to other countries in the LMB, providing the Government with an opportunity to earn foreign income to support socio-economic development.In 2010, the country has a total of 14 hydroelectric power plants, with a combined capacity of 2,540 MW. However, development emphasis on expanding land cultivation and increasing exploitation of hydropower potential is putting additional pressure on the resource base.

5.4.3 Environmental Quality

In Lao PDR, surface water is the major water source for urban supply as most towns are located along the rivers, while groundwater is the main source for the rural population. Whilst still within acceptable limits both surface and groundwater quality is declining. With rising populations in urban and upland areas, water pollution issues will become increasingly important in the near future. Only 64% of Lao people have access to safe drinking water.

Throughout Lao PDR there is a high incidence of gastrointestinal diseases, such as diarrhea and dysentery, caused by inadequate water supply, poor sanitation and sewerage, and poor hygiene. It was found that 70% of the urban households have access to satisfactory sanitation facilities such as cistern flush or pour flush toilets, but this sharply contrasts with the 36 percent coverage in rural areas where 80 percent of the population lives.

5.5 Existing Physical Environment in the Project Area

5.5.1 Geology, Geomorphology and Seismology

*5.5.1.1 **Background Information***

The project area is located along the Mekong River in northern Lao PDR have complex geology containing palimpsest sandstone and schist interbedding.

Topographically, the whole area is high in the north and west, and low in the south and east, with mountains extending smoothly. The highest elevation of the surveyed area reaches 1 ,000m. There are valleys among mountains, and the water systems are quite developed. The lowest elevation of the river valley is around 200m. The difference in elevation between mountain range and valley is around 150m-200m. The river valleys of the Mekong and its large tributaries are open and have gentle

slopes. The discontinuously developed area on both banks of the river is I grade terrace. The gulley on both banks is developed to anmedium extent. Flood plain or bela is distributed discontinuously near the river bank and in the river. The above features indicate that the topographical feature of the area is erosional, denuded and residual mountain landform. Sub-order tectonic units are of medium cutting low mountains and hills. In terms of fluvial landform, it belongs to floodplain valley.

The landform on both banks of the reservoir is gentle, and plants on both banks are prosperous. At the bank of the river, strongly weathered bedrocks are outcropped; rock strata are steep, and the natural mountain massif is stable in general. After the impoundment of the reservoir, some sections may be subject to bank failure and small scale of slumping due to reservoir bank rebuilding, but it will not cause significant impact to the reservoir and the station.

PakLay Hydropower Station is a run-of-river type hydropower station with low head and great flow. The strength of the reservoir rocks is not high. Stress will be released when it is accumulated to a certain extent.

*5.5.1.2 **Methodology***

- **Geodetic surveying system**

  The same plane and elevation coordinate system are used for the surveying of the complex area and the reservoir area, namely, Laos National Coordinate System and Lao National Elevation System.

- **Elevation survey**

  The Lao PDR National Surveying and Mapping Bureau carried out the surveying of two class III benchmark branch lines to the complex area and to the reservoir end. The two benchmark branch lines were used as the initial triangulation elevation numerical data of Class IV electromagnetic distance measurement.

- **Sources of information**

  The geology, geomorphology and seismology statistical data comprises a literature review and secondary data available from previous reports both local and international scales. Detailed field investigation will be carried out only if crucial field evidence is needed to confirm those data.

5.5.1.3 Geology/Geomorphology Conditions of The Project Area

Geology is the most crucial fundamental for dam construction. Site selection and dam design are actually carried out based on the geologic setting. In addition, geological information is very important for indicating potentials of earthquake and mineral deposits. Therefore, geology including regional structure and rock formation must be investigated initially before mineral resources, seismic risks and other geological hazards will be assessed in detail. However, additional data of specific aspect will be collected in order for the completion of the assessment. Seismology is of enormous concern in all mega projects because it may cause enormous threat to the project. On the other hand, a construction plan can be designed in

advance to protect and avoid the risks. Vulnerable and risky areas will also be taken into account for future monitoring. Previous records of earthquakes have to be collected and interpreted along with tectonic setting and structural geology of the local and even regional area for this assessment.

The reservoir area at the lower dam site lies between the Pile No. km 1818 ~ km 1938 at the main stream of the Mekong River, and the reservoir area at the upper dam site lies between the Pile No. km 1829 ~ km 1938 at the main stream. The left bank of the reservoir area belongs to Vientiane, and the right bank belongs to Sayaboury. The reservoir has the normal pool level of 240.00 m a.s.l., the reservoir area at the lower dam site has the backwater length of about 120 km, and the reservoir area at the upper dam site has the backwater length of about 109 km. At the normal pool level, the reservoir at the lower dam site has a storage capacity of 1.166 billion m^3, and the reservoir at the upper dam site has a storage capacity of 890 million m^3.

5.5.1.4 Seismology

a)Earthquake and seismic history in the project area

Located in the fold orogenic belt in early Kimmeridgian Age of Indo-Chinese Epoch, the regional tectonic stability of the Project is mainly controlled by surrounding regional fault zones. The largest fault zone closest to the project is northwestern Dien Bien Phu fault zone (the straight-line distance to Paklay dam site is about 120km) and second to it is Sagaing fault zone and Red River fault zone (the straight-line distance to Paklay dam site is about 500km). The Dien Bien Phu fault zone has the same historical changes with the Red River fault zone: three phases of folds and one phase of cracking changes in later period. It is generally considered that the two fault zones belong to the same conjugated system during the Indosinian orogeny. According to the seismic records and statistics provided by the United States Geological Survey (USGS), there have been 127 earthquakes occurring around the Dien Bien Phu fault zone since 1973, the maximum earthquake magnitude is 6.9 (June 24, 1983). There have been 4 significant worldwide earthquakes since 2150 B.C. (the significant worldwide earthquake means the earthquake causing the loss more than USD 1 million, causing deaths of more than 10 people or with the earthquake magnitude greater than 7.5), the maximum magnitude is 7.0 (occurring on December 26, 1941).

- Besides, for the NNE fracture F1 near the dam site (about 5 km closest to the left bank of lower dam site and about 3 km closest to the left bank of upper dam site), no new activities have been found for microrelief through survey on earth surface and no records have ever been kept of the occurrence of moderately strong seismic activities along this fault in history.

b)Probable seismic hazard at the dam site

The PLHPPsite is situated in a relatively stable region. According to the seismic hazard assessmentreportfor project site ofPaklay Hydropower Project in Laos, it is recommended that thepeak ground acceleration of the dam site with 50-year exceedance probability of 10%(475-year return period) is 0.133g, the peak ground acceleration of the dam site with100-year exceedance probability of 4% (2,475-year return period) is 0.290g, and the peakground acceleration of the dam site with 100-year exceedance probability of 2%(5,000-year return period) is 0.384g. According to the report, the basic earthquake intensityof the dam site is VII.

5.5.2 Mineral Resources

5.5.2.1 Introduction

Since Lao PDR opened for foreign investment other countries have conducted surveys on many economic minerals (e.g., gold, corundum, coal etc.). These show that Lao PDR has many valuable mineral resources. There is a possibility that the implementation of the PLHPP may have implications for the future exploitation of these resources and this component of the ESIA will present the most up-to-date information on mineral resources in the project area and the potential significance of the projects impact on their exploitation.

There is also the potential for environmental concerns related to toxic elements, particularly heavy metals that may occur within the particular mineral deposits. Consequently the study will also assess the potential for impacts from these materials.

5.5.2.2 Methodology

The information on regional geology and mineral resources will be compiled from Lao and international sources. In terms of data on mineral deposits and geological data will be used to crosscheck information on economic minerals. Field investigation and sampling will be done as necessary to verify secondary data. If necessary, sample analysis protocols will be developed for specific mineral samples.

5.5.2.3 Sources of information

This study will mostly use secondary data available from previous reports both local and international. Field investigation will be arranged to check and verify the existing data. Some mineral samples will be collected for detailed study if important occurrence is suspected. Information on mineral resources and the study area will be integrated with the GIS being developed for the project.

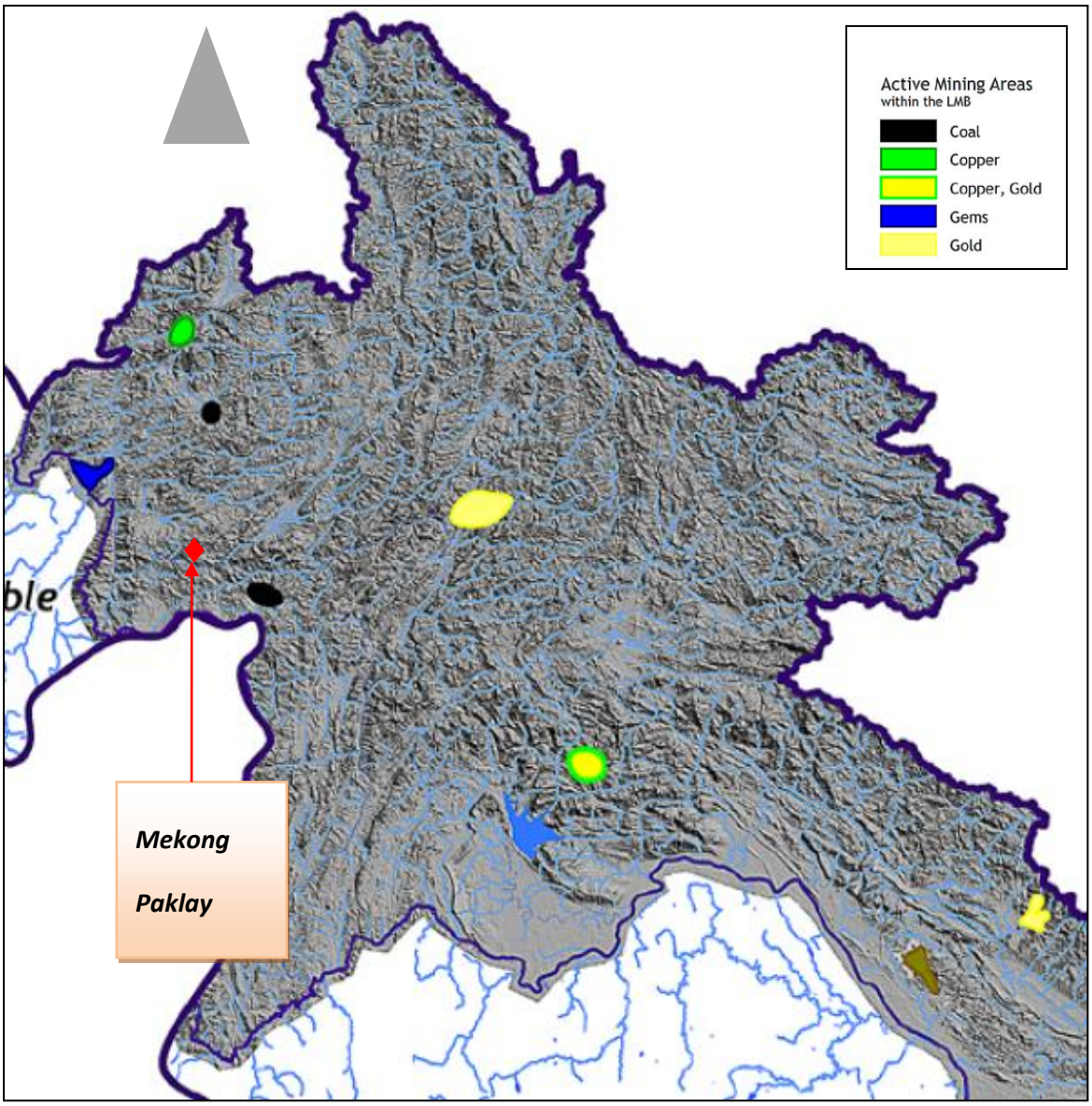


Figure 6: Mineral Deposits in Project Area

5.5.2.4 Mineral resources in the project area

As indicated in ***Figure above***, no important mineral deposit is recorded or reported on the left-bank of the Mekong in the PLHPP area. The Department of Geology and Mines have approved four mineral exploration areas for rivers draining to the left bank the reservoir. These are four separate areas for gold exploration of 504 ha, 581 ha, 1,121 ha, and 1,211 ha, which belong to Dao Lao, a Russian company. Gold is also recovered by artisanal miners from alluvial sand deposits alongside the Mekong River by panning and the use of mercury to separate the gold fines. There are at least five villages located along this stretch of the river that are recovering gold by this method. Gold panning is carried out during the dry season when the sand bars are exposed and when labor is freed from rice farming activity. No other mining is carried out within the reservoir area.

5.5.3 Climate and Meteorology

5.5.3.1 Introduction

The study of atmospheric characteristics and transport of air contaminants are important in evaluating the effects of air pollution from the Project. The atmospheric residence time of pollutants depends on their types (gaseous or particulates), their physical properties and atmospheric conditions. Wind velocities and directions determine the extent to which the contaminants will be diluted, and dictate the paths they will follow and the potentially affected environmental parameters.

Construction of a dam in a natural water course may affect ambient air in a number of ways. The construction will increase dust and introduce machine-generated gases. The extent and degree of these kinds of effects will depend on the activities and mitigation employed during construction.

Generally, operation of a hydropower project has a relatively minor impact on atmosphere and air quality. Many natural processes assist in the purification of air but the most important are the meteorological conditions of the area on both a local and regional scale. The potential severity of pollutants and the associated impacts can be determined from weather parameters such as air temperature, wind speed and direction, cloud cover, and stability conditions. This section will describe both regional and local meteorological conditions representative of the area and identify potential impacts.

5.5.3.2 Methodology

Meteorological data including atmospheric pressure, air temperature, relative humidity, precipitation, wind speed and direction had been collected and obtained from the primary sources such as Department of Meteorological and related agencies.

A survey and compilation of existing secondary ambient air quality data had been conducted using Lao PDR and international archives to describe the existing ambient air quality of the study area and to assess any impact that would occur.

5.5.3.3 Sources of information

As there is no permanent meteorological station in the Mekong Paklay basin, the study based on information from appropriate representative station(s). However, since part of the basin is divided from the existing meteorological stations by mountain ranges, the study consider hill effects for both data selection and climate and air quality condition assessments.

5.5.3.4 Climate of the project area

The climate of the project location is proposed sub-tropically and strongly influenced by the annual southwest monsoon rains that affect the region from

April/May to September/October. The dry season (Northeast monsoon) occurs from mid October to mid May. When atmospheric is high, it's a dry period with low humidity and temperature. The lowest temperature is from December – January (13-17˚C) and the highest is in April (between 35-38˚C). The rainy season is influenced by the southwest monsoon which runs from mid May to mid October. This is a period of heavy and frequent rainfall.

According to the temperature, rainfall and evaporation rate of the water reported by the Xayabouri Meteorological Station (Xayabouri Province), the annual precipitation of the rainfall in Xayabouri is 1,281 mm, and 80% of the total rainfall is concentrated from May to September. While the evaporation rate starts to increase in February before the hot and dry season arrives. The detailed information on rainfall, temperature and evaporation in Xayabouri region between 1997-2006 as reported by Department of Meteorology and Hydrology Topography's report are highlighted in the Table below.

Table 5: Information on Climate at Xayabouri (1997-2006)

Month	Maximum Temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	Evaporation (mm)
January	28	14	4	2
February	31	15	11	3
March	33	18	44	4
April	34	22	107	3
May	32	23	178	2
June	32	24	136	2
July	31	24	189	2
August	30	24	210	2
September	30	23	278	1
October	30	22	90	2
November	29	18	28	2
December	27	15	6	2
TOTAL	**31**	**20**	**1,281**	**2**

Source: Department of Meteorology and Hydrology Topography

5.5.4 Basin Hydrology

*5.5.4.1 **Introduction***

Lao PDR lies almost entirely within the LMB. Its climate, landscape and land use are the major factors shaping the hydrology of the rivers. The mountainous landscape means that only 16 per cent of the country is farmed using lowland terrace or upland shifting cultivation. With upland shifting agriculture (slash and burn), soils recover within 10 to 20 years but the vegetation does not. Shifting cultivation is common in the uplands of Northern Lao PDR and is reported to account for as much as 27 per cent of the total land under rice cultivation (Lao Agricultural Census, 2000). As elsewhere in the basin, forest cover has been

steadily reduced during the last three decades by shifting agriculture and permanent agriculture. The cumulative impacts of these activities on the river regime have not yet been measured.

The capitol cities of Lao PDR and Cambodia, Vientiane and Phnom Penh, are both located near the Mekong River. This results in increased interest on the part of both countries regarding decisions affecting the LMB. Lao PDR has 6.8 million people and water resources that have the potential to be developed. Cambodia has 10 million people and relies on the Tonle Sap (the Great Lake) for the majority of its freshwater fish. Any degraded water quality from the Mekong River can impact this lake and those whom depend on its resources. Northeast Thailand has over 20 million people; due to excessive vegetation removal, soil erosion, and salinization of arable lands, water quality is declining in nearby water bodies that stress the quality of the water resources.

The final portion of the LMB has about 20 million Vietnamese whom depend heavily on rice paddy production in the Mekong Delta. The rice production occurs on about 2.5 million hectares and is some of the most highly productive agricultural land in the world. During the dry season, production occurs at a fraction of the total possible in order to limit salt water intrusion. If water quality and quantity decline in the dry season (due to salt water intrusion), the Mekong Delta could be irreversibly impacted since it is already heavily impacted by the tide which can vary by four meters during the dry season.

In an effort to facilitate cooperation with managing the Mekong River Basin water usage, the Mekong River Commission (MRC) was established in 1957. The MRC represents The Kingdom of Cambodia, The Lao People's Democratic Republic, The Kingdom of Thailand, and The Socialist Republic of Vietnam whose countries are directly impacted by the Mekong River. These countries signed an agreement in 1995 (MRCS, 2005) regarding the sharing and protection of the Mekong River's resources under the guidance of the MRC, with a primary focus on the LMRB. The Upper Mekong River Basin (UMRB) is located in portions of China and Myanmar (Burma); they participate only as dialogue partners because the Mekong River is not as critical a resource for those two countries as shown in table below.

Major tributary systems develop in the Lower Mekong River Basin as shown in figure below. These systems can be separated into two groups: tributaries that contribute to the major rainyseason flows, and tributaries that drain low relief regions of lower rainfall. The first groups are left bank tributaries that drain the high-rainfall areas of Lao PDR. The second groups are those on the right bank, mainly the Mun and Chi rivers that drain a large part of Northeast Thailand. These two groups of tributaries are also marked by different levels of resource development. For example, in Thailand there is little room for further expansion of irrigation development. In Lao PDR, there is a lot of potential for water resources development of all kinds.

Table 6: Summary Information of the Mekong River Basin

Description	Mekong River Basin (MRB) Countries						
	China	Myanmar	Lao PDR	Thailand	Cambodia	Vietnam	Total MRB
Area (km^2)	165,000	24,000	202,000	184,000	155,000	65,000	795,000
Catchment as % of MRB	21	3	25	23	20	8	100
Flow as % of MRB	16	2	35	18	18	11	100

Source: Overview of Mekong Hydrology of the Mekong River Basin, 2005)

Project Hyfrology Station near the Dam Site

Figure 7: Mekong River Basin

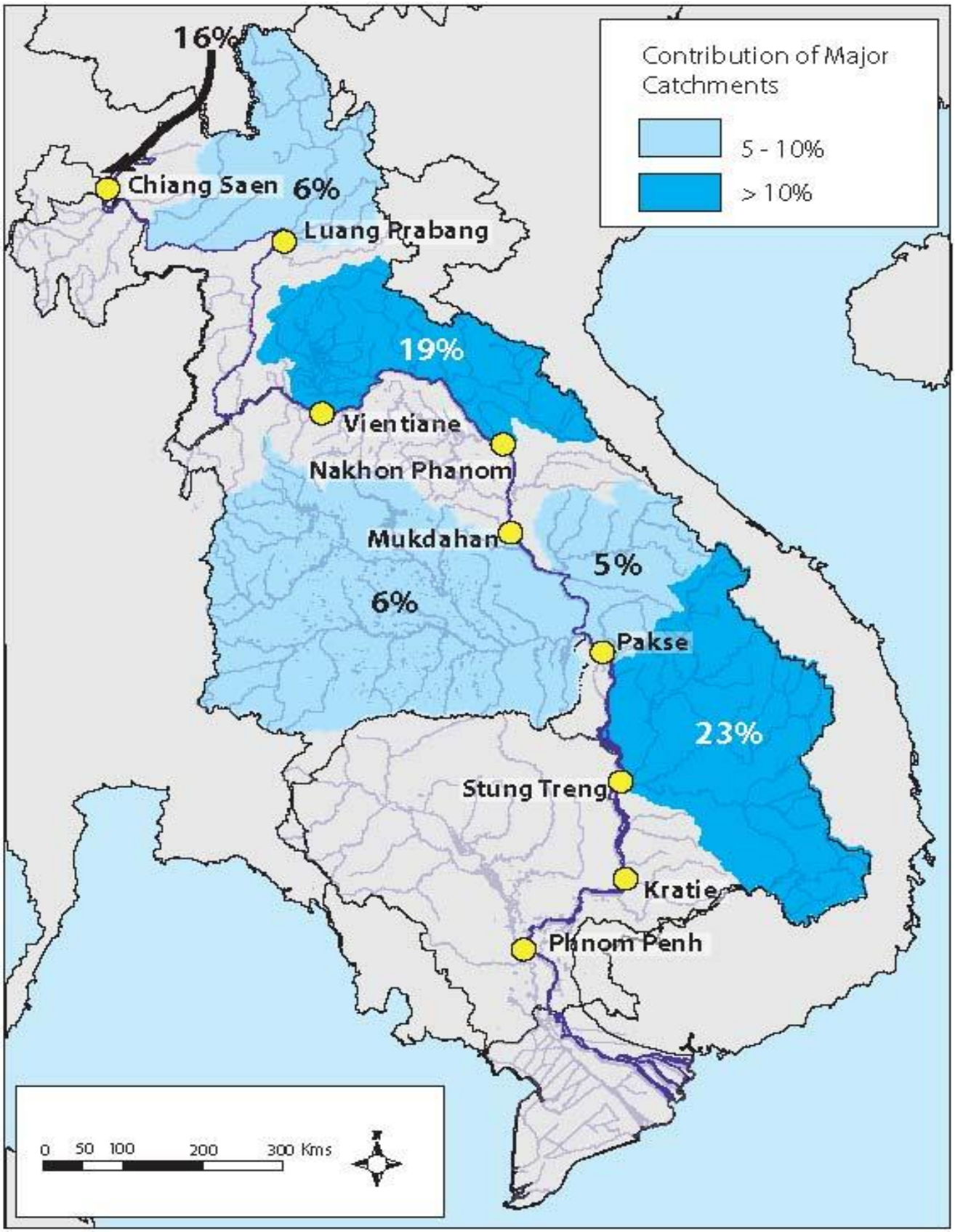


Figure 8: Hydrological Stations and Major Contributories to Flow

5.5.4.2 Methodology

- Review secondary data regarding Mekong hydrology and major waterways from the relevant literature and documents, such as the Feasibility Study for the Mekong Paklay Hydropower Project, Lao PDR Reports on hydrology, etc.
- The study and investigation of Mekong Hydrology and water resources from other previous research.

5.5.4.3 Sources of information

The main sources of information for hydrology in the project area are collected from the Mekong River Commission (MRC), the Feasibility report on PLHPP, and scientific reports from various sources.

5.5.4.4 Hydrology of the Project Area

a) **Hydrological Characteristic in the LMB**

The climate in the LMB is governed mainly by alternating between the rainyseason, characterized by the southwest monsoon (May-October) with heavy rainfall, and the dry season, characterized by the northeast monsoon (November-February), which is relatively dry. About 75 percent of the total rainfall occurs during the rainyseason. This pattern results in a large difference in the water flow contributions to Mekong River between the rainyand the dry seasons. The water level in the Mekong River may differ by up to 15 m between the two seasons. The average annual rainfall in the region is 1877 mm, ranging from 500 mm in the central dry zone in North-East of Thailand to more than 4000 mm in the mountains of Laos and Bac Quang in Viet Nam (FAO, 2003). The hydrology of the region is dominated by the typical monsoon climate, which induces large inter-seasonal variations in river flows.

This hydrological study is aimed to generate a long term stream flow data for the energy simulation and to generate a flood hydrograph for the project components design. Seasonal variations in flow overprint this basic pattern. During the dry season (December to May), the contribution from the Upper Mekong River Basin is proportionally much greater, while the input from the major east-bank tributaries declines.

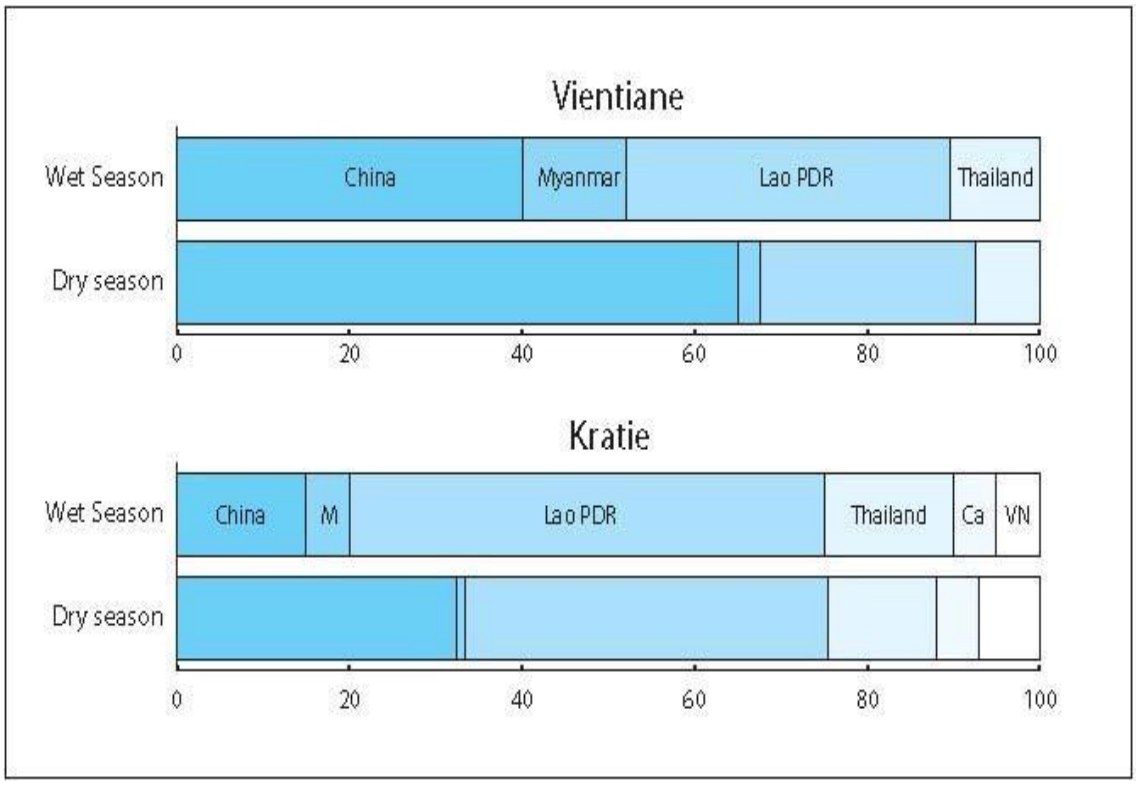


Figure 9: Variation in the Contribution between Rainyand Dry Seasons

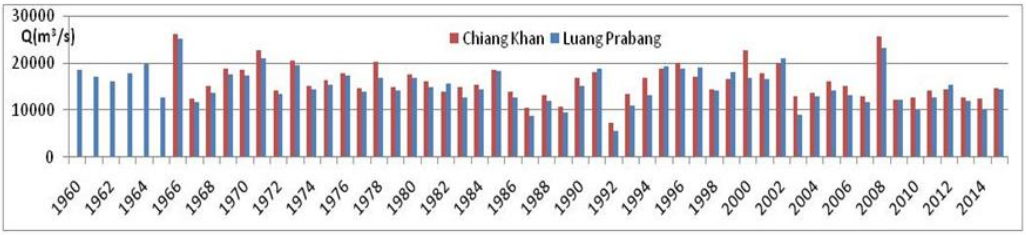
b) Water levels, discharges and the onset of the flood season

There are two ways to define the onset of the flood season. One is simply to set calendar dates, which is by and large arbitrary. Another is to provide a definition that extracts meaningful information with respect to the onset and termination of flood conditions, how this timing and duration of 'the flood season' varies from year to year and therefore whether the conditions under specific review are typical or otherwise. An intuitively attractive designation is that period of the year when discharge and water levels exceed their long term annual average. In the case of the Kratie Hydrological Station, for example, the mean annual discharge is 13,600 cumecs, so in any year the flood season is that period when the daily discharge is higher. A major advantage of this simple definition, other than the fact that it is logical in many ways, is that on the Mekong mainstream, during a typical year, there is usually only one up-crossing and a single down-crossing of this value. It is therefore quite precise. In years when there are more, and only in exceptionally dry years is this generally the case, then the latest up-crossing and down-crossing defines the season.

In consideration of the consistency of design flood results of the upstream and downstream cascades, the recommended flood results at the damsite are: 34,700m^3/s for the design flood discharge (2000-year flood) and 38,800m^3/s for the check flood discharge (10,000-year flood).

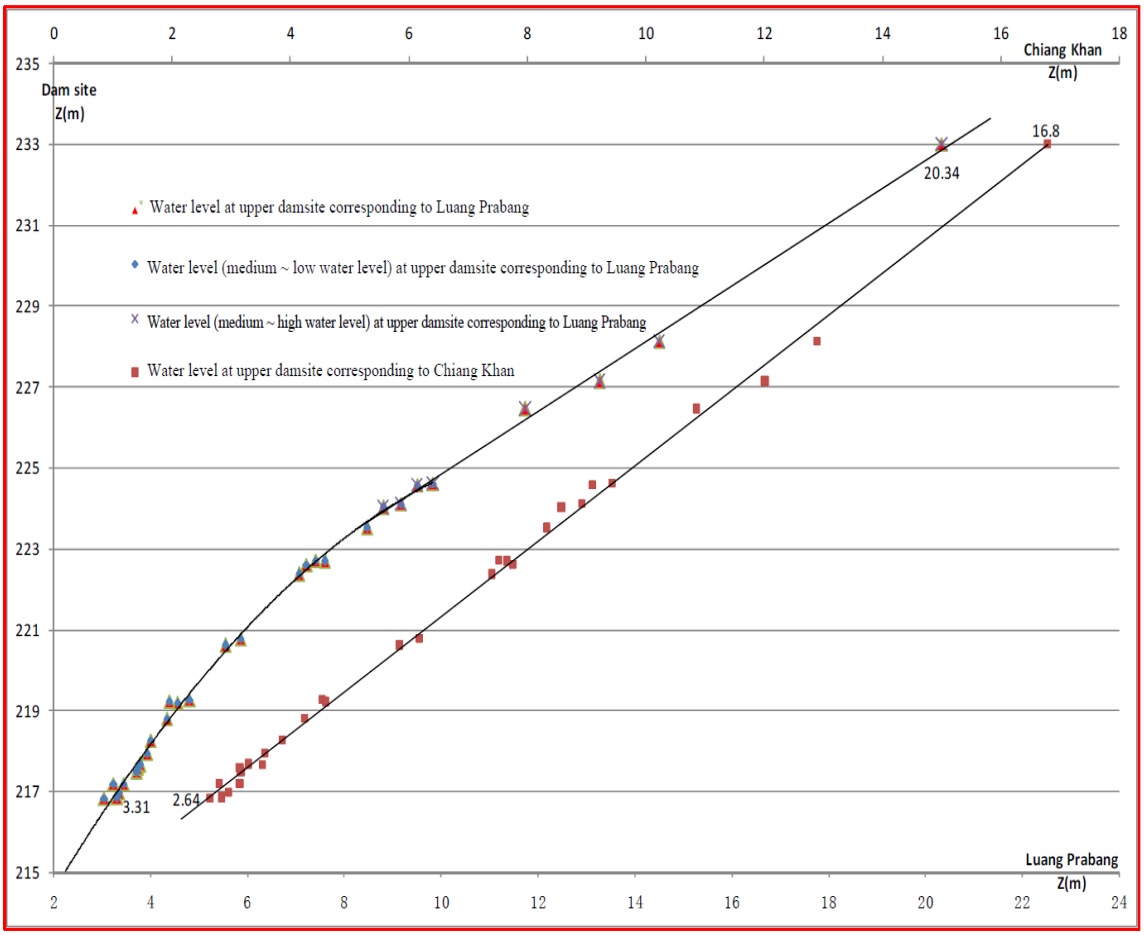
Annual Maximum Peak Discharges at Damsite (Recommended) Qm:m³/s

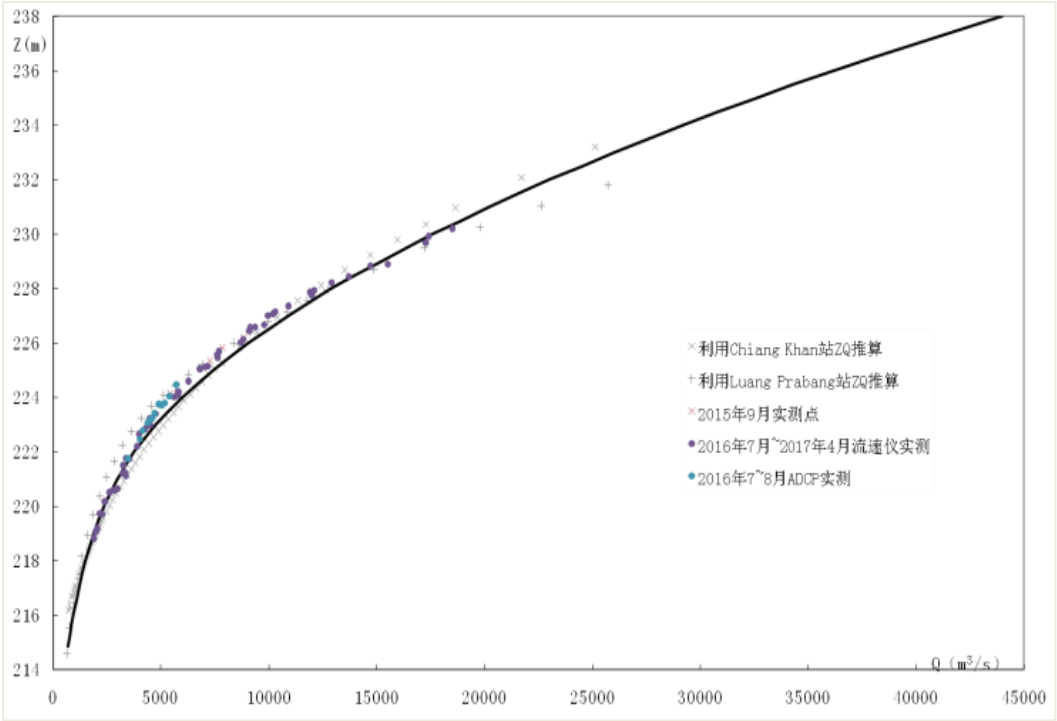
Item	P(%)										
	0.01	0.02	**0.05**	0.1	0.2	0.5	1	2	5	10	20
Qm	**38,800**	37,000	**34,700**	33,000	31,200	29,000	27,200	25,500	23,000	21,100	19,000



The data from Chiang Khan and Luang Prabang stations has been supplemented, and the composite stage-discharge relations of the two stations over the last ten years analyzed and checked;

- The results of stage-discharge relation at the damsite have been checked;
- The stage-discharge relation at the damsite has been preliminarily verified by the measured stages and discharges at the damsite section;





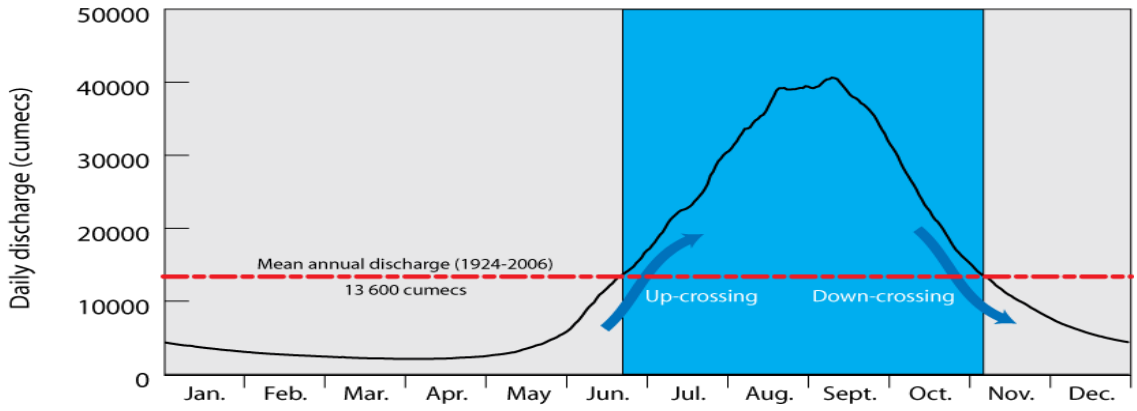
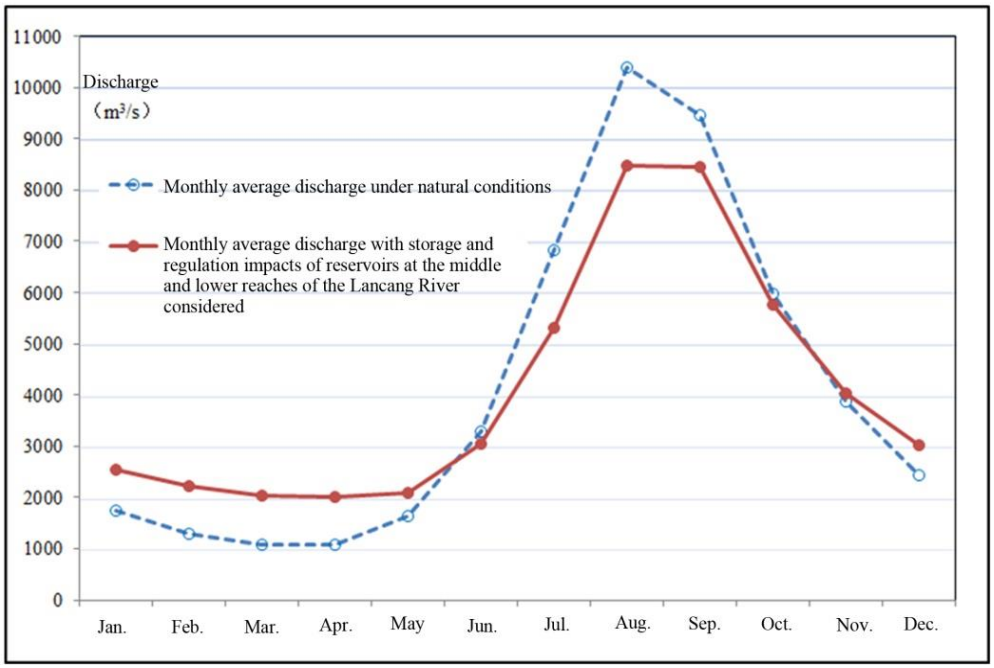
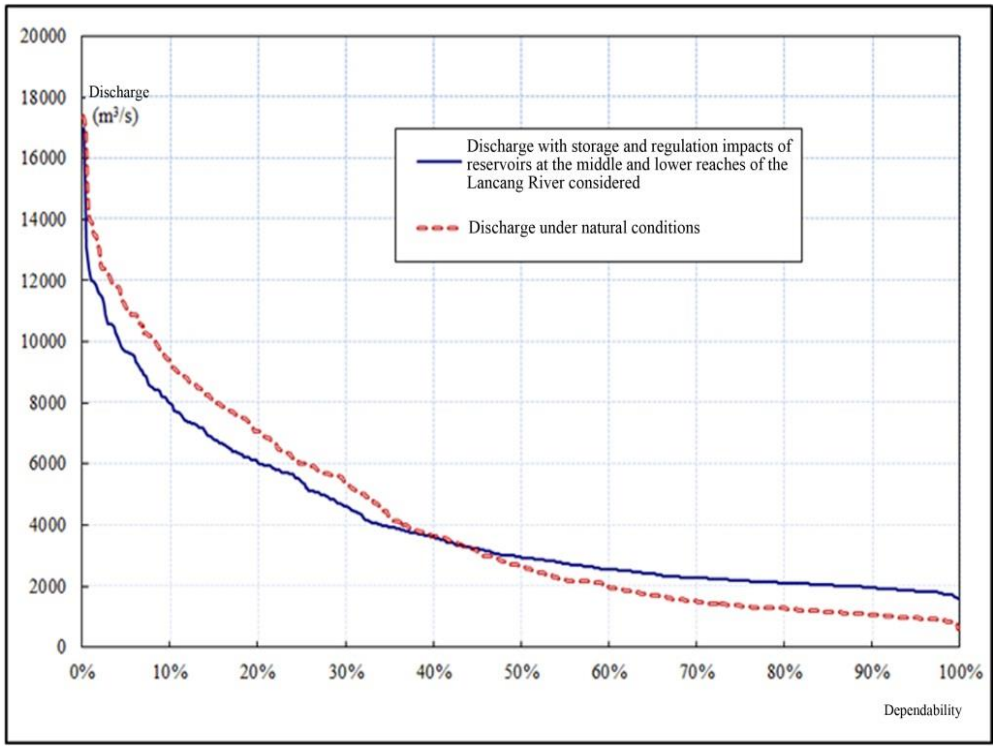


Figure 10: Flood Season with the Mean Annual Hydrograph at Kratie

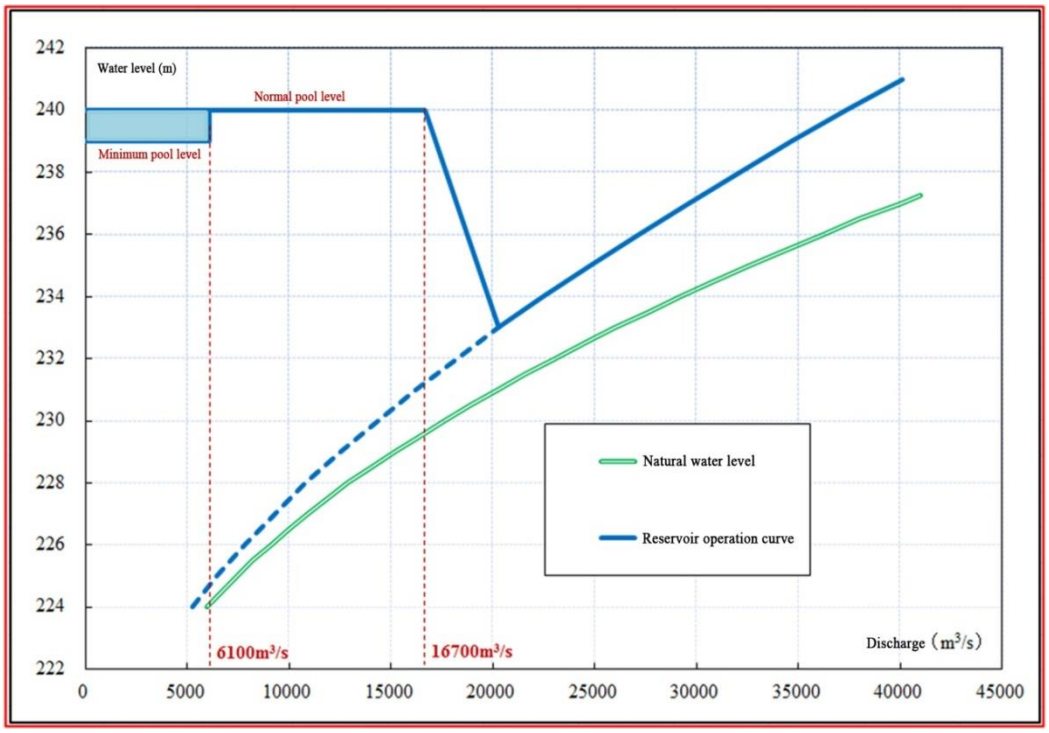
Impact of Upstream Reservoirs on Runoff at Paklay Damsite: The analysis and computations indicate that, under the regulation and storage impacts of the reservoirs on the middle-lower reaches of the Lancang River, the average annual discharge at the Paklay Damsite is basically consistent with that under natural conditions. However, with a relatively considerable variation in annual distribution, the average discharge would decrease by about 14% in flood season and increase by about 50% in dry season.





Impact of Upstream Reservoirs on Runoff at Paklay Damsite : Only qualitative analysis has been carried out since the detailed data are not available. The analysis indicates that the discharge at the Paklay HPP would decrease in flood season and increase to some extent in dry season upon the establishment of the reservoirs on the tributaries, which would favor the power generation benefits of the Paklay HPP.

The reservoir operation mode has been adjusted following the operation principles of run-of-river hydropower stations. For details, see the figure below:



c) Hydrological Stations Related to PLHPP

The location of the Paklay dam is on the mainstream of the Mekong River, therefore the relevant hydrological stations that directly link to the dam are the stations on the mainstream. The available hydrological database on the mainstream covers a significant period of time, with records available form as early as the 1973s at Chiang Saen, Chiang Khan, Vientiane, Mukdahan, Nakhon Phanom and Pakse, and at least from the 1960s elsewhere. The relevant stations and available flow records are shown in the Table below.

Table 7: LMB Hydrological Stations

No.	Name of Station	Data type (daily)	Period of record
1	Chiang Saen	Flow (cumecs)	01/01/1973-31/12/2010
2	Luangprabang	Flow (cumecs)	01/01/1973-31/12/2010
3	Chiang Khan	Flow (cumecs)	01/01/1973-31/12/2010
4	Vientiane	Flow (cumecs)	01/01/1973-31/12/2010
5	Nongkhai	Flow (cumecs)	01/01/1973-31/12/2010
6	Nakhonphanom	Flow (cumecs)	01/01/1973-31/12/2010

7	Mukdahan	Flow (cumecs)	01/01/1973-31/12/2010
8	Pakse	Flow (cumecs)	01/01/1973-31/12/2010
9	Khong Chiam	Flow (cumecs)	01/01/1973-31/12/2010
10	Stung Treng	Flow (cumecs)	01/01/1973-31/12/2010
11	Kratie	Flow (cumecs)	01/01/1973-31/12/2010

(Sources: MRCSKB Mekong River Commission Secretariat, Phnom Penh, 2010)

The summary of the mean annual flows (in various units) along the mainstream and the incremental growth in mainstream runoff as the major left bank tributaries enter the system taken as a whole is in table above. The mean annual flow entering the lower Mekong from China is the equivalent of a relatively modest 450 mm depth of runoff. Downstream of Vientiane this increases to 650 mm as the principal left bank tributaries, such as the Nam Ngum and Nam Theun, enter the mainstream, only to fall again in response to the right bank entry of the major Nam Chi/Mun system from Thailand. Although, this tributary complex drains 20% of the lower system, average annual runoff is only 250 mm. Runoff in the mainstream increases again with the entry from the left bank of the Se Kong from southern Lao PDR and Se San and Sre Pok complex from Viet Nam and Cambodia.

*5.5.4.5 **Analysis of Hydrological data***

The hydrological data available for both water and flow from 1970-2010 in the provided sufficient and consistent information for analytical purposes. Long term mean monthly water level and flow of the main station along the lower Mekong River mainstream provided a thorough understanding from the upstream to the downstream. Mean monthly water levels of the stations upstream and downstream of the Mekong Paklay Main Dam site are shown in Table and Fig. below.

Table 8: Selected Mekong Mainstream: Mean Annual Flow (1973 –2010) in the LMB

Mainstream Site	**Catchment area**	**Mean annual flow as**			**% total Mekong**
	km^2	**discharge** (cumecs)	**volume** (km^3)	**runoff** (mm)	
Chiang Saen	189000.00	2679.7	84.51	447.12	18.49
Luang Prabang	268000.00	3937.5	124.17	463.33	27.17
Chiang Khan	292000.00	4200.0	133.00	430.00	29.10
Vientiane	299000.00	4431.0	139.73	467.34	30.58
Nakhon Phanom	373000.00	7418.2	233.94	627.19	51.19
Mukdahan	391000.00	7782.2	245.42	627.67	53.70
Pakse	545000.00	9893.06	311.99	572.45	68.27
Kratie	646000.00	12770.3	402.73	623.41	88.12
Total	760000.00	14500	457.00	600.00	100.00

(Source: HHP Don Sahong, 2010)

Table 9: Mean Monthly Water Level (1970-2010) at Main Station in the LMB

Month	**CS**	**CK**	**LPB**	**VTE**	**NKh**	**NKPN**	**MDH**	**PS**	**KC**	**ST**	**KT**
Jan	1.88	4.31	4.55	1.67	2.18	1.60	1.86	1.27	2.25	2.59	7.33
Feb	1.51	3.43	3.78	1.12	1.62	1.16	1.52	0.96	1.86	2.29	6.63
Mar	1.36	2.91	3.38	0.82	1.31	0.90	1.33	0.79	1.66	2.11	6.22
Apr	1.53	2.91	3.50	0.90	1.42	0.92	1.34	0.80	1.64	2.12	6.21
May	2.21	4.10	4.51	1.76	2.35	1.74	2.01	1.40	2.33	2.59	7.22
Jun	3.39	6.37	6.51	3.45	4.16	4.37	4.37	3.68	4.87	4.18	10.57
Jul	5.14	9.31	9.88	6.10	6.89	7.26	7.12	6.32	7.93	6.13	14.39
Aug	6.01	11.32	12.32	8.32	9.11	9.55	9.49	9.08	11.07	8.32	18.35
Sep	5.66	11.14	11.80	8.34	9.13	9.31	9.20	9.02	11.01	8.42	18.84
Oct	4.54	9.11	9.35	6.11	6.71	6.25	6.14	6.11	7.64	6.43	15.61
Nov	3.38	7.12	7.26	4.04	4.55	3.74	3.75	3.45	4.66	4.35	11.35
Dec	2.41	5.40	5.51	2.47	2.99	2.30	2.46	1.94	2.96	3.15	8.74

(Source: MRCSKB, 2010)

Notes: CS-Chiang saen, CK-Chiang Khan, LPN-Luang Prabang, VTE-Vientiane, NKh-Nong Khai, NKPN-Nakhonpranom, MDH-Mukdahan, PS-Pakse, KC-KhongChiam, ST-Stung Treng, KT-Kratie.

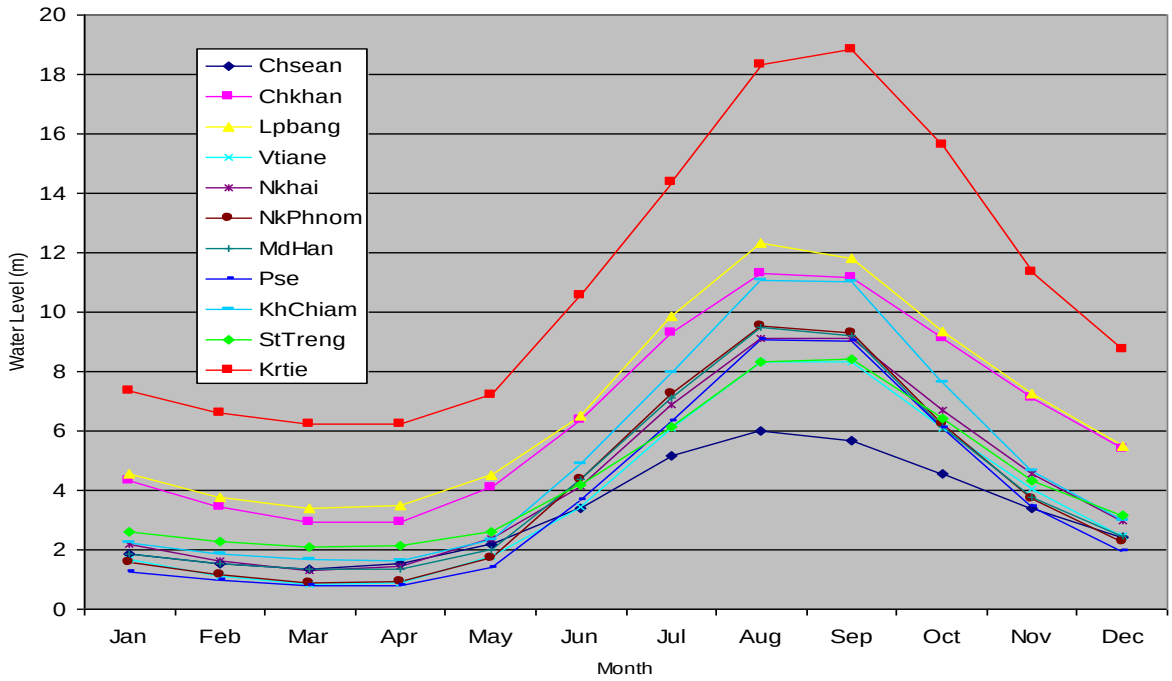


Figure 11: Mean Monthly Water Level (m) 1970-2010 at Main Station in the LMB

The contributions of the various water level inputs from upstream of the Chiang khan gauge which is situated immediately below the Paklay HPP ***(Fig. below).***

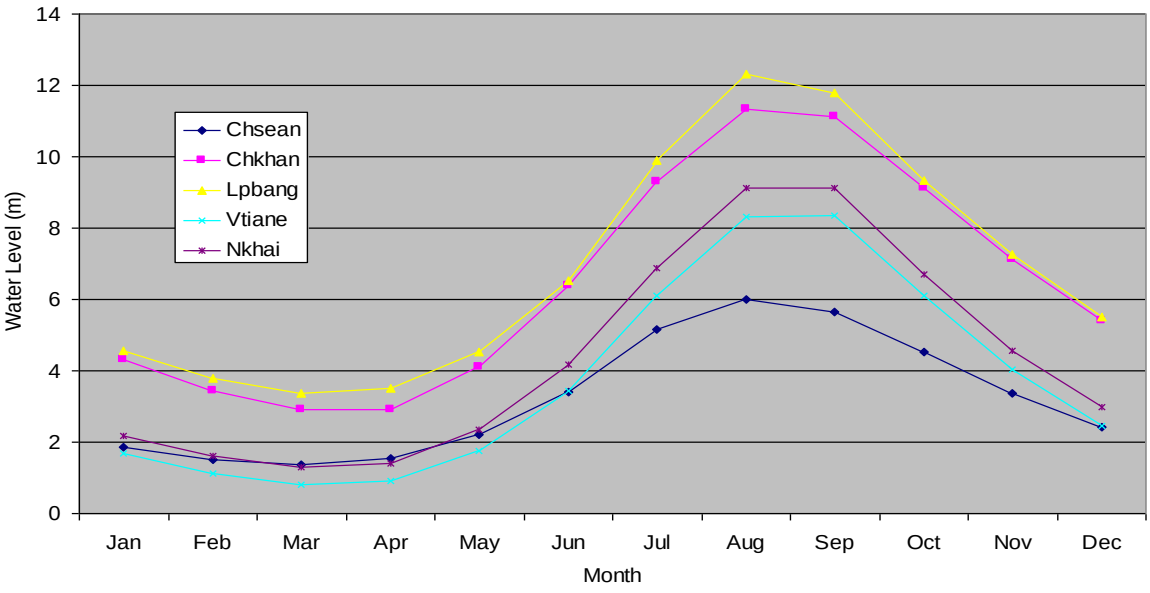


Figure 12: Mean Monthly Water Level 1970-2010 in Upper Zone of LMB (Chiang Saen, Chiang Khan, Luang Prabang, Vientiane and Nongkhai)

The hydrological data available of flow from 1970-2010 in the MRCSKB provided sufficient and consistent information for analytical purposes. The mean monthly flow of the stations up and downstream of the Paklay Dam site is shown in ***Table*** and ***Fig. below***.

Table 10: ***Mean monthly 1970-2010 at Main Station in the LMB***

Month	CS	CK	LPB	VTE	NKH	NKPN	MDH	PS	KCh	ST	KT
Jan	893.41	1795.55	1403.51	1780.84	1605.38	3237.03	2762.87	5293.74	2664.65	3980.80	3692.86
Feb	681.55	1334.16	1038.46	1447.89	1300.05	2558.60	2298.41	4628.34	2146.43	3123.32	2541.99
Mar	604.23	1106.78	872.36	1284.39	1152.31	2191.58	2057.05	4240.47	1888.79	2675.77	1936.51
Apr	697.13	1110.13	922.55	1328.79	1207.76	2223.65	2069.82	4258.01	1875.28	2707.38	1935.10
May	1146.25	1768.05	1426.75	1887.96	1759.57	3562.76	3060.64	5325.17	2843.09	4206.27	3617.60
Jun	2119.22	3464.86	2710.24	3259.21	3176.01	8833.37	7592.48	9532.46	7317.69	13015.46	10740.68
Jul	4064.63	7048.40	5843.85	6381.54	6440.93	16049.03	14644.01	15518.12	13941.04	31403.97	21213.42
Aug	5194.89	10387.35	8723.89	9748.12	9963.78	22558.99	22057.01	23243.42	21936.37	64574.25	35279.07
Sep	4686.48	9976.05	7970.97	9738.19	9960.85	21839.78	21069.87	23560.54	21749.98	65360.52	37867.13
Oct	3268.00	6465.58	5087.19	6201.26	5957.14	13221.31	11687.89	16396.15	13113.35	33574.11	26647.00
Nov	2080.80	4056.51	3207.75	3761.50	3447.71	7262.87	6016.88	9833.28	6690.23	12740.12	12817.58
Dec	1249.85	2508.52	1945.03	2338.59	2121.68	4433.83	3670.28	6630.82	3728.50	6031.19	6474.42

(Source: MRCSKB, 2010)

Notes: CS-Chiang saen, CK-Chiang Khan, LPN-Luang Prabang, VTE-Vientiane, NKh-Nong Khai, NKPN-Nakhonpranom, MDH-Mukdahan, PS-Pakse, KC-KhongChiam, ST-Stung Treng, KT-Kratie.

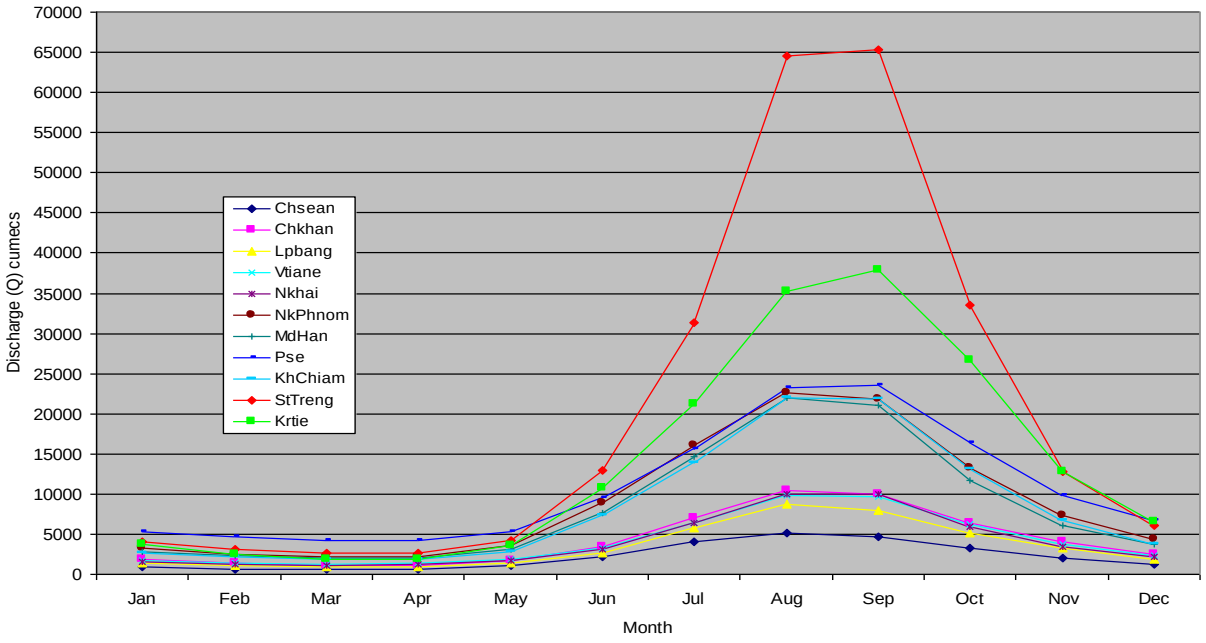


Figure 13: Mean monthly (1970-2010) at Main Stations in the LMB

The contributions of the various flow inputs from upstream of the Chiang khan gauge which is situated immediately below the Paklay dam site

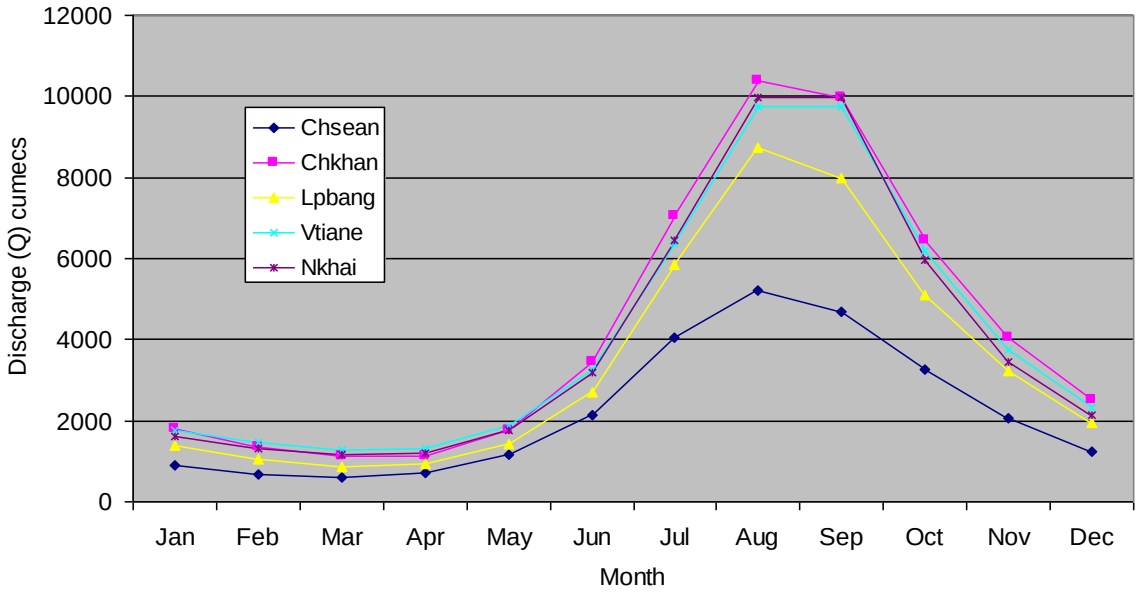


Figure 14: Mean monthly Flow (1970-2010 at Stations in Upper Zone of the LMB (Chiang Saen, Chiang Khan, Luang Prabang, Vientiane and Nongkhai)

accuracy of hydrologic stations, sectional precipitation distribution and other reasons, themean annual flow at the upper damsites over the years is separately 4050 m^3/s and 4040m^3/s according to the corrective calculation of the area ratio via the runoff data of upstreamLuang Prabang Hydrologic Station and downstream Chiang Khan Hydrologic Station atthe stage. The mean annual flow over the years is 4060 m^3/s at the damsite viainterpolation algorithm.

The monthly mean annual flow of the upper damsite is 4060 m^3/s and thecorresponding annual runoff is 128 billion m^3based on the statistics of monthly averageflow in 56 years from 1960 to 2015. Refer to Table 2.3-1 for mean monthly flow at theupper damsite.

Table 11: Monthly Discharge (Q) at Paklay Station

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Q (m3/s)	1,740	1,310	1,120	1,150	1,690	3,210	6,610	10,250	9,280	5,880	3,810	2,440	**4,060**
%	3.59	2.70	2.31	2.37	3.49	6.62	13.63	21.14	19.14	12.13	7.86	5.03	**100**

(Source: FS, 2017)

Through analyses on the calculated monthly average flow data at the upper damsiteover the years, the ratio between the maximum monthly average flow and minimummonthly average flow of each year is 3.62~17.2. The maximum monthly average flow is17,400 m^3/s (August 1971), being 27.5 times as the minimum monthly average flow (633m^3/s, March 2004), while the maximum annual average flow is 5,720 m^3/s (1966), being2.17 times as the minimum annual average flow (2,630 m^3/s, 1992). Through analyses onthe statistical results of mean monthly flow over the years, the maximum monthly averageflow accounts for 21.14% of the mean annual flow, while the minimum monthly averageflow only accounts for 2.31%. The total flow in July to October accounts for 66.03% of themean annual flow over the years, while

that in January to May and in December (6 monthsin total) accounts for 19.49% of the mean annual flow. Therefore, the annual variance ofrunoff within the damsite reach is relatively large, while the inter-annual variance isrelatively small.

5.5.5 An Introduction to Water Quality Study

*5.5.5.1 **Introduction***

As the project is on the Mekong mainstream there may be effects on surface water quality especially Down Stream. The impacts on water quality may be related to specific activities during construction and/or operation. During construction the activities that may cause changes in water quality include dredging, excavating, and surface runoff from construction and camp sites. The placement of the dam will result in some degree of impoundment and this will affect water quality and the aquatic environment both upstream and downstream. Direct physical changes upstream include increased water depth, increased water retention time, and possible thermal stratification. These direct changes will affect a broad spectrum of water quality parameters both upstream and downstream.

*5.5.5.2 **Methodology***

The following methods are employed in the water quality study for the PLHPP.

- Review related data on water quality of the Mekong River.
- Study pollutant sources discharging to the Mekong River and other river branches in the project study area.
- Conduct water quality sampling in the Mekong River and other rivers in the study area. The sampling protocol had been designed specifically for this project and was included both dry and rainy seasons. The duration of performing water quality sampling included:
  - Dry season sampling: 03-06 February
  - Rainy season sampling: 13-16 September

The water quality we collected at FS stage will be baseline for future and before start construction the project will start collect the water quality quarterly. Field sampling results from 7 stations in the Mekong River and the Nam Xong confluence with the Mekong are as follows.

- Station 1: Mekong mainstream at Ban Pha Liap 0797144 E , 2048706N
- Station 2: Mekong mainstream , (Pak Nam Pa) down the confluence with Nam Pha 0776326 E, 2039918 N
- Station 3: Dam site (upperstream option) 0770534 E, 2032337 N
- Station 4: Mekong mainstream, confluence with Nam Phoun, at Ban Moung Nua 0770562 E, 2032420 N

- Station 5: Dam site (lowerstream option) 0769061 E, 2032399 N
- Station 6: Nam Xong, confluence with Mekong mainstream, 0758122 E, 2021689 N.
- Station 7: Paklay, confluence with Mekong mainstream. 0755083 E, 2017323 N.

Water samples are taken at the mid depth of the waterway in case of rather low running water. In case of fast running water, the samples are taken at a 30 cm. depth underneath water surface. Conductivity, dissolved oxygen, pH and rate of flow are measured on site. The sampled water is kept in plastic polyethylene bottles for determination of chemical parameters and glass bottles for bacteria analysis in the laboratory. All parameters for surface water and ground water are displayed in the Tables below. Methods of collecting, handling, preservation and the analysis are performed by using the standard methods for the examination of water and wastewater, APHA, AWWA and WEF (1998).

Table 12: Parameter Index and Methods for Surface Water quality

Character.	Parameter	Unit	Analytical Methodology
1.Physical	1.1 Temperature	^oC	Thermometer
	1.2 Transparency	M	Secchi Disc
	1.3 Conductivity	µS/cm	Conductivity Meter
	1.4 Suspended Solids	mg/l	Dried at 103-105^oC
	1.5 Turbidity	NTU	Turbidimeter
	1.6 Total Dissolved Solids	mg/l	Dried at 103-105^oC
2.Chemical	2.1 pH	-	pH Meter
	2.2 Dissolved Oxygen	mg/l	Dissolved Oxygen Meter
	2.3 BOD	mg/l	5-day BOD Test Method
	2.4 COD_{Mn}	mg/l	Closed Reflux,
	2.5 Total Hardness	mg/l as $CaCO_3$	EDTA Titrimetric Method
	2.6 Total Phosphate	mg/l	Ascorbic Acid Method
	2.7 Total Potassium	mg/l	AAS Method
	2.8 Total Nitrogen	mg/l	Cadmium Reduction and Colorimetric Method

Character.	Parameter	Unit	Analytical Methodology
	2.9 NO_3-N	mg/l	Cadmium Reduction Method
	2.10 NH_3-N	mg/l	Titrimetric Method
	2.11 Cd	mg/l	AAS Method
	2.12 Hg	mg/l	Cold Vapour AAS Method
	2.13 Cu	mg/l	AAS method
	2.14 Fe	mg/l	AAS method
	2.15 Mn	mg/l	Persulface Method
	2.16 Ni	mg/l	AAS method
	2.17 Ai	mg/l	ICP Method
	2.18 As	mg/l	AAS Method
	2.19 Pb	mg/l	AAS method
	2.20 Zn	mg/l	ICP Method
3. Bacterial	3.1 Total Coliform Bacteria	MPN/100 ml	Multiple Tube Fermentation Technique
	3.2 Fecal Coliform Bacteria	MPN/100 ml	Multiple Tube Fermentation Technique

Table 13: Parameter Index and Methods for Ground Water Quality

No.	Parameter	Unit	Analytical Methodology
1	Temperature	^oC	Thermometer
2	pH	-	pH Meter
3	Conductivity	µS/cm	Conductivity Meter
4	Turbidity	NTU	Turbidimeter
5	Total Harness	mg/l $CaCO_3$	EDTA Tritimetric method
6	Calcium	mg/l $CaCO_3$	Atomic Absorption Spectrometric Method
7	Magnesium	mg/l $CaCO_3$	Atomic Absorption Spectrometric Method
8	Iron,Total	mg/l Fe	Atomic Absorption Spectrometric Method
9	Manganese,Total	mg/l Mn	Atomic Absorption Spectrometric Method
10	Alkalinity,M.O	mg/l $CaCO_3$	Tritation Method
11	Chloride	Mg/l Cl	Mecuric Nitrate Method
12	Nitrogen,Nitrate	mg/l	Cadmium reduction Method
13	Sodium	mg/l Na	Atomic Absorption Spectrometric Method
14	Potasium	mg/l K	Atomic Absorption Spectrometric Method
15	Total Coliform Bacteria	MPN/100 ml	Multiple Tube Fermentation Technique
16	Fecal Coliform Bacteria	MPN/100 ml	Multiple Tube Fermentation Technique

5.5.5.3 Sources of information

The water quality study comprises a literature search and study as well as a field study for water quality sampling and analysis. The results will be compared to surface water quality of Lao National and other acceptable regional standards and the significance of the impacts on water quality will be assessed.

5.5.5.4 Result of Water Quality Study (Dry season)

The findings of the dry season were interpreted and compared with the surface water quality standard issued by Notification of The Standard of Lao Water Supply and classifications and objectives of surface water usage category.

Surface Water

During this period, surface water temperature for all seven stations were in range of 25.7-28.6 C. With respect to dissolved oxygen, the concentration in range of 4.2-5.2 mg/l which were slightly low level for the water flow with turbulence when passing the rapid area. The pH values of water from upstream to downstream sites were quite similarly in range of 7.8-7.9.

No significant differences of water hardness and the solids contents both suspended solids and dissolved solid among the stations were observed. Water hardness was in range of 100-220 mg/L.

BOD and COD , were high at all stations showing the high local contaminations, household sewage, husbandry , agricultural fertilizers and some inland activities that release the organic matters to Mekong river. BOD values of the water in the study area were in range of 1.1-3.2 mg/L while COD values were high within range of 1.5-2.7 mg/L. Both upstream and downstream from project sites showed slightly high values of BOD and COD of surface water.

Iron (Fe) concentrations at all station in Mekong river at PakLay project area were higher than acceptable limit of surface water standard of Lao water supply and Manganese (Mn) concentration was found high at Paklay water confluence with Mekong river (Station 7).

Increased turbidity levels were observed at all sampling stations with the transparency value of 0.2-0.3 metre. Heavy metals, lead, cadmium, and mercury, nickel, arsenic and chromium were present although at much lower concentrations than their acceptable limits.

Overall the results of the study show that the surface water quality in Mekong mainstream from the area of Ban Pha Liap , from upstream to downstream area at PakLay town are good of there are no heavy metal contents over acceptable limits. The most important that must to concern are the value of BOD and COD which were very high at all stations. This need to have mitigation measure to prevent the problem of water deterioration in the future. The organic matters from any sources should be prohibiting not to dumping to the natural water body with any manners. Total phosphate and some nitrates concentration were found at lower value than rainyseason and are in acceptable of surface water standard.

Table 14:Results of Water Quality Analysis of Mekong Surface Water

Parameters	Units	Sampling Stations							Surface Water Standard	Standard of Lao PDR Water Supply
		1	2	3	4	5	6	7		
water temperature	^oC	21.8	22.4	21.7	23.3	21.7	22	25.3		
Transparency	cm	40	50	40	40	40	40	10		
Turbidity	NTU	40.4	8.4	48.0	39.0	27.4	39.3	204		5
Total Suspended Solids	mg/l	53.0	12.0	64.5	43.5	82.0	118.5	418.5		
Total Dissolved Solids	mg/l	164.0	203.0	176.0	146.0	155.0	174.0	328		500
Conductivity	µS/cm	292.7	346.7	293.4	250.3	291.4	258.9	410.4		
pH	unit	7.9	8.1	7.9	7.8	7.8	8	8.1	5-Sep	
Total hardness	mg/l as $CaCO_3$	152.0	181.0	150.0	244.0	100.0	132.0	220		500
Dissolved Oxygen	mg/l	8.1	7.9	8	7.4	7.9	7.1	8.6	6	
COD	mg/l	1.8	1.8	2.3	2.5	1.3	1.5	2.7	5	

BOD	mg/L	3.2	2.7	1.5	1.5	1.5	1.1	1.5	1.5	5
Nitrate ion (NO3-)	mg/l	2.49	3.53	4.28	2.55	3.68	1.87	3.38	<0.5	50
Ammonia ion (NH4+)	mg/l	0.18	0.09	0.18	0.15	0.12	0.25	0.53	0.2	0.5
Total Phosphate (T.P)	mg/l	0.8	0.3	0.8	0.7	0.8	0.8	2.2		
Total Cromium (Cr)	mg/l	5.982	8.8	7.257	8.73	16.42	16.01	16.01	0.05 (CR^{6+})	0.05
Nickle (Ni)	mg/l	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0.1	0.05
Iron (Fe)	mg/l	0.630	0.220	0.910	0.900	0.530	0.800	3.060		0.3
Manganese (Mn)	mg/l	0.060	ND <0.03	0.080	0.090	0.050	0.070	0.340	1.00	0.1
Lead (Pb)	mg/l	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	0.05	0.05
Arsenic (As)	mg/l	ND < 0.005	ND < 0.005	ND < 0.005	ND < 0.005	ND < 0.005	ND < 0.005	ND < 0.005	0.01	0.05
Mercury (Hg)	mg/l	ND <0.0005	ND <0.0005	ND <0.0005	0.001	0.001	ND <0.0005	ND <0.0005	0.002	0.001
Zinc (Zn)	mg/l	ND <0.05	ND <0.05	ND <0.05	ND <0.05	ND <0.05	ND <0.05	ND <0.05	1	5
Copper (Cu)	mg/l	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0.1	1

Aluminum(Al)	mg/l	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	1.460	0.270		0.24
Cadmium (Cd)	mg/l	ND <0.01	ND <0.01	ND <0.01	ND <0.01	ND <0.01	ND <0.01	ND <0.01	0.005	0.01
Faecal Coliform	MPN/100 ml	>23	>23	>23	>23	>23	>23	>23	1000	0
Total Coliform	MPN/100 ml	>230	>230	>230	>230	>230	>230	>230	5000	2.2
water temperature	^{o}C	21.8	22.4	21.7	23.3	21.7	22	25.3		
Transparency	cm	40	50	40	40	40	40	10		

N.D = Non Detection

MPN = Most Probable Number

a) Ground water

The result of ground water quality analysis obtained from three ground shallow waters at Ban Khae and Ban Muang was shown in the Table below.

During dry season investigate, the ground water level in the shallow pond were in range of 120-250 cm, from 450-900 cm. depth of ground surface level.

The pH of the ground water was 6.5-7.4. and there was high in turbidity level of 73 NTU at Ban Muang Nua (Station 2) while the others were clear water with the turbidity values of 2.8-10.7 NTU. High total coliform bacteria and Fecal coliform bacteria were found, which was high as the results found during rainyseason.

Overall, there was no difference of ground water quality of these two sources and the ground water in Paklay town at the sampling site had no coliform bacteria contamination.

Table 15: Results of Water Quality Analysis of Ground Water

Depth	cm	450	900	750	
Depth of water	cm	150	120	250	
water temperature	^{o}C	25.1	24.2	26	
Turbidity	NTU	2.8	73	10.7	5
pH	pH	6.8	7.4	6.5	
Conductivity	microS/cm.	937	356	365	
KMnO4 consumed	mg/l	3	14	3	10
Total hardness	mg/l	410	174	146	500
Total dissolved solids (TDS)	mg/l	751	208	258	500
Total Suspended Solids (TSS)	mg/L	13	87.5	2	
Zinc (Zn)	mg/l	N.D <0.05	N.D <0.05	N.D <0.05	4
Total Cromium (T.Cr)	mg/l	N.D <0.02	N.D <0.02	N.D <0.02	0.05
Nickle (Ni)	mg/l	N.D <0.01	N.D <0.01	N.D <0.01	0.05
Iron (Fe)	mg/l	0.06	0.24	N.D <0.01	0.3

Manganese (Mn)	mg/l	N.D <0.03	0.28	N.D <0.03	0.1
Copper (Cu)	mg/l	N.D <0.1	N.D <0.1	N.D <0.1	1
Lead (Pb)	mg/l	N.D <0.02	N.D <0.02	N.D <0.02	0.05
Arsenic (As)	mg/l	N.D<0.005	N.D<0.005	N.D<0.005	0.05
Aluminum (Al)	mg/l	0.53	1.63	0.6	0.24
Mercury (Hg)	mg/l	N.D < 0.0005	N.D < 0.0005	N.D < 0.0005	0.001
Cadmium (Cd)	mg/l	N.D <0.01	N.D <0.01	N.D <0.01	0.01
Faecal coliform	MPN/100ml.	>23	>23	>23	0
Total coliforms groups	MPN/100ml.	>230	>230	>230	2.2

5.5.5.5 Result of Water Quality Study (rainy season)

(a) Surface Water

The detailed results of the water quality analysis from seven stations is shown in the Table below. Surface temperature of surface water in the Mekong river from Ban Pha Liap to PakLay town recorded during the survey ranged between 25.3-28 ^{o}C. The temperature is influenced by several factors including air temperature, wind speed, and topographic condition of Mekong River. Surface water temperature was found to fluctuated slightly (in the range of 0.5-0.7 ^{o}C) between stations during well-mixing period of high water flow.

Dissolved oxygen concentration (DO) reflects productive condition of the water. The DO levels in the river were generally found to be at high levels (6 mg/L). In each sampling, horizontal distribution of DO between stations was seemed to be consistent with level of primary producers (phytoplankton) and high water turbulent at rapid area.

Water pH in the Mekong river in the PakLay HPP area found in the ranged between 7.49-7.98.

Turbidity and conductivity revealed other complex influences to water quality including effect from precipitation, inflow and mixing regime of water column. High levels of turbidity (reaching over 200 NTU) in surface water were found around upstream area and in the upper section of project area (e.g station 3 and 5).

The conductivity of the river water was found to be at relative high level, with ranges of 171-381 microseimens/cm. Slightly higher conductivities were found in the lower section of project area (e.g. in the station 6 and 7).

From the field survey, the water quality of rainyseason are in very good quality by the mean of dissolved oxygen even through the water is relative turbid . The water quality

shows a very good condition with high dissolved oxygen. Total Solids are high concentration due to the influence of high water flow. Nitrate are in high ranged of 1.87-4.28 mg/l which ammonia are 0.07-0.52 mg/l . The water in this area showed the contamination of coliform bacteria. Total coliform bacteria are in range of higher than 230MPN/100 ml and faecal coliform bacteria are higher than 23 MPN/100 ml in all stations. There are no significant concentration of heavy metals found in this area except for iron which show high dissolved concentration in the water at Ban Pha Liap (station 1).

BOD values of the water in the study area were in range of 3.7-5.4 mg/L while COD values were high within range of 4.2-6.8 mg/L.

The surface water quality of Mekong river from seven sampling sites in Paklay hydropower project area shows a good quality but level of BOD and COD were higher than surface water standard ; Medium quality water suitable for human consumption after normal treatment process for contaminated bacteria , and also suitable for irrigation supply and aquatic biota. (NEAP , 2000)

Table 16: Results of Water Quality Analysis of Mekong Surface Water

Parameters	Units	Sampling Stations							Surface Water Standard	Standard of Lao PDR Water Supply
		1	2	3	4	5	6	7		
water temperature	°C	26.7	28	26.5	25.3	26	26.8	28		
Transparency	cm	30	35	25	22	31	30	30		
Turbidity	NTU	96.0	71.0	212.0	75.0	202.0	15.0	144		5
Total Suspended Solids	mg/l	2.0	3.0	12.0	3.3	0.3	11.0	11.0		
Total Dissolved Solids	mg/l	62.9	130.0	85.7	91.4	167.1	228.6	228.6		500
Conductivity	µS/cm	197.0	213	195	171	191	381	288		
pH	unit	7.49	7.58	7.61	7.57	7.78	7.98	7.93	6-9	
Total hardness	mg/l as $CaCO_3$	110.0	110.0	80.0	76.0	110.0	178.0	140		500
Dissolved Oxygen	mg/l	5.96	6.63	6.17	6.24	6.13	6.09	4.35	6	
COD	mg/l	4.2	6.1	4.9	5.3	4.2	4.2	6.8	5	

BOD	mg/L	4.0	5.4	3.7	4.5	3.9	3.7	5.2	1.5	5
Nitrate ion (NO_3^-)	mg/l	2.49	3.53	4.28	2.55	3.68	1.87	3.38	<0.5	50
Ammonia ion (NH_4^+)	mg/l	0.16	0.42	0.28	0.2	0.3	0.07	0.52	0.2	0.5
Total Phosphate (T.P)	mg/l	0.88	0.62	0.79	0.62	0.88	0.49	0.92		
Total Cromium (Cr)	mg/l	5.982	8.8	7.257	8.73	16.42	16.01	16.01	0.05 (CR^{6+})	0.05
Nickle (Ni)	mg/l	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0.1	0.05
Iron (Fe)	mg/l	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02		0.3
Manganese (Mn)	mg/l	0.180	ND <0.03	ND <0.03	ND <0.03	ND <0.03	ND <0.03	0.080	1.00	0.1
Lead (Pb)	mg/l	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	ND <0.02	0.05	0.05

N.D = Non Detection

MPN = Most Probable Number

(b) Ground Water

Ground water samples was obtained in the project area from well at the Ban Khae and Ban Muang village. The shallow water at these area now are used for wash and household cleaning , not for drinking. The villager used water from small stream or pond for their consumption.

The result of ground water quality analysis obtained three shallow water was shown in Table below

The pH of the ground water was in range of 6.54-6.89. and there was high in total hardness and dissolved solid at Ban Khae but generally normal value of hardness , dissolved solid and suspended solids at well water at Ban Muang. Heavy metal content in ground water was found very low and were in the standard of Lao water supply. High total coliform bacteria and Fecal coliform bacteria were found, which was much higher than the standard.

Table 17: Results of Water Quality Analysis of Ground Water

Parameter	Unit	Station			Standard of Lao Water Supply
		1	2	3	
Depth	cm	450	900	750	
Depth of water	cm	150	120	250	
water temperature	^{o}C	28.1	27	27.8	
Turbidity	NTU	98	509	169	5
pH	pH	6.62	6.89	6.54	
Conductivity	microS/cm.	102	158.9	484.2	
KMnO4 consumed	mg/l	13.4	31	19.2	10
Total hardness	mg/l	336	100	34	500
Total dissolved solids (TDS)	mg/l	592	164	318	500
Total Suspended Solids (TSS)	mg/L	136	169	152	
Zinc (Zn)	mg/l	N.D <0.05	N.D <0.05	N.D <0.05	4
Total Cromium (T.Cr)	mg/l	N.D <0.02	N.D <0.02	N.D <0.02	0.05
Nickle (Ni)	mg/l	N.D <0.01	N.D <0.01	N.D <0.01	0.05

Iron (Fe)	mg/l	0.55	2.21	1.85	0.3
Manganese (Mn)	mg/l	0.2	0.25	0.32	0.1
Copper (Cu)	mg/l	N.D <0.1	N.D <0.1	N.D <0.1	1
Lead (Pb)	mg/l	N.D <0.02	N.D <0.02	N.D <0.02	0.05
Arsenic (As)	mg/l	0.003	0.004	0.008	0.05
Aluminum (Al)	mg/l	0.53	1.63	0.6	0.24
Mercury (Hg)	mg/l	N.D < 0.0005	N.D < 0.0005	N.D < 0.0005	0.001
Cadmium (Cd)	mg/l	N.D <0.01	N.D <0.01	N.D <0.01	0.01
Faecal coliform	MPN/100ml.	>23	>23	>23	0
Total coliforms groups	MPN/100ml.	>230	>230	>230	2.2

5.5.6 Erosion and Sedimentation

5.5.6.1 Introduction

The Greater Mekong can be divided into two parts: the Upper Mekong River Basin (UMRB) in Tibet and China (where the river is called the *Lancang Jiang*), and the Lower Mekong River Basin from Yunnan downstream from China to the South China Sea. The UMRB makes up 24 per cent of the total area and contributes 15 to 20 per cent of the water that flows into the Mekong River. The catchment here is steep and narrow. Soil erosion has been a major problem and approximately 50 per cent of the sediment in the river comes from the UMRB. It is now prohibited to plant crops on land that exceeds a 25 per cent slope. Therefore, any future development must come from hydropower generated on the mainstream because there are no major tributary systems flowing into this reach of the river.

The Mekong River Basin is extremely important for the four riparian countries that are downstream of China and Myanmar (i.e. Thailand, Laos, Cambodia and Vietnam in Southeast Asia. The livelihoods of millions of people are dependent on the Mekong and its floodplains. The sediment of the Lower Mekong River Basin (LMRB) has critical implications for aquatic ecology; fisheries, agriculture, water supply and river navigation. However, in comparison with other large rivers

(such as the Yangtze River and the Yellow River), studies on the sediment generation, transportation and deposition in the LMRB are sparse.

*5.5.6.2 **Methodology***

- Secondary data regarding sedimentation of the Mekong River Basin are reviewed from relevant literature and document
- The investigations of the sediment load of the Mekong River in previous studied area are performed.

*5.5.6.3 **Sources of information***

The erosion and sedimentation statistical data comprises a literature review as well as a statistical data from the Mekong River commission (MRC) for different periods of time.

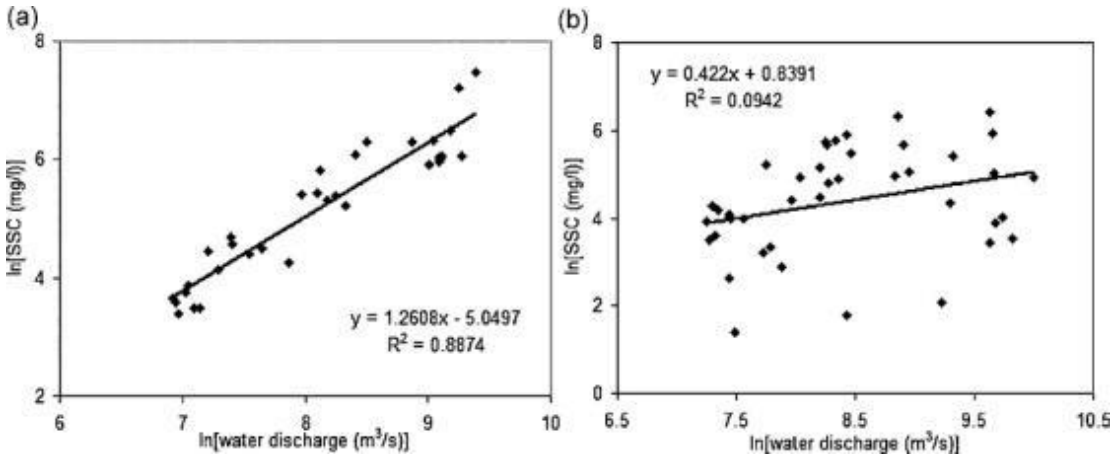
5.5.6.4 Analysis of Erosion & Sedimentation in the Project Area

a) **Sediment Loads in selected stations in Lower Mekong River Basin**

The Mekong River is a steeply sloping river which begins in the Himalayas, an area of active geological uplift. The upper basin provides the river sediment transportation with up to 50 percent of the sediment that is discharged into the South China Sea. All sections of the river have high sediment loads and in the study of the low Pak Mong dam it was considered that the rate of sediment accumulation would be 75,000.00 m^3/year which translates to an erosion rate of 4.2 t/ha/yr. ; this estimate would include both natural and induced erosion and suspended and bed load sediment (HPP-IEE, 2009).

Hydropower development of large dams and reservoirs has been fast in the Mekong Basin (Barlow, 2008). In recent decades, the reservoirs have represented the most important influence to the land-ocean sediment fluxes in the world (Walling and Fang, 2003; Syvitski et al., 2005). However, reports on the impact of the Chinese dams, such as the Manwan, Xiaowan, Jinghong, and Dachaosan dams in the Lancang River (or the Upper Mekong River Basin), on the sediment downstream has not been consistent. Lu and Siew (2006) and Kummu and Varis (2007) reported that the sediment load at Chiang Saen, which is the nearest station to the Chinese dam sites, was reduced to half after the completion of the Manwan dam in 1993; however, such an impact on the sediment load was not significant for the downstreram stations. By contrast, Walling (2008) indicated that the Manwan and Dachaosan dams did not have a significant impact on the sediment loads in the Lower Mekong River Basin and the sediment rating curved to generate the sediment products, it is illustrated in figure below.

Sediment Data Collection On Site



(Source: Wang and et al., 2009)

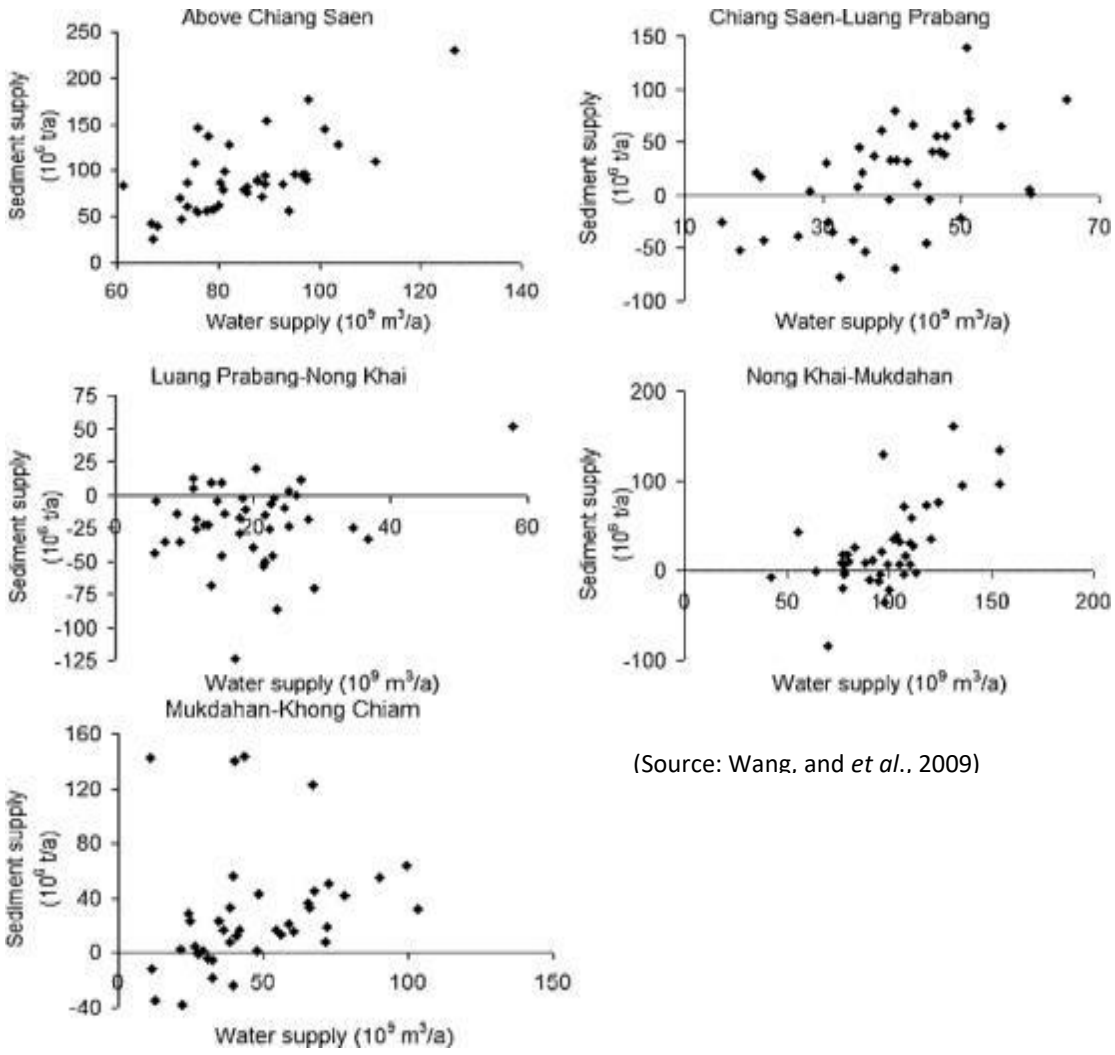
Figure 15: Rating Curve at Nong Khai Station in 1975 and 2002

Fu et al. (2008) reported that the impact of the dams on the suspended sediment concentration (SSC) and the sediment flux was insignificant atYunjinghong, which is 401 km downstream of the Manwan dam in China. Walling (2005) argued that the SSC data at Chiang Saen used by Lu and Siew (2006) and Kummu and Varis (2007) came from a water quality sampling program, which might underestimate the sediment load due to the fact that the sediment samples were collected 0.3 m below the water surface rather than through a depth integrated vertical. Such debates on the possible impact of the Chinese dams into the Lower Mekong Basin (LMB) may be attributed to the lack of long term and accurate sediment measurement in the LMB because an expensive and time consuming traditional measurement method was used (Gao and O' Leary, 1997). Lu and Siew (2006) and Kummu and Varis (2007) reported that the sediment load at Chiang Saen (SSC measurements) in the Lower Mekong River is sporadic. For example, there were no SSC measurements at Chiang Saen during 1976–1993, i.e. 18 years before the operation of the Manwan dam (cf. Walling, 2008). In fact, measurements for only 28 years at Chiang Saen, 16 years at Luang Prabang, 30 years at Nong Khai, 42 years at Mukdahan and 25 years at Khong Chiam.

In some years, fewer than 10 Suspended Sediment Concentration measurements were taken; if these years are excluded, then these five stations have even fewer years of measurements (i.e. 25, 11, 29, 38 and 22 years). The serious lack of measurement data has hindered estimation of the sediment loads (Walling, 2005). Walling (2005), Lu and Siew (2006) and Kummu and Varis (2007) only calculated the sediment loads for the years with sediment measurements using the rating curve method (Walling and Webb, 1988; Cohn, 1995; Asselman, 2000). For example, during the period of 1962–1980, the sediment loads were estimated for only 1 year at Luang Prabang and not at Pakse (cf. Lu and Siew, 2006). Hence, a comparison of the pre-and post-dam sediment loads, which was based on the annual sediment loads of a limited number of years, requires more supporting evidence.

The previous studied attempted to investigate the possibility of estimating the sediment

loads for the years without good quality Suspended Sediment Concentration (SSC) measurements in the Lower Mekong basin. It aimed to estimate the annual sediment loads for the individual years at the five mainstream stations of Chiang Saen, Luang Prabang, Nong Khai, Mukdahan and Khong Chiam. The temporal and spatial sediment variations have been analyzedbut the bed loads were not included due to a lack of bed load data.



(Source: Wang, and *et al*., 2009)

Figure 16: Sediment Load at 5 Stations in Upstream /Downstream of Paklay HPP

For the sediment data of Paklay downstream dam site, by using the mean monthly sediment concentration records for Apr. 1967 ~ Mar. 1968 and Apr. 1969 ~ Mar. 1977 of Chiang Khan Hydrological Station and the mean monthly discharges of the downstream dam site of the same year, we calculated the mean monthly sediment discharge rate and correlated the mean monthly discharge and mean monthly sediment

discharge rate of the downstream dam site (see Fig.). Then, the mean monthly sediment discharge rate and mean monthly sediment concentration and discharge of the downstream dam site for Jan. 1960 ~ Mar. 1967, Apr. 1968 ~ Mar. 1969, and Apr. 1977 ~ Dec. 2002 were calculated by using the mean monthly discharge data and mean monthly sediment discharge rate data of the downstream dam site. Through statistical calculation, the characteristic values of the sediment at Paklay dam site are as shown in Table below.

Table 18: Characteristic Values of the Sediment at Paklay D/S Dam Site

Name	Mean Annual Sediment Discharge	Annual maximum sediment discharge	Mean annual sediment concentration
	10^4 t	10^4 t	g/m^3
Downstream dam site	6,670	13,100	510

b) Comparison of some previous studies with the Lower Mekong River Basin

In western Asia, the Indus has some of its source tributaries in the Hindu Kush Mountains, while the Tigris and Euphrates rise in the mountains of Turkey and Armenia respectively. Monsoon rains cause the Indus to flood between July and September. The Tigris and Euphrates are affected by seasonal rains that overlap with snow-melt run-off and cause flooding from March to June. The floods on the Euphrates inundate low-lying areas to form permanent lakes that have no outlets. Water loss from these lakes is mainly by evaporation, although some of the water is withdrawn for irrigation.

It was found that most of the large rivers of Asia that flow generally southward have their sources in the mountains and flow through varied climatic conditions before discharging to the sea. Peak flows generally occur when run-off from melting snow is supplemented by monsoon rains. The Ganges and Irrawady receive snow-melt from the Himalayas and southern Tibet respectively from April to June, and the flow rate is just beginning to decline when the July monsoon begins. Flooding can occur from July to October. The Mekong is somewhat similar. It has its beginnings at an altitude of about 4,900 m in China's Tanglha Range. Snow-melt is later here, so peak flows do not occur until August/September in the upper reaches of the river and October in the lower reaches. Minimum flow in the Mekong occurs from November to May.

Data on erosion of the world's river basins are far from complete. In general, however, erosion can be said to vary according to the following influences:

- Amount and pattern of rainfall and resultant river regime.
- Slope of the land.
- Extent of destruction of vegetation.
- Regeneration of vegetation.
- Soil type and resistance to the effects of temperature changes.

Erosion rates are thus extremely variable, with highest rates occurring usually in mountain streams where human intervention has resulted in extensive damage to vegetation. Erosion is primarily responsible for the amount of sediment transported to the sea. The mean annual sediment loads transported by several major rivers are shown in Table below.

An understanding of the discharge regime of a river is extremely important to the interpretation of water quality measurements, especially those including suspended sediment or intended to determine the flux of sediment or contaminants. The discharge of a river is related to the nature of its catchment; particularly the geological, geographical and climatologically influences.

Table 19: Mean Annual Sediment Loads of Some Major Rivers

River	**Basin Area** *(10^3 km^2)*	**Mean Annual Sediment load** *(10^6 t a^{-1})*
Amazon	6,300	850
Brahmaputra	580	730
Congo (Zaize)	4,000	72
Dabube	816	65
Ganges	975	1,450
Indus	950	435
Irrawady	430	300
Orinoco	950	150[1]
Mekong	**795**	**160[1]**
Ob	2,430	15
Rhine	160	28

(Source: World Resources institute, 1988)

[1] Average discharge taken from Meybeck et al. (1989) taking into account existing dam

5.6 Existing Biotic Environment in the Project Area

5.6.1 Aquatic Environment of PLHPP

*5.6.1.1 **Introduction***

Plankton organisms, benthic invertebrate animals, aquatic plants and the fishery were studied. In order to get accurate data, sampling was performed in both the rainy and dry seasons.

*5.6.1.2 **Methodology of Study***

Introduction:

The following methods were employed for the project study:

- Secondary data from literature and related documents was reviewed.
- Field surveys and collection of aquatic organisms at 7stations (the same location as of water quality samplings) to represent the rainyand dry seasons were conducted.
- Samples collected were fish species, plankton, benthic invertebrate and aquatic plants. Fishery activities were also observed and recorded. Altogether 7 sampling stations were selected to cover all waterways of the project area.
- All samples were collected, particularly fish, and were identified, weighed and counted. As for plankton and the benthic invertebrate, density in cells/m^3 and number of animals/m^2 were evaluated.
- The further data collection will work with LARREC andMInistry of Agriculture before construction which will be officlal bade line for GOL to monitor through out the CA period. The importance is that we need to identify long ter monintoring sampling stations and the organisation to work with project to ensure we have consistency of methodlogy and parameters in whole Lonwe Mekong Region.

There were six sampling stations:

- Station 1 Mekong mainstream at Ban Pha Liap 0797144 E , 2048706N.
- Station 2 Mekong mainstream , (Pak Nam Pa) down the confluence with Nam Pha 0776326 E, 2039918 N.
- Station 3 Dam site (upperstream option) 0770534 E, 2032337 N.
- Station 4 Mekong mainstream, confluence with Nam Phoun, at Ban Moung Nua 0770562 E, 2032420 N.
- Station 5 Dam site (lowerstream option) 0769061 E, 2032399 N.
- Station 6 , Nam Xong, confluence with Mekong mainstream, 0758122 E, 2021689 N.
- Station 7 Paklay, confluence with Mekong mainstream. 0755083 E, 2017323 N

Freshwater Plankton Sampling:

The freshwater plankton sampling was carried out at same station as the water samples were

collected. Thirty liters of water were collected from the depths between 0 to 30 cm by using a plankton net. The sampled water was passed through plankton net of 59 microns mesh size in order to separate the aquatic life from the water. The sample of aquatic life was then preserved with 5% formalin solution for further laboratory analysis.

The data of freshwater planktonic organisms at each sampling station can be easily compared by computing "Species Diversity Index (SDI)" by employing the following equations:

$$\text{Species Diversity Index} = \sum_{i=1}^{N}\left[\left(\ln\frac{Ni}{N}\right)\times\left(\frac{Ni}{N}\right)\right]$$

Where: Ni=Population density of each species
N=Total population density of all species

The evaluation criteria for Species Diversity Index (SDI) are as follows (Table 1):

Table 20: Evaluation criteria for species diversity Index

SDI Range	SDI Interpretation
0 –1	Slight Diversity
1 – 2	Moderate Diversity
2 – 3	High Diversity
3 – 4	Heavy Diversity

The collected and preserved freshwater plankton samples were further analyzed in the laboratory for identification of plankton organisms and for determining their abundance.

Freshwater Benthos Sampling:

Freshwater benthos sampling was carried out at the same station as the water sampling, the sediment at the bed was collected with the help of Ekman dredge sampler. The collected samples (prepared by 5 composite grab samples) were then sorted out through a series of sieves to separated benthic macro-invertebrate organisms. Retained organisms were preserved with 7% formalin solution for further laboratory analysis.

Freshwater Fish Sampling:

The freshwater fish sampling was carried out at same station as the water sampling by using suitable gear such as beach seine, gill net or cast net depending on the characteristics of the study

area. A beach seine of about 1 cm mesh size and 50 m long was used to cover the water surface area and then the samples were collected.

Fisheries Activity Survey:
Fishery activities were observed, discussed and recorded with local people in the vicinity of the sampling stations and nearby villages; data gathered included amount of harvested fish and processing procedures. All information gathered was recorded.

Aquatic Plant observation:
Aquatic plants were identified at the same stations that the water samples were collected.

Aspects of Concern for the study:
- Type and abundance of plankton, benthos and fish.
- Fish species, abundance and diversity in the concerned water bodies.
- Impacts of changing water levels and flow regime on fish habitats including floodplains, flood scrub-land, rapids and rock pools.
- Deterioration of water quality may lead to serious impact on aquatic ecological system during construction and operation.
- Fish Blockage mitigation due to dam construction.
- Inadequate minimum flow downstream from reservoirs will lead to serious impact on aquatic ecological system.

Data analysis:
- Identify, describe and map the various aquatic habitats found in the project area.
- Types and density of phytoplankton and zooplankton: comparison of data gained from the proposed stations and secondary data.
- A correlation between the total density and the community of phytoplankton and zooplankton.
- Density and biomass of benthos species: comparison of data gained from the proposed stations and secondary data.
- Assess potential impacts of the project development in construction phase and operation phase on fishery resources.
- Identify fish and other aquatic animals according to family, genus and to species. Type, density, and diversity of fish in the concerned waterways.
- Separate fish into migratory and non migratory fish. Description of all fish species, identified with

regard to migration requirements, food and breeding requirement.

•Fishery and other aquatic animal's production - assess the value of the resource.

•Fishing methods and importance of fishery activities in the nutrition and livelihood requirements of affected communities.

5.6.1.3 ***Results of Aquatic Ecology Study***

Plankton Organisms

A) First sampling period-rainyseason-September

The total density of plankton ranged from 0.06 - 0.240 million cells per cubic metre (cell/cu.m). This is a low density and is normal for running turbid water.

At every station Phytoplankton of the diatom algae group (Phylum Bacillariophyta) followed by the euglenoid group was the dominant species (according to density). The total number of phytoplankton species found at each sampling station was 2-9 while for zooplankton 1-3 species were found. Eight species of diatom algae were found; the most abundant group of diatom algae was genus *Synedra* at all sampling stations and was in a range of 35,000-194,040 cell/cu.m.

There were very few green algae or other groups of phytoplankton found during this season due the high level of suspended sediments which prevents any significant increase in the number of phytoplankton.

Four species of Zooplankton were found including 3 species of Protozoa and 1 Rotifera species. The more numerous group was protozoan. The total density of zooplankton ranged from 5,000-15,040 individuals / cu.m of water. See full table below.

Table 21: RainySeason Plankton Sampling

TAXA or Group	**Station**						
	1	2	3	4	5	6	7
Phytoplankton							
Cyanophyta (blue green algae)							
Lyngbya limnetica	3,760						
Oscillatoria sp.	3,760	4,400	10,000	3,840	23,100	8,280	12,180
Chlorophyta (green algae)							
Pediastrum simplex	3,760						
Spirogyra sp.					4,620		

,							
Euglenophyta (euglenoids)							
Euglena spiroides							8,120
Euglena proxima							4,060
Phacus quinquemarginatus							4,060
Trachelomonas oblonga		70,400					4,060
Trachelomonas volvocina		314	10,000				16,240
Bacillariophyta (diatom)							
Coscinodiscus sp.	3,760	4,400					
Cyclotella sp.					4,620		
Hydrosera triquetra							4,060
Navicula anglica				3,840			
Pleuroseira laevis							4,060
Surirella linearis				42,240			
Surirella robusta	7,520						
Synedra ulna	45,120	83,600	35,000	107,520	194,040	37,260	44,660
Zooplankton							
Protozoa							
Arcella vulgaris					4,620		
Centropyxis aculeata	3,760	4,400	5,000	7,680	4,620	4,140	4,060
Centropyxis ecornis	11,280	4,400			4,620		8,120
Rotifera							
Lecane curvicornis							4,060
Density of Phytoplankton	**67,680**	**163,114**	**55,000**	**157,440**	**226,380**	**45,540**	**101,500**
Density of zooplankton	**15,040**	**8,800**	**5,000**	**7,680**	**13,860**	**4,140**	**16,240**
Total density	**82,720**	**171,914**	**60,000**	**165,120**	**240,240**	**49,680**	**117,740**
numbers species of phytoplankton	**6**	**5**	**3**	**4**	**4**	**2**	**9**
number species of zooplankton	**2**	**2**	**1**	**1**	**3**	**1**	**3**
Diversity index of phytoplankton	**1.16**	**0.91**	**0.91**	**0.52**	**0.52**	**0.47**	**1.75**
Diversity index of zooplankton	**0.56**	**0.69**	**-**	**-**	**1.10**	**-**	**1.04**

B) Second sampling period-dry season-February

Five Phyla (Chlorophyta, Bacillarariophyta, Cyanophyta, Pyrrophyta and Euglenophyta) of phytoplankton and two zooplankton phyla (Protozoa and Mollusca) were found in the samples collected during the dry season.

Phytoplankton of the Phylum Bacillariophyta were the most numerous at every station and*Synedra ulna* was the dominant species (same as in the Rainyseason). Three species of green algae (Chlorophyta) were identified from the samples at rather low densities. Diatom was the dominant group during this period.

The species diversity of diatom (Bacillariophyta) was high compared with other phytoplankton. Altogether 10 species were identified. The Phytoplankton densities were in the range of 0.076-0.344 million cell/cu.m. The lowest density of phytoplankton was at Ban Muang Nua Village (Station 3) and station 5. The highest was at Station 4 (Mekong River confluence with Nam Phoun)

A total of 5 species of Protozoan were found at low densities. The density of zooplankton ranged from 4,300-60,720 individuals / cu.m of water. The density of zooplankton was very low at the upper sampling station. See table below for complete details.

Table 22: Dry Season Plankton Sampling

TAXA or Group	**Station**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Phytoplankton							
Cyanophyta (blue green algae)							
Oscillatoria sp.			10,200	5,840	9,040		
Chlorophyta (green algae)							
Closterium gracile	8,720		5,100				
Pediastrum simplex	4,360	5,900					
Spirogyra sp.				17,520	18,080		5,060
Euglenophyta (euglenoids)							
Trachelomonas oblonga						4,600	
Trachelomonas volvocina	4,360						

Bacillariophyta (diatom)							
Aulacoseira granulata		5,900					
Bacillaria paxillifer	4,360		5,100				
Coscinodiscus sp.			5,100				
Cyclotella sp.						4,600	
Eunotia robusta						4,600	
Hydrosera triquetra	4,360						
Pinnularia gibba				23,360			
Pleuroseira laevis		11,800		23,360	4,520	9,200	20,240
Surirella robusta	4,360			11,680		9,200	30,360
Synedra ulna	87,200	171,100	51,000	256,960	58,760	87,400	50,600
Pyrrophyta (dinoflagellate)							
Peridinium sp.				5,840			
<u>Zooplankton</u>							
Protozoa							
Arcella vulgaris				5,840	4,520		15,180
Centropyxis aculeata							5,060
Centropyxis ecornis				5,840	4,520	4,600	35,420
Difflugia lebes	4,360	5,900	5,100				
Difflugia oblonga							5,060
Mollusca							
*Pelecypods larvae					4,520		
Density of phytoplankton	117,720	194,700	76,500	344,560	90,400	119,600	106,260
Density of zooplankton	4,360	5,900	5,100	11,680	13,560	4,600	60,720
Total density	122,080	200,600	81,600	356,240	103,960	124,200	166,980

numbers species of phytoplankton	7	4	5	7	4	6	4
numbers species of zooplankton	1	1	1	2	3	1	4
Diversity index of phytoplankton	1.03	0.50	1.08	0.99	0.98	1.00	1.17
Diversity index of zooplankton	-	-	-	0.69	1.10	-	1.08

Benthic invertebrate animals

A) First sampling period-rainy season-September

Very few benthic organisms were found at the river bottom or near the shore at sites between the village of Ban Pha Liap and the town of Paklay. Three phyla of benthic organisms were found: Annelida (aquatic segmented worm); Arthropoda (mostly insect larvae, small freshwater prawns and crabs), and Mollusca which was comprised of snails and freshwater shellfish.

Chironomid larvae of Families Tubificidae and aquatic worm Naididae were found at almost every station at a density of 2-6 organisms / sq.m. All the benthic fauna were found at each sampling site in a pocket near the shore area where there was low water flow and muddy-sand substrate.

The diversity of benthic animals ranged from 3- 5 species at each sampling site so this part of the Mekong River is not abundant in benthic invertebrate animals.

B) Second sampling period-dry season-February.

There were 3 phyla of benthic fauna found. Two families of aquatic worms (Annelida), six families of Arthropoda and two families of Mollusca were identified from the collected samples.

Aquatic worms of the Family Naididae were found at Ban Pak Kan Village sampling station with the density of 22 organisms / sq.m.

Small freshwater prawns (Macrobrachium lancesteri) were found at all stations with a density of 44-110 ind./sq.m. The total density of benthic invertebrate animals found ranged from 110-220 ind./sq.m.

The benthic fauna found at the sampling stations were low in species diversity and not abundant.

Fish species composition, size and distribution

A) First sampling period-rainy season-September

Thirty-eight species belonging to 10 families were found in the samples collected during sampling which was in the early rainy season. Four to ten species were found in each sampling station upstream of project area and four to eight species were found in downstream area.

Henicorhyncus siamensis (Pa soi) was the species found in the upstream area; sized between 12.2-12.6 cm.TL. Pa Pab (Parachela oxygastroid and Parachela siamensis and Palalaubuca harmandi) were the most numerous species at station 2 at the Nam Pha confluence with the Mekong River.

In the upstream areas (Station 1-3) , 8-11 species were found with low diversity index (1.21-1.3 cells cu m). Pa Kot *Hemibagrus neumurus,* and *Hemibagrus wyckii* were valuable species caught at bigger sizes than other species. Many of the larger fish species such as herbivorous were caught in their juvenile stage (e.g. *Hypsibarbus* spp. *Cyclocylichthys* spp) .

At downstream station 5 (in the proposed downstream damsite), Pa kae (*Bagarius yarelli*) and Pa kod (*Hemibagrus neumurus*) were found at moderately big sizes (400 g).

The table below shows the individual standing crops of fish that were caught at each sampling station and their total weight estimated. From the average water surface area enclosed, 200 sq.m., and the total weight harvested (ranging between 67.9- 840 g.), the estimated average standing crop at the various stations ranged from 0.480 to 4.956 kg/ha with the average standing crop for all seven stations being 5.38 kg/ha during the rainy season. The standing crop in six sampling areas is sometimes difficult to calculate because of conditions of high flow at the sampling sites

The estimate of the proportion of carnivorous, omnivorous and herbivorous species were calculated relating only to total weight caught at each area of fish sampling(see below). The estimated F/C ratio (forage and carnivorous fishes species) at the various station ranged from 2.2:1 to 6.4:1.

Table 23: Forage/Carnivorous fish ratio, diversity index and Estimated of Standing Crop at each sampling station during Rainyseason period.

Station	F/C ratio	Species diversity index	Estimated Standing Crop (kg/ha)
1 Ban Pha Liap,	3.5:1	1.032	2.451
2 Pak Nam Pa,	6.1:1	1.754	0.945
3 Propose upper damsite	3.7:1	1.854	0.842
4 Pak Nam Phoun	5.2:1	2.120	0.650
5 Proposed lower dam site	2.2:1	1.823	4.956
6 Nam Xong, at Mekong confluence,downstream	3:1	2.212	0.480
7 PakLay, at Mekong			

confluence, downstream	6.4:1	2.320	3.257
Average		1.873	1.940

B) Second sampling period-dry season-February

Twenty -seven species belonging to 16 families were found in the samples collected from seven sampling stations . The samples were collected from the beach at each sampling site

Eight species were found in Station 1 (Ban Pha Liap). The fishing area is the calm area near the shore and also the ripple area. The school fish Pa seum (*Kryptopterus cheveyi* and Pa tong (*Notopterus notopterus*) were the dominant fishes in this area. Fishers will come to set gill nets during the early rainy season when the turbid water from upstream triggers these fish to pass this area.

At Pak Nam Pa, downstream, at stations 2 and 3 (in the proposed upper dam site option), 8-11 fish species were found . Fish from this area are very abundant and mostly at valuable prices. The herbivorous and plankton feeder fish found in this area were Mystacoleucus marginatus ,and Parambassis siamensis Sikukia and carnivorous fish, also valuable, namely, Pa Boo *Oxyeleotris marmoratus* and *Channa striata*, were abundant.

Fish species found at Ban Muang Nua (Station 4) (in the proposed lower option damsite (Station 5), included 7-8 species from Three families, Cyprinidae, Bagridae and Sisoridae. Fishes at this station were small herbivorous fish and large carnivorous fish such as Pa kod Lueng *Hemibagrus nemurus* and Pa Kae *Bagarius yarelli*.

Eight fish species were found downstream at Pak Nam Xong and Paklay (station 6-7). There were small to medium size Cyprinidae, which was the dominant group. Many fish of economic value were also found including *Oxyeleotris marmoratus, and Cyclocheilichthys armatus, Chana gachua)* .

Table 24: Forage/Carnivorous fish ratio, diversity index and Estimated of Standing Crop at each sampling station during Dry season period

Station	**F/C ratio**	**Species diversity index**	**Estimated Standing Crop (kg/ha)**
1 Ban Pha Liap,	3.2:1	1.654	2.564
2 Pak Nam Pa,	5.8:1	1.325	0.441
3 Propose upper damsite	3.5:1	1.721	0.828
4 Pak Nam Phoun	6.2:1	2.310	0.557

5 Proposed lower dam site	2.2:1	1.986	5.292
6 Nam Xong, at Mekong confluence,downstream	2.9:1	2.334	0.655
7 PakLay, at Mekong confluence, downstream	2.4:1	2.390	3.391
Average		1.96	1.961

People living along project area and Fishing Gears

Fish distribution

A total of 56 fish species from 17 families were collected from seven sampling stations during the Rainyseason and dry season.

Widely distributed fish species found at almost all sampling stations in thet rainyand dry season were Pa Pian (*Barbonymus gonionotus*), Pa sai tan tar khao (*Cyclocylichthys armatu*s), Pa kee York or Knarm larnk *(Mystacoleucus marginatus*).

The exotic fish found in the Mekong river during this study were Pa Nai (*Cyprinus carpio)* and Pa Nin (*Oreocromis niloticus*). These species have become valuable fish; found in the Mekong main stream, reservoirs and cultured ponds.

The most abundant area of fish was upstream of the Paklay project area, particularly the upper area of Ban Pha Liap. This where local people go to fish during the early rainyseason and early dry season.

Fishery Activities

Fish caught in the project area by local fishermen during the rainyand dry season were of small size. The medium size and large size were only sold at local restaurants in the Paklay town. Species included Pa Kod (*Hemibagrus wyckioides*) and Pa Jok (*Cyclocylichthys enoplos*).captured in the upstream area between Xayaboury and Paklay town. During the rainyseason survey, only one fish species was found at Paklay morning market which was caught in the Mekong river. This was Pa Boo (*Oxyeleotris marmoratus)*; sized 1-1.5 kg. The small fish, Pa Pian (*Barbonymus gonionotus* and Poropuntius laoensis, were sold during the dry season. Most fish sold at the Paklay morning market were from cultured ponds , *e.g, Pangasius hypopthalmus,* from the Thai border, Also Pa duk (*Clarias gariepinus)* and Pa Chon *Channa striata*), were from cultured ponds in PakLay. Frogs (*Ranatigrina*) was also cultured in cages at the Mekong river in the Paklay town area.

During the survey, very few fishermen were found fishing in the Mekong river. Fishing gear being used included drift gill net, and stationary gill net. The amount of catch per day per person was stated to be lower than 1 kg, which might be of naturally low productivity. All fish caught were for household consumption. It was also indicated that not many families went fishing in the river. The main occupation of most families was from agriculture consisting of field crops and vegetables and generally including some livestock husbandry. Few fish from the Mekong were found in the local market; they were mostly economic fish of small size, such as Pa Kod (*Hemibagrus filamentus)* , Pa Kor (*Channa striatua),* Pa Lod (*Macrognathus siamensis* , and *Mastacembelus favus).* Some fish was caught from tributaries of the Mekong river about 3-5 km from Paklay town and sold at Paklay morning market. Any fish of large size especially carnivorous fish were directly sold to local restaurants.

There was no inland aquaculture activities found to be operating in the project area based on both observation and discussions with local government officials and residents. Captured fish were generally more expensive than cultured fish. At Paklay morning market, any captured(wild) fish were sold at higher prices than cultured fish, such as Pa duk (Hybrid *Clarias* species) and Nile tilapia (*Oreochromis niloticus).*

Aquatic weeds.

Most of the plants observed in the upstream river bed and on both banks were not true aquatic weeds. During the dry season, only some emergent plants such as Kok (*Cyperus* sp.) and Haew Song Kratiam (*Scirpus* sp.) were occasionally found. Other aquatic weeds such as Paeng Puay Nam (*Jussuaea repense*) were also observed growing in pocket swamps nearby the river downstream. During the rainyseason, emergent species such as Kok (*Cyperus* sp.) were observed growing sporadically in the upstream river bed.




Consultation with Mr.Douangkham Singhanouvong (Deputy Director of LARReC) to set the scope of work to get more data and lean about best practice in Laos about fish passage and fish sampling system that go along with guide lines of MRC.

5.7 Existing Terrestrial Environment in Project

5.7.1 Introduction

The "Project Area" in this report is broadly covers the main area of the proposed reservoir, the catchment area and also the downstream area. The project area was surveyed to provide baseline information on the land uses and the distribution of forest resources including flora and fauna as well as wildlife and wildlife habitat. Baseline data helps determine the likely impacts of the project on the fauna and flora and assess how such impacts might be mitigated through appropriate interventions.

The method used in assessing the biological environment is based on map compilation, literature review and field surveys. Initially, an analysis of maps and available literature on the land uses and forest resources including wildlife and wildlife habitat was undertaken. This was followed by an extensive indigenous information survey conducted during February-March 2012 in all of the villages within the proposed project area. Survey villages were then selected on the basis of their vulnerability to either direct or indirect impacts from the proposed hydropower project. Key persons in each survey village were selected for interview. Selection was based on the person having experience of the forest, forest products, Non-timber Forest Products (NTFPs), wildlife and wildlife habitat. Selected villagers were divided into two study groups: a group of wildlife-experienced participants and a group of forest and forest product participants. The interviews were conducted at the same time.

Some interviewees were sensitive to questions regarding hunting which can skew the distribution of interview results. During the end of the 1990s, the government in an attempt to protect biodiversity collected rifles and guns. When the villagers were asked what kind of animals were hunted in their village boundary, they often answered that no animals had been hunted since the time guns were collected. Yet animal parts could be seen around the villages.

5.7.2 Forest and Vegetation

In terms of forest cover in Xayaboury and Vientiane provinces where the project is the following data is from the report on land use and forest cover (see Department of Forestry, MAF, July 2005). Approximately 35% of the total land area of the Xayaboury province is covered by current forest; 59% is covered by Potential Forest which includes almost 50% Unstocked Forest, about 2.3% of Fallow Forest or a past shifting cultivation area and about 7.2% bamboo forest. As for Vientiane province (excluding Xaysomboun district; former Xaysomboun Special Zone), about 24.3% is covered by Current Forest, while about 60.5% is covered by Potential Forest which consist of about 17% bamboo forest, about 41% Unstocked Forest and about 2.3% past shifting cultivation area.

5.7.3 Forests and Flora Conservation in Lao PDR

The Paklay HPP project lies within the central-northern highlands of the Lao PDR; one of the three main physiographic units in the country and characterized by rugged hill topography mostly between 300 and 1,400m in altitude. The Lao landscape has historically been dominated by dense forest and, despite recent clearing, Laos still retains significantly more forest coverage than neighbouring countries (Duckworth et al, 1999). The original forests of the central northern highlands were predominantly mixed deciduous forests. However, shifting cultivation and

conversion of forestland into agricultural land (teak, rubber tree plantation and other cropping) have removed much of the original forest and large areas of bamboo and other secondary vegetation are now present especially in the mountainous areas. Collection of NTFPs such as leaves, shoots, flowers, roots, fruits, flowers and bark both as a source of food or medicine by local people has also contributed to forest destruction.

5.7.4 Land Use and Forest Survey

The specific objectives of the survey for this project were:

1) Describe the status of flora in the project area and identify any high value habitat or rare and endangered species.
2) Describe use of flora and forest type resources in the project area by the local community.
3) Assess the impacts of the Paklay HPP on flora and plants in the project area, particularly on high value habitat and rare or endangered species, or on species of particular importance to the local community.
4) Recommend management and mitigation measures that will minimize any adverse impacts of the Paklay HPP on flora, forest type and resource use.
5) To observe the importance plant species used by villages within and around the project area and also near the project area.
6) Focus on the value of commercial trees and investigate forest types and medicinal plants used within the project area.
7) To consider the endangered species of flora in that area and exiting sites.
8) To record the project area geology, topography and also note any likely tourism/ecotourism sites.

5.7.5 Land Use and Forest within the Project Area

5.7.5.1 Methodology applied for field Data Collection for Land Use Survey

As mentioned above, the method involved in assessing the biological environment was to compile all maps and available literature on the land use and forest resources of the project area. The main method used in the forest survey was also applied for the survey of wildlife including the use of questionnaire-based interviews with villagers especially senior persons selected on their experiences with the vegetation and non-timber forest products. The villagers were questioned in relation to the land use as well as the lists of vegetation and NTFPs.

The first field data collection was conducted during February 2012 by NCG's field data collection team.Some data was updated from November 2015 to October 2016. In order to fulfill the objectives of the study particularly the primary or field data collection, temporary sample plots were arranged in a line plot system covering the reservoir area according to land use, geographic conditions and forest types. The sample plots were located in the proposed reservoir and watershed areas. The temporary sample plots were divided into 3 types according to their shapes and size as follows:

1) The circular sample plots with a radius of about 18 meters (or about 0.1 hectare of area) from which the data of trees whose Diameters at Breast Height(DBH) equal and above 20 centimeters were collected. Other significant information recorded included tree species,

circle or diameter and height as well as the data on bamboo types including number of the clumps, stems per clump found in the plot. All data related to wildlife were also recorded within this kind of sample plot such as the sighted animals, foot-prints, nests, burrows, hair or feathers, molts, sound and so on.

2) The square plot of 5x5 meters (25 square meters) were established in the middle of circular one from which the information of small trees and/or saplings (a tree whose Diameters at Breast Height(DBH) is less than 20 centimeters and whose height exceeds 1.3 meters), tree species, number of tree and their average height as well as all NTFP species were recorded.

3) The square plots of 2x2 meters (4 square meters) will be established within the square plot of 5x5 meters from which the data concerning sapling or seedlings (all undergrowth vegetation) which height is less than 1.3 meters; species, number of trees or seedlings of each species as well as the all NTFPs were also recorded.

5.7.5.2 Vegetation Type and Classification

The classification of forest types for this study is based on the national classification of the Forest Inventory and Planning Division, Department of Forestry since 1982, and the preliminary national forest record, which was developed primarily for forest conservation purposes. This classification system provides one of the most reliable descriptions of vegetation types in Southeast Asia, while allowing the addition of site-specific detail such as species composition. In addition, this classification system formed the basis for forest protection and management through the land allocation process and is thus the most commonly used forest classification system in the Lao PDR. The principles of the classification are also based on lavational distribution; dominate phonology, rainfall patterns, and conifer presence. There are several categories of forest classification in this system. The Box 1 below shows the detailed classification and definition for each forest or land use type.

Box 1: Definition of Land Use and Forest Types (in Lao PDR)

1. **CurrentForest:**
CurrentForestincludes natural forests and plantation forests. It is used to refer to land with a tree canopy cover of more than 20% and an area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m. The basis for the distinction between forest and other land use groups is the crop density. The natural forests are classified into forest types which compose Upper and LowerDryEvergreenForests, Upper and Lower Mixed Deciduous Forests, DryDipterocarpForest, GalleryForest, ConiferousForest, Mixed Broadleaved and ConiferousForest and PlantationForest.
   - ***DryEvergreenForest (DE):*** The DryEvergreenForest type has a lower proportion of evergreen trees than the Evergreen type, 50% -80%. Except for in disturbed stands there is very little bamboo. Soil is usually deep. The forest consists of a considerable number of species of which 2 to 3 species tend to be predominant.
   - ***Mixed DeciduousForest (MD):*** In the MixedDeciduousForest type the deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous trees. Most often bamboo occurs in this type of forest.
     i) ***UpperMixedDeciduousForest (UMD):*** This type of forest is located at an altitude above 200 m. In moist areas there might be a lot of climbers, and it could be difficult to distinguish this

forest type from the Dry Evergreen type. In dry regions the difference can be clearly seen. The type appears quite open with a considerable amount of bamboo and undergrowth.

ii) ***LowerMixedDeciduousForest (LMD)****:* This forest is located at an altitude below 200 m.

- ***DryDipterocarpForest (DD):*** The DryDipterocarpForest occurs in open stands. The tree diameter is comparably small and the height of the stand varies from 8 to 25 meters. The crowns do not spread out widely. This type of forest is normally found in places with shallow soil, where the hard pan emerges above the ground, and on latirized soil. On the most poor and shallow soils the trees are crooked and do not exceed 10 meters in height: If the crown cover is less than 20% and the stand is undisturbed the vegetation type should be classified as Savannah.
- ***The GalleryForest (GF):*** is not characterized by tree species composition but could be i.e. either deciduous or evergreen. Clues used for identification of this forest type are the occurrence of some other land use types in its vicinity such as streams and villages. In areas where streams are likely to overflow seriously, the forest is often left along the low bank of the streams (both persistent and intermittent ones) forming a long band of forest with the stream bed on one side and, for, example, paddy fields on the other. The width of the GalleryForest will not be more than 100 m.
- ***ConiferousForest (S):***TheConiferousForest is usually single storied and open but the young growth may sometimes form a dense second storey. This forest type occurs in higher elevations with a cool climate. The characteristic species of this type are pines but (Pinus kesiya or Pinus merkusii) but other coniferous trees such as i.e. Cunninghammia may also be predominant.
- ***Mixed Broadleaved and ConiferousForest (MS):*** The MS Forest is a transition type between the coniferous and the broadleaved forest types. The coniferous trees could be mixed with either deciduous or evergreen trees. It is also found in higher elevations.

2. PotentialForest:

Previous forest areas where the crown cover has been reduced below 20% for some reason (logging or shifting cultivation) are classified as PotentialForest. The potential forest includes Bamboo, Old shifting cultivation areas (young secondary forests) and Temporary Unstocked areas. PotentialForest is consisted of UnstockedForest, Bamboo and Ray.

- ***Unstocked Forest (T):*** Unstocked Forest Areas are previously forested areas in which the crown density has been reduced to less than 20 % because of logging, shifting cultivation or other heavy disturbance. If the area is left to grow undisturbed it becomes forest again. Abandoned ray and disturbed stands with a crown density less than 20% should be classified as Unstocked Forest Areas. Old ray in which seedlings, sapling and trees cover more than 20% of the area should be classified as some type of CurrentForest.
- ***Bamboo (B):*** If an area is covered with bamboo and the over storey has a crown cover less than 5% it should be classified as BambooForest.
- ***Swidden* (Ray) *(RA) (or Past Shifting Cultivation Area):*** Ray is an area where the forest has been cut and burnt for temporary cultivation of rice and other crops. The area should be classified as Ray from the time of clear cut until one year after it has been abandoned. Areas being prepared for clear-cut but not yet clear-cut and areas that have been abandoned for more than 1 year should not be classified as Ray.

3. Other Wooded Areas

***Areas with tree where the site conditions are so poor that the crown cover can never be expected to exceed 20% are classified as Other Wooded Areas*.** This includes SavannahForest, Heath, Stunted and Scrub forests.

- ***Savannah/Open Woodland:*** is an area where the soil conditions are unsuitable for tree growth as well as agriculture production. The tree cover in the Savannah should be at least 1% but not more

than 20%. The trees are drought resistant and mostly short with graminaceous and herbaceous plants forming an understorey. Savannahs should not be mixed up with those grass covered areas that sometimes occur after shifting cultivation. Normally, the Savannah does not occur on steep slopes but in plain areas.

- ***Heath, Stunted and Scrub forests:*** is an area covered with scrub and stunted trees. The soil is shallow and rocky.

4. Other Non-Forested Area

- ***Grassland:*** is unfertile or degraded land on which no trees or shrubs grow. t might be an area that is too dry for tree growth that has been covered by grasses. It could also be an area that has originally been covered by trees which has been heavily disturbed by cutting and fire and gradually depleted. One reason for the absence of trees could be that of big areas have been deforested that the seed supply from surrounding forest has ceased. Areas being burnt over and over again (every year) for production of fodder and for hunting purposes etc. could also be classified as Grassland. That type of Grassland could be found on higher elevations in the Northern part of Laos. Grassland could also occur on deep sand with high moisture content.
- ***Swamps:*** are areas where the soil is saturated with water. The soil may basically be fertile but the lack of oxygen limits it's agriculture or forest-production capacity. The Swamp could have a high ecological or environmental value and the flora and fauna may be rich. The typical tree species found in the Swamps are trees which can grow in water, i.e. Adina cordifolia, Rhus succedanea and Barringtonia acutangula.
- ***Water Body:*** *is t*he land use class Water includes rivers, water reservoirs (i.e. ponds and dams for irrigation and hydro power) and lakes. Water reservoirs and lakes should have an area of 0.5 ha and rivers should be at least 10m wide to be classified as Water. In other cases it should be joined to adjacent land use class.
- ***BarrenLand, Rocky Area:*** Unfertile or seriously degraded land on shallow soil and rocky areas on which neither trees nor grasses can grow.
- ***Urban Area:*** Urban Areas include all areas being used for permanent settlements such as villages, towns, public gardens etc. It also includes roads having a width of more than 5 m and areas under electric high power lines. Any type of land under high power lines, except Rice Paddy, should be classified as Urban Areas.

5. Permanent Agricultural Land

- ***Agricultural Plantation (RP):*** Areas of agricultural land being used for production of other crops than rice, i.e.various kinds of vegetables, for fruit tree cultivation etc. Plantations with cash crops, such as coffee, tea, cocoa and cotton are also referred to this land use class.
- ***Rice Paddy (RP):*** Areas permanently being used for rice cultivation. Old paddy that has been abandoned and not been in use for more than one year should not be classified as Rice Paddy.
- ***Other AgriculturalLand (OA):*** Agricultural land being used for other agricultural purposes than agricultural crop cultivation, i.e. grazing of cattle, should be classified as Other Agricultural Land, unless the tree cover exceeds 20%. In that case it should be classified as some type of CurrentForest depending on the tree species composition.

Source: Report on the Assessment of Forest Cover and Land Use (MAF, DOF, July 2005).

5.7.5.3 Description of Land Use, Forest and Vegetation Type in the Reservoir Area

The description of land use, forest and vegetation types in this section is mainly focused on the areas covered by the proposed reservoir that will be inundated. As mentioned above, the project area lies within two provinces; Xayaboury and Vientiane in central and northern Lao PDR,. The landscape of the area has historically been dominated by dense forest; however, shifting cultivation has removed much of the original forest and large areas of fallow land, unstocked forest, bamboo and other secondary vegetation are now present.

The project area lies within the proposed protection forest especially along both sides of the Mekong River (See Land Use map below). The larger portion of the forest and land use types in the reservoir is covered by unstocked and bamboo forest due to the conversion of forest and shifting cultivation from time to time. The slash and burn of shifting cultivation can convert the dense forest into unstocked forest and then if slash and burn repeated from time to time it will convert from unstocked forest into bamboo forest and so on.

According to the field reconnaissance survey and village interviews, we found that a larger portion of the study area has been already significantly disturbed many years ago by heavy logging, conversion of forest land into other land use types such as slash and burn for agricultural cultivation and cash crops including tree (teak, rubber and cash crop plantation), burning for hunting and so on especially within and around the proposed reservoir and dam site both sides of the Mekong river. The latest satellite image map (forest cover map) indicates that most of the area along both sides of Mekong river were covered by the unstocked and bamboo forests; only a small portion was covered by mixed deciduous forest (MD) and dry dipterocarp forest (DD). Apart from these there are some small portions of swidden (Ray), rice paddy field and also grassland especially where the area is quite flat and easy to access not only along the rivers but in the upper area as well.

The Paklay district will be affected the most by innundation while the Sanakham District 0.14 as shown below.

Table 25:Land Use and Forest Types of each affected district in the Proposed Reservoir Area of 240 masl

No	Land Use and Forest Type	Affected Area (ha)
1	Bamboo Forest ป่าใบแขม และจำพวกป่าไผ่	427.83
2	Gallery Forest ป่าแถมน้ำ	426.295
3	Mixed Deciduous Forest ป่าปะสมปรุมใบ	929.296
4	Unstocked Forest ป่าเลื่า	1,102.13
5	Water Bodies (Nam Kong) ຂອບເຂດປ່າທີ່ກວມເອົາແມ່ນ້ຳ	2,431.54
6	Dry Dipterocarp ป่าโคมา	157.89
7	Ray ไธ่	72.53
8	Scrub ป่าพุ่ม	120.08
9	Rice Paddy ทิ่งนา	202.52
10	Grassland ทิ่งหย้า	80.67
	Grand Total (ha)	**5,951**

Remarks: DOF has already approved this number in 2020

The forest land and forest will potential impact from the Pak Lay Mekong HPP by referring to the satellite image 2019, which still not do the detail survey, but the purpose is for the watershed management budget calculation, replantation, aquatic and wildlife management and Non-Timber forest for Pak Lay Mekong HPP, so we use the satellite image 2019 as the baseline data;

The pool area is about 5,951 ha, and the construction area about 271 ha when to compare to the 3 type of forest the area will be inundated will cover the forest as follows:

1. To cover the forest land area and the National Protection Forest Nam Feaung Area 259 ha.
2. To cover the forest land area and the National Protection Forest Phoumouk-Nongdeang-Yotnammee about 1,094 ha.
3. To cover the forest land area and the Phouphadam Production Forest about 6 ha.
4. To cover the forest land area and the Houaysiat Production forest about 68 ha.
5. To cover the forest land area and the area not categorized to the 3 type of forest is about 4,524 ha.

The forest land and forest will potential impact by referring to the satellite image 2019, we see that the Mixed Deciduous Forest about 1.355 ha, Dry Dipterocarp about 158 ha, Unstocked Forest about 1,102 ha, Bamboo Forest about 428 ha, Scrub about 120 ha, Ray about 72 ha, Rice paddy about 203 ha, Grassland about 81 ha and Water Bodies about 2,432 ha

Construction Area about 271 ha

- The Access Road area about 34 ha, cover the forest land and forest that still not manage in the 3 type forest.
- The dam area about 97 ha, cover the forest land and forest that still not manage in the 3 type forest.
- The waste disposal area and the concrete processing area on the left bank is about 78 ha, in this cover forest land and forest that still not manage in the 3 type forest (water bodies) about 13,65 ha and cover the National Protection Forest Phoumouk-Nongdeang-Yotnammee about 64,36 ha.
- The camp area is about 10 ha, cover the forest land and forest that still not manage in the 3 type forest.
- The Office area about 21 ha, cover the forest land and forest that still not manage in the 3 type forest.
- The waste disposal area and the concrete processing area on the right bank is about 22 ha, cover the forest land and forest that still not manage in the 3 type forest.
- The borrow pit area about 9 ha cover the forest land and forest that still not manage in the 3 type forest.

5.7.6 The Main Tree Species within the Project Area

All tree species were recorded in the sample plots that were set-up in the survey area during the field survey. The forest types are classified according to the classification and definition of Forest Inventory and Planning Division, Department of Forestry. In addition to the broad categorization of vegetation according to the land use planning classification system, a closer identification of plant communities was undertaken for the areas likely to experience the most impact from the proposed hydropower development.

According to the field survey and villager interviews, as mentioned above, a large portion of the study area had been converted from forest land into other land use types such as slash and burn for agricultural cultivation and hunting. Within and around the proposed reservoir and damsite, the area is covered mainly by unstocked and bamboo forests; however, the project area lies within a proposed NPA and there still remain some tree species that belong to different types of forest.

The Main Tree Species (with DBH ≥ 20 cm):

According to the field survey, trees with Diameters at Breast Height (DBH) of equal or more than 20 centimeters, it was found that within the two main forest types there are more than 10 main tree species. The average volume of stand tree with DBH of equal or more than 20 centimeters for Unstocked forest type per one hectare was very low; it was lower than 10 cubic meters per hectare. We found that the main big tree in the area was a cotton tree with DHB ranging from 20 cm up to 60 cm. The detail tree species from the survey is indicated in the Table below:

Table 29:Forest Types and the Main Tree Species (with DBH ≥ 20 cm) within the Project Area

No	Forest Types	Scientific Name	Lao Name	Classification
1.	**Unstocked,**	• *Lagerstroemia floribunda*	May Peuay	Managed List 1
	Degraded	• *Delonix regia (Bojer ex Hook)*	May Sa Khang	Managed List 2
	and	• *Bombax anceps*	May Ngew Paa	Managed List 3
	Bamboo	• *Crypteronia paniculata*	May Sa Arm	Managed List 3
	Forests	• *Wrightia tomentosa*	May Mouk Noy	Managed List 3
		• *Cassia garrettiana*	May Khi Lek Dong	Managed List 3
		• *Castanopsis annamonsis*	May Khi Mou	Managed List 3
		• *Spondias pinnata*	May Mak Kok	Managed List 3
		• *Albizia lucidior*	May Sa Khae	Not Classified
		• *Baccaurea Oxycarpa Gagnepain*	May Mak Fay (Dong)	Not Classified
		• -	May Deua Pong	Not Classified
		• -	May Ta Pou	Not Classified
		• -	May Nam Khoy	Not Classified
		• -	May Mak Fong	Not Classified
		• -	May Por Sa Hou	Not Classified
Average Volume of stand Trees per Hectare for Unstocked and Bamboo Forests is about 7.475 m^3				

Note: - Classification of the tree species is based on the Instruction of the Ministry of Agriculture and Forestry No. 0116/MAF.07, dated 17th May 2007.
- The tree species and average Volume of the above tree species per one hectare are for all stand trees with the Diameters at Breast Height (DBH) of equal and more than 20 cm.

The Tree Species (with DBH <20 cm and >1.3 meters of height):

As it has been mentioned above, all tree species with DBH less and more than 20 centimeters were recorded in the sample plots especially within the proposed reservoir area during the field survey. However, for the tree species with DBH of less than 20 centimeters and the height of more than 1.3 meters are shown in the Table below:

Table 26:The Main Tree Species (with DBH <20 cm and >1.3 meters of height) found within the Project Area

Forest Types	Scientific Name	Lao Name
Unstocked and Bamboo Forests	1. *Cassia garrettiana*	May Khi Lek Dong
	2. *Carallia lucida*	May Bong Nang
	3. *Lagerstroemia floribunda*	May Peuay
	4. *Wrightia tomentosa*	May Mouk Noy

Forest Types	Scientific Name	Lao Name
	5. Bombax anceps	May Ngew Paa
	6. Castanopsis annamonsis	May Khi Mou
	7. Delonix regia (Bojer ex Hook)	May Sa Khang
	8. Spondias pinnata	May Kok Noy
	9. -	May Bi Men
	10. -	May Mak Kheng
	11. -	May Por Hou Sa
	12. -	May Khao Lam Dong
	13. -	May Nam Khoy
	14. -	May Som Phor
	15. -	May (Ton) Hon
	16. -	May Hon Khuan
	17. -	May Kon Tha
	18. -	May Nam Hork
	19. -	May Mak Kheo
Average Number of Trees per one Hectare for Unstocked and Bamboo Forests		

Note: The average Number of the above tree species per one hectare is focused on the trees with the diameter below heart (DBH) of less than 20 centimeters and height of more than 1.3 meters.

Figure 17: Images of current Land Use and Forest Conditions within the Proposed Reservoir Area

Forest Condition within the proposed Reservoir Area

Trees and Forest Condition in the proposed Reservoir

Cropping and Paddy Field

5.7.7 The Status and Use of Forest Products and NTFPs

Forest products especially NTFPs play an important role in the rural economy, as per the following:

- animal proteins (from wild meat, fish, frogs, shrimp, soft-shelled turtles, crabs and molluscs)
- calories, vitamins and dietary fiber (from mushrooms, bamboo shoots, honey, wild fruits and vegetables)
- materials for house construction and handicraft production (bamboo, rattan, pandanus, bloom-grass, paper mulberry)
- traditional medicines
- cash income (from the sale of NTFPs).

Although the area is quite far away from the town and market, NTFPs collected within the project area by most villagers are for both daily food and household utilization and for sale,.

In terms of forest products, basically, all plant species were divided into timber and NTFPs, and then categorized according to the use. It was noted that some plants have been classified in more than one category of use because people use the same plant for different purposes. The commonly used species included rattan (including rattan-shoot), bamboo (shoots and poles), broom-grass, which are traded at the local and national levels. Other species such as edible mushrooms, wild vegetables, wild fruits, wild groundnuts and a variety of barks that local people use for chewing and dyeing, are also important NTFPs. However, within the project area, most NTFPs are used only for daily food and for house construction such as bamboo, tree leaves etc. Some NTFPs are used for sale as part of income sources of local people.

Some main NTFPs species found and used by local people are described below:

Mushrooms:

Some mushroom species are well grown in Unstocked forest, but only during the early rainy season especially from May to July. Since the field survey was carried out firstly in the dry season and secondly at the end of the rainy season, data concerning mushroom species is insufficient. However, from the village interviews, we know that there are some main species of mushroom that are found within the project area and most of them are for daily food. These include Het Pheung *(Boletus sp.)*, Het Hu Nou *(Auricularia polytricha-Montagne-Saccardo)*, Het Khao *(Lentinus sp.)*, Het Khon Kong *(Hiatula sp., Lepiota sp.)*, Het Ka Tan (*Auricularia sp*), Het Deng and etc. The local price for mushrooms range from 15,000 kip up to 25,000 kip per one kilogram depending on species and market demand.

Bamboos and Bamboo Shoots:

These are an important NTFP for local people; there are some main species that are used mainly for food and partly as a saleable resource. The common species found within the project area include May Sang (*Dendrocalamus membranaceus Munro*) and May Phay Paa *(Bambusa arundiana var. spinosa)*. In terms of quantity, these species are the most heavily collected species in the study area. Bamboo-shoots are used as daily food, especially May Phay Paa *(Bambusa arundiana var. spinosa)* in the rainy season (June to September). Other species are used as temporary housing materials and

household consumption such as for weaving, fencing and so on. They are found along the streams up to the hills, and are widespread throughout the study area in bamboo forest except in the rocky areas in Unstocked Forest.

Figure 18:Images of Bamboo Forest and Bamboo Species within the Project Area

Rattans and Rattan Shoot (*Palmae* sp.):

There are only two main species that are used mainly for local consumption as food such as Nhot-Nhae *(Calumus sp., C. tenuis Roxburgh),* and Nhot-Wai (*Calumus sp.*). There are two main species of rattan (Wai) such as Wai Hang Nou *(Calamus javensis Blume)* and Wai Thork (*Rattans generally*). They can be found in unstocked and even in the bamboo forest especially in the rainy season and early dry season. All parts of rattan including rattan cane and shoots are very important products for local consumption such as weaving and food and also as a source of income of local people.

Figure 19:Pictures show Rattan/Rattan-shoot found within the Project Area

Apart from the above main species of NTFPs, there are some species within the project area that play important roles in the livelihoods of local villagers. These include wild vegetables, wild fruits, wild groundnuts, wildflowers, tree barks, climbers/canes and so on (see Table below). Most of these NTFPs are important sources of food and for earning additional income for most local villagers who live traditionally dependent on natural resources to support their livelihoods especially where the forest is still abundant. Some of these plants and NTFPs are very important in terms of herbs for local medicine. Table below shows the main species of plants and NTFPs found within the Project Area

Table 27: **Main species of Plants and NTFPs found within the Project Area**

No	Name of the main NTFP Species found within and around the project area		
	Lao Name (English Name)	**Scientific Name**	**Location**
1	Wai (Rattan)	*Rattans generally*	Unstocked Forest
2	Wai Noy (Rattan)	*Calamus javensis Blume*	Unstocked Forest
3	Kheua Wai Din	*Combretum decandrum Roxburgh*	Unstocked Forest
4	Kha Khom (Kha Paa)	*Alpinia Malaccensis*	Unstocked Forest
5	Dok Pheung (Orchid)	*Orchidaceae*	Unstocked Forest
6	Phak Kud Paa (Wildvegatable)	*Cythea spinulosa wall*	Unstocked Forest
7	Phak Ii Leud Paa (Wildvegatable)	*Piper albospicum DC,P.lotot C.*	Unstocked Forest
8	Teuy	*Pandanus species generally*	Unstocked Forest
9	Ya Nang (Wildvegatable)	*Limacia traindia Mers*	Unstocked Forest
10	Phak Say Taan (Wildvegatable)	*Amomum Xanthioides Wallich*	Unstocked Forest
11	Kuay Paa (Wild-banana)	*Musa acuminata colla,M paradisiaca L*	Unstocked Forest
12	Khem (Bloom grass)	*Thysanolaena latifolia (Roxburgh ex Hornem) Honda*	Unstocked Forest
13	Laou (Bloom grass)	*Erianthus arundinaceus(Retzius)*	Unstocked Forest
14	Man Paa (Groundnut)	*Adinandra laotica Gagnepain*	Unstocked Forest

No	Name of the main NTFP Species found within and around the project area		
	Lao Name (English Name)	**Scientific Name**	**Location**
15	Koy (Groundnut)	*Dioscorea hispida Dennstedt*	Unstocked Forest
16	Het Khao (Mushroom)	*Lentinus.sp*	Unstocked Forest
17	Het Hu Nou (Mushroom)	*Auricularia polytricha-Montagne-Saccardo*	Unstocked Forest
18	Het Ka Tan (Mushroom)	*Auricularia sp*	Unstocked Forest
19	Por	*Sterculia species generally*	Unstocked Forest
20	Mak Deua (Wildfruit)	*Ficus species generally*	Unstocked Forest

Note: Some of the above plants and NTFPs are collected from field survey and some are collected from villager's interview especially the seasonal NTFP species.

Figure 20: Images of some NTFP species within the Project Area

5.7.8 Conservation and National ProtectionForests in the Project Area

The Government of Lao PDR has developed a national conservation and protection forest system. The program to establish National Biodiversity Conservation Areas (NBCAs)[1] has been active since 1989. So far the government has established 24 NBCAs plus two corridor areas, making a total area of about 3.6 million hectares or covering approximately 15% of the country's area. In addition, provinces and districts have designated their own conservation areas[2] and protection

[1] The Lao term ***'Pa Sa-Nguan Heng-Sat'*** means ***"National Conservation Forest"***. To distinguish them from other types of conservation forest, the term 'National Biodiversity Conservation Areas (NBCA)', which more accurately reflects Government intent according to the wording of the Decree, has been adopted for English use *(Berkmüller et al. 1995)*.

[2] Total 57 provincial biodiversity conservation areas (PBCAs) totaling 932,000 ha and 144 district biodiversity conservation areas (DBCAs) totaling 504,000 ha.

forests[3] bringing the overall national total to about 12 million hectares or approximately 50% of the total land area. Xayaboury province consists of only one national conservation forest area (NBCA) namely Nam Pouy NBCA located on the north-west part of the project area. Because of conversion of land use and forest types, some of the land and forests within the project area have been disrupted by human activities (logging, slash and burn cultivation and others), and therefore it is unlikely there would be any forest conservation of any kind existing.

However, although the project area does not adjoin any NBCAs, it lies within the proposed National Protection Area (NPA) namely Pak Mouk-Gnot Nammee. This NPA covers some important habitat areas, village conservation forests as well as special spirit forests within a unique geological site. Due to the steepness of these areas and the pattern of settlement concentrating on more accessible land, some vegetation has remained relatively intact, and some areas especially above the reservoir are inaccessible providing important habitat for a range of species.

However, the area is under pressure from continuing patterns of shifting cultivation as well as conversion of forestland into agricultural production purposes including tree plantation (mostly teak and rubber). In the more remote and steep areas there are patches of pristine forest especially in Mixed Deciduous Forests, which are located outside of the reservoir area. These areas are difficult to access by boat or by foot (more than a day's walk due to no access road). Hunting and forest clearing for other purposes are reduced in areas that are difficult to access on foot.

[3] Total 69 protection forests (6.8 m. ha) are planned and under studying for official establishment (some of these have been established in the provincial and district levels including 23 provincial protection forests totaling 461,000 ha and 52 district protection forests totaling 56,000 ha).

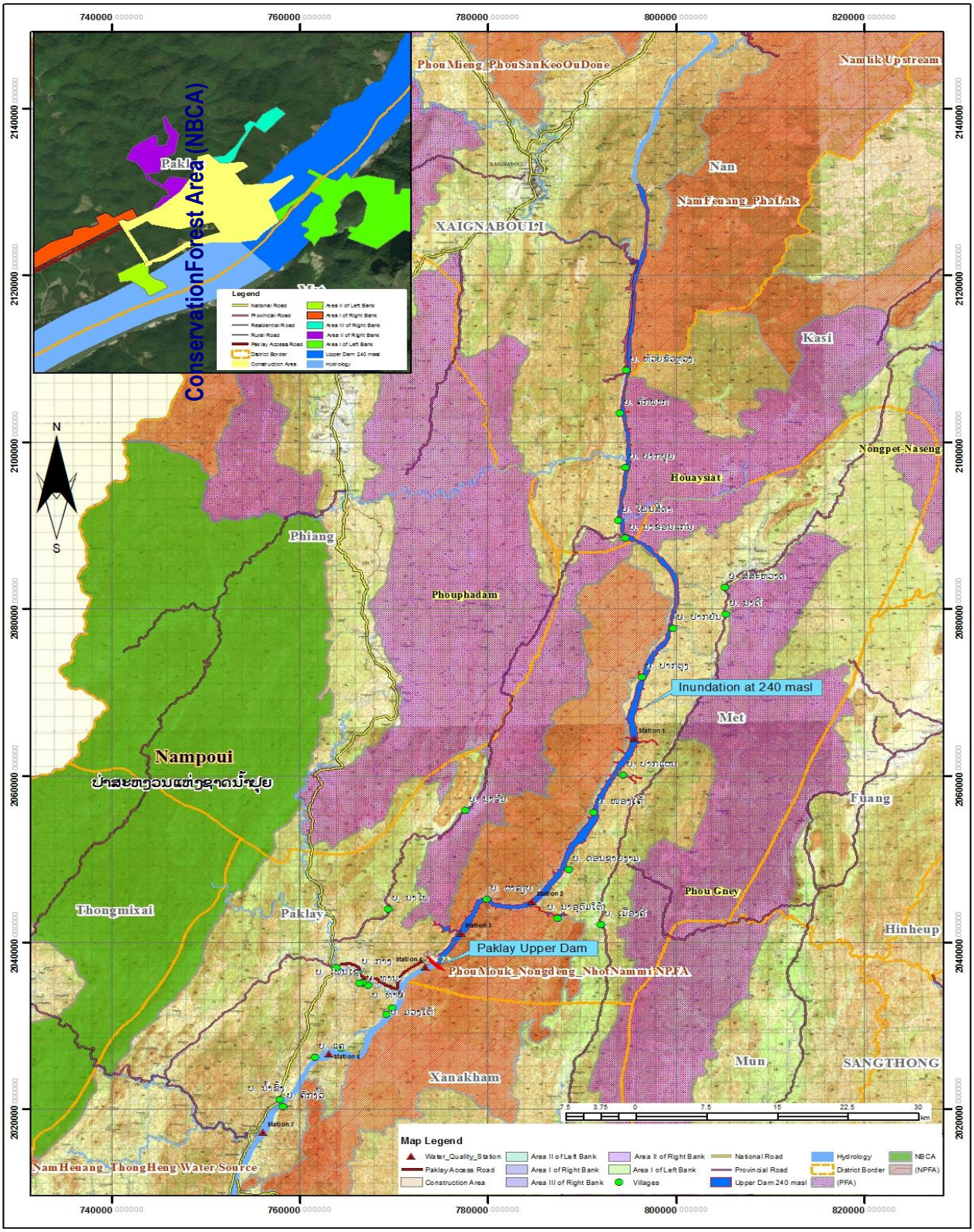


Figure 21:Map showing the Protection and Conservation forest within the Project Area

Figure 22: Signposts identifying Village Conservation & Regeneration Forests within the Project Area

5.8 Wildlife and Wildlife Habitats

5.8.1 Introduction

Wildlife refers to undomesticated animals and plants, which are living in nature.It includes many types and species of vertebrates or invertebrates of varying sizes and habitats such as mammals, birds, reptiles, amphibians, fishes, insects and all types of plant communities.

The Lao PDR is still harboring rich fauna of many species in habitats that are less depleted than in many other countries in the region. The Lao PDR's wildlife has less to do with conservation efforts than with the country's low population density and consequently extensive forest cover. Although hunting pressure in the country is still far and wide, the relative abundance of habitat and, in some areas, isolation from human settlements and inaccessibility has provided partial protection for the country's wildlife. However, human population and development pressures have been on the increase, which is resulting in dramatic declines in the wildlife population throughout the country.

5.8.2 Wildlife Surveys

According to the Wildlife and Aquatics Law of the Lao PDR, wildlife and aquatics living in nature within the country is the property of national community, which is represented by the state. The government encourages and promotes the conservation, protection, development and reproduction of wildlife and aquatics to help conserve the environment and the socio-economic well-being of Lao people. For every development project, therefore, a wildlife survey is a necessary part of any method to assess the impact of a project on wildlife habitat and populations. Accurate data and information is essential to assess the significance of the impact and to support wildlife management planning during project construction and operation.

The methodology applied in this project has also been applied in other hydropower projects in Lao PDR. The main method used in the wildlife survey is quite similar to the survey of forests. Expert observation is used both in the forest and in the local market as well as the use of questionnaire-based interviews with villagers especially of senior persons who have experience with wildlife and wildlife habitat. The villagers were questioned in relation to the wildlife species found within and around their villages in connection to the project area.

The field data collection was conducted during February-March 2012 by Wildlife Experts under the NCC's field data collection team. As a starting point, lists of wild animals known to exist in the area were obtained from the various organizations. Data collection was then carried out with the assistance of district officials who helped interview villagers with checklists that included pictures to assist villagers identify species. Information collected on key species was checked against information recorded by nearby projects. Experienced villagers were asked about their use of wildlife and also how wildlife impacted negatively on their livelihood. The survey and interview information was categorized according to the source: upstream, reservoir area, downstream and around affected villages along the Mekong river.

As mentioned above, within and around the project area, wildlife conditions were assessed by visual inspection and interviews as well as secondary data and information gathered from relevant authorities. According to these sources, the only significant remaining habitats are on the steep inaccessible slopes and undisturbed forests in the upper areas of the project area especially in the Nam Pouy NBCA. The majority of significant wildlife species have been eliminated from the project area either due to indiscriminate hunting which has for generations been a part of local livelihoods or habitat losses through agricultural clearing mainly slash and burn for cultivation. Nevertheless, from village interviews, there are still some main species found within and around the project area.

In terms of mammals, villagers indicated that many years ago, therewere abundant wildlife including large populations of key species in the project area. However, at present, these mammals are declining and some of them are likely to have become endangered species, due to habitat loss especially along the Mekong River and its tributaries where accessible. Hunting is also a main cause as well as collection of species for pets and medicinal uses. However, according to all data sources, there still remains some wildlife species found within and around the project area as indicated in the following tables.

In terms of Reptiles and Amphibians, species recorded are indicated in the following table. Provisionally at-risk species that were recorded as present by the surveys include the Reticulated Python, Bangal Monitor and King Cobra.

The bird species data wasgathered using expertise observation, interviews with villages and secondary data from relevant authorities. Species identified were compared with a list of species recorded in the Lao PDR. Bird species found in the project area as indicated in the following table

Table 28:Some Wildlife Species information within the Project Area

No.	Lao Name	English Name	*Scientific Name*	Data Obtained/Sources		
				Villagers' Interview (Villagers found)	Observed at Local Markets/ Villages	Found in the Field/ Forest
I.	***Some Mammal Species:***					
01	ກວາງ	Sambar Deer	*Cervus unicolor*	Last 2 Years		
02	ຟານດົງ	Roosevelts' Muntjac	*Muntiacus rooseveltorum*	Recent		
03	ຟານເລົ່າ	Red Muntjac	*Muntiacus muntjac*	This Year	✓	
04	ໄກ້	Lesser Mouse Deer	*Tragulus javanicus*	This Year	✓	
05	ໝູ່ປ່າ	Wild Boar	*Sus scrofa*	Recent	✓	
06	ປ່າງລື້ອ	Giant Flying Squirrel	*Ratufa bicola*	This Year		
07	ລີ່ນຄວາຍ	Chinese Pangolin	*Manis Pintadactyla*	Last 2 Years		
08	ເໝັ້ນ	Porcupine	*Hystrix brachyura*	This Year		
09	ເຫງັ້ນຫາງກ່ານ	Large Spotted Civet	*Viverra megaspila*	This Years		
10	ເຫງັ້ນຫາງຂໍ	Masked Palm Civet	*Paguma larvata*	Last Year		
11	ເຫງັ້ນອີ້ມ		*Paradoxurus sp.*	This Year		
12	ກະຕ່າຍປ່າ	Siamese hare	*Lepus pequensis*	This Year		
13	ອີ້ນ ໃຫຍ່	Large Bamboo Rat	*Rhizomys sumatrensis*	This Year	✓	
14	ລີງລົມ ທຸກຊະນິດ	All Slow Loris Species	Nycticebus sp.	Last Year		
15	ລີງ	Monkeys	*Macaca sp.*	This Year		
16	ກະຮອກໜ້ີ	Black Giant Squirrel	*Ratufa bicolor*	This Year	✓	
17	ກະຮອກທອງແດງ	Pallars's Squirrel	*Callosciurus erythraeus*	Recent		
18	ກະເລນ	Irrawaddy Squirrel	*Callosciurus pygerythrus*	Recent	✓	✓
19	ກະຈ້ອນ	Berdmore's Squirrel	*Menetes berdmorei*	Recent	✓	
20	ເຈຍ ທຸກຊະນິດ	All Bat species	*Vespertilionidae sp.*	Recent	✓	✓
II.	***Some Bird Species:***					
1	ໄກ່ປ່າ	Red Junglefowl	*Gallus gallus*	Recent	✓	✓
2	ນົກແກ້ວທຸກຊະນິດ	All Parakeets Species	*Psittacula sp.*	Recent	✓	
3	ນົກເຂົາທອງ	Reb Collared Dove	*Streptopelia tranquebarica*	Recent	✓	✓
4	ນົກສາລິກາ	Hill Myna	*Gracula religiosa*	Recent	✓	✓
5	ແຫລວປ່ານ້ອຍ	Imperial Eagle	*Aquila heliaca*	This Year		
6	ນົກ ກະແຕ້	Great Thick-knee	*Esacus recurvirostris*	This Year		✓
7	ນົກ ກະແຕ້ຫ້ອຍ	River Lapwing	*Vanellus duvaucelii*	This Year		✓
8	ນົກເຄົ້າ	Owls	*Asio, Otus, Glaucidium, Athene, Ninox, Ketupa, Strix sp.*	Recent		✓
9	ນົກອ້ຽງໂມ່ງ	Common Myna	*Acridotheres tristis*	Recent	✓	✓
10	ນົກກະເຫວົ່າ	Asian Koel	*Eudynamys scolopacea*	Recent		✓
11	ນົກ ກະຈາບ	Asian Golden Weaver	*Ploceus hypoxanthus*	Last Year		✓
12	ນົກແຂກເຕົ້າ	Red Breasted Parakeet	*Psittacula alexandri*	Recent		

No.	Lao Name	English Name	*Scientific Name*	Data Obtained/Sources		
				Villagers' Interview (Villagers found)	Observed at Local Markets/ Villages	Found in the Field/ Forest
13	ນົກ ກົດປີດ	Greater Coucal	*Centropus sinensis*	Recent	✓	
14	ນົກໂຮ່ (ນົກຫອນຄວາຍ)	Hoopoe	*Upupa epops*	This Year		✓
15	ແຫລວໜູ	Changeable hawk Eagle	*Spizaetus cirrhatus*	This Year		✓
16	ນົກເປົ້າທຸກຊະນິດ	All Green Pigeons	*Treron sp.*	Recent		
17	ນົກເຕັນຊ໊ອ	Common King fisher	*Alcedo atthis*	Recent		✓
18	ນົກໄກ່ນໍ	White Breasted Waterhen	*Amauromis phoenicurus*	Recent		
19	ນົກເຂົາຂັນ	Spotted Dove	*Streptopelia chinensis*	Recent		✓
20	ນົກແຊວ	Drongo Species	*Dicrurus sp.*	Recent		✓
21	ນົກກ່າໆ	Parakeets	*Psittacula sp.*	Recent		✓
22	ນົກ ຕັ້ງລໍ	Great Berbet	*Megalaima virens*	Recent		✓
23	ນົກ ຮຸ້້ມ	Barred Buttonquail	*Tumix susciter*	Recent	✓	✓
24	ນົກແອ່ນທົ່ງນ້ອຍ	-	*Glareola lactea*	-		✓
25	ນົກຂອນໂດກ	-	-	-		✓
26	ກາ	-	-	-		✓
III.	***Some Reptile Species:***					
1	ກະທ້າໆ	Water Dragon	*Pysignathus cocincinus*	Last 2 Years	✓	
2	ແລນ	Bangal Monitor	Varanus bengalensis	This Year	✓	
3	ງູເຫລືອມ	Reticulated Python	*Python reticulates*	Last Year		
4	ງູຈົງອາງ	King cobra	*Ophiophgus hannah*	Last Year		
5	ງູສີງດິງ		*Zamenis sp.*	Recent	✓	
6	ງູສາ	Radiated Ratsnake	*Elaphe radiata*	This Year		✓
7	ງູຍ້ວ ທຸກຊະນິດ	All Green Snake Species	*Trimeresurus gramineus sp.*	Recent		✓
8	ກັບແກ້ທຸກຊະນິດ	All Gekko Species	*Gekkonidae sp.*	Recent		✓
9	ຈີ່ໂກະ		*Scincidae sp.*	Recent		✓
10	ກະປອມ	Forest Crested Lizard	*Calotes emma sp.*	Recent		✓
IV.	***Some Amphibian Species:***					
1	ເຕົ່າ	Turtle	*Xenochrophis flaviounctata*	Last Year	✓	
2	ກົບ - ຍ້ວ	Common Lowland Frog	*Rana rugulosa*	This Year	✓	✓
3	ອີ້ງ	Toad	*Kaloula mediolineeata*	This Year		
4	ຄັນຄາກ	Common Asiatic Toad	*Bufo melanostictus*	This Year		✓

No.	Lao Name	English Name	*Scientific Name*	Data Obtained/Sources		
				Villagers' Interview (Villagers found)	Observed at Local Markets/ Villages	Found in the Field/ Forest
V.	***Some Insect Species:***					
1	ແມງກະເບື້ອທຸກ ຊະນິດ	All Butterflies Species		Recent		✓
2	ເຜິ້ງ		*Bees*	Recent	✓	✓
3	ຕໍ່/ ຕໍ່ຫົວເສືອ		*Bees*	This Year	✓	✓
4	ແມງຂາມ ທຸກຊະນິດ	Beetle Family		This Year		✓
5	ແມງລັບທຸກຊະນິດ	Beetle Family		This Year		✓
6	ບ້ຽ	Black Widow		This Year		✓
7	ຕັກແຕນທຸກຊະນິດ	Grasshopper		Recent	✓	✓
8	ຈິ້ລ-ຈິ້ນາຍ	Crickets		Recent	✓	✓
9	ແມງ ດາ	Meang Da		Recent	✓	✓
10	ແມງ ແຄງ			Recent	✓	✓
11	ແມງ ຈີ້ນູນ			Recent		✓
12	ແມງ ມັນ			Recent		✓

Figure 23: Images of some wildlife/bird/insect species within and around the Project Area

Paradoxurus sp.

Large Bamboo Rat
(Rhizomys sumatrensis)


Water Dragon
(Pysignathus cocincinus


Monkey (Macaques)


Green pigeons(Treron sp.)


Imperial Eagle
(Aquila heliaca)


Hill Myna
(Gracula religiosa)


นกจอกฟ้า
(Nok Jok Fa)

5.8.3 Threats to wildlife

Threats to wildlife in the Lao PDR include direct human uses of which the most important are among the following:

- local hunting for consumption, recreation, internal trade, as well as livestock and crop protection
- capture of wildlife for local, national and international trade,
- capture of wildlife for traditional oriental medicines and foods,
- commercial logging (legal and illegal),
- infrastructure
- forest fires as well as cutting and clearing of forest and other habitats for agriculture

5.8.4 Legal Protection of Wildlife and Wildlife Habitats

❖ The protection of wildlife involves the protection of wildlife habitat through maintenance of conservation zones and application of measures to prevent devastation. As mentioned, the Wildlife and Aquatics Law of the Lao PDR states that wildlife and aquatics living in nature within the country is the property of the national community as represented by the state. Wildlife and aquatics that individual organizations purchase for captive reproduction, as part of an investment, is considered private property in accordance with the law.

❖ The wildlife law also determines the principles, regulations and measures in the husbandry and use of wildlife and aquatics in a sustainable manner, that is, without any harmful impact on habitats. This involves encouraging people as a whole to understand and recognize the significance of wildlife and aquatics and thereby have a caring relationship. In addition the law also prohibits individuals, local organizations and international organizations in the Lao PDR doing anyone of the following:

- Taking into their possession any wildlife and aquatics in the prohibited category including carcasses, parts and organs of such animals.
- Any torment or cruelty of wildlife and aquatics
- Illegal catching, hunting, trading and having the wildlife and aquatics in one's possession without legal permission.
- Catching aquatics and hunting wildlife in the conservation zone during the breeding season.
- To produce, import, sell and use any tool for illegal hunting methods involving guns or rifles, explosives, chemicals, poisons, electricity, ray or sound wave, etc.
- Devastation of wildlife conservation zones, reservoir conservation, habitats and feeding zones of wildlife and aquatics directly or indirectly through clearing, resettlements, slash and burn, felling, use of pesticide or herbicide and other activities which violate the law.
- Occupation and damageof boundaries of reservoir conservation, wildlife conservation zones and the habitats.
- Husbandry of wildlife and aquatics for business purposes in the city and community areas which pollutes or contaminates the environment.
- Import, export, re-export, transshipment, or moving of wildlife and aquatics at risk of infected diseases and animal's health.
- Bribery and attempts to of staff and officers to fake any documents and stamps.
- Threatening to or any obstruction of civil servants in carrying out their tasks in the care of wildlife and aquatics.
- Any other actions that are in violation of law and regulations of wildlife and aquatics.

In terms of wildlife habitats, as mentioned, the GOL has developed a national protected area system through the establishment of NBCAs. Under the Lao government system, the Ministry of Natural Resource and Environment (MONRE) in collaboration with the Ministry of Agriculture and Forestry (MAF) have overall responsibility for the management of forest. The MONRE has overall responsibility to manage NBCAs and National Protection Forests while the MAF has overall nationwide responsibility to manage Production Forests. The MAF delegates responsibility to the Technical Department of Forest Resource Management and Department of Forestry (DoF) respectively. Through these technical departments specific responsibilities are decentralized to the Provincial Natural Resource and Environment Department and Provincial Agriculture and Forestry Department, At the district level direct management of each forest category is assigned to district natural resource and environment offices and agriculture and forestry offices who manage the conservation, protection and production of forests and thereby wildlife and aquatics. In addition to the NBCAs and NPAs, the provinces and districts have also established a number of Provincial and District Protected Areas (PPAs and DPAs) including protection forests[4].

[4]The Forestry Law also defines "protection forests" as a distinct forest category among the three categories of forest which is not intended for protection of biodiversity, environment or culture but for watershed protection, erosion control, national security and/or prevention of natural disasters.

Extreme hunting pressure has reduced the population of wildlife near towns, noticeably of birds (e.g. crows, Coppersmith- Barbet). The wildlife numbers are also reduced to low levels in populated rural areas. Hunting is the major factor pushing wildlife species in the Lao PDR to extinction. Very few of mammals, reptiles, amphibians and birds are not traded internationally. The wholesale removal of wildlife from Lao forests along international borders is a major local concern (J. Baker and W.G. Robichaud personal communication 1999).

Since 1991, many wildlife surveys have been conducted in Lao PDR in collaboration between the Department of Forestry and other international organizations including NGOs such as the World Conservation Union (IUCN), the World Wildlife Fund (WWF), and the Wildlife Conservation Society (WCS). The field surveys have mostly focused on assessment of habitat cover and it's condition, and on establishing inventories of species including mammals, reptiles, amphibians and birds (including bats). In the last decade, exploration of wildlife has uncovered increasing densities of mammals, reptiles, birds and some amphibians' species such as elephants, tigers, monkeys, deer, turtles (*Manouria impressa*), soft-shell turtle species, water monitor, flying lizard, python, king cobra, Siamese fire back, peafowl species. However, it is expected that with more development, more intensive land use and higher population densities that the overall population of wildlife and endangered species including some Red List (IUCN) and very rare species will continue to decline.

The government has collected hand-made guns and rifles since 1998, and also passed laws to help and protect wildlife and aquatics. The Lao government and related international organizations the IUCN, the WWF and WCS have made efforts to conserve wildlife. Both are trying to implement more laws and regulations to protect wild animals. Even with these efforts, and despite some some success in decreasing wildlife trade endangered species are still found for sale in markets as dried, fermented or fresh meat. Some are sold live as pets or for future slaughter. Hunting is still a factor exerting significant pressure on wildlife populations.

Globally threatened species are listed as vulnerable, endangered or critical. Global status information is based on the 1996 IUCN Red List of threatened wildlife species (IUCN, 1996). Endangered mammals that appear on the mammals survey list include the Asian elephant, the Banteng (wild cow), and the Duoc Languer. Mammals that are listed as globally threatened and vulnerable include the Asiatic Black Bear, the Eastern Porcupine and the Pygmy. However, according to the Lao Forestry Law, Wildlife and Aquatics Law and other regulations concerned, some endangered and threatened species of wildlife have also been listed as indicated in the Prime Minister Decision No. 81/PM, dated 13 August 2008 and the MAF' Decision No. 0070/MAF, dated 1st August 2008.

6.BASELINE SOCIAL CONDITION

6.1Global Social Issues

As mentioned earlier, the global number of population was 6.6 billion and would be growing year by year. While the ecosystem services upon which life depends are being stretched to the limit due to record levels of consumption:

- In 2006, the world used 3.9 billion tons of oil. Fossil fuel usage in 2005 produced 7.6 billion tons of carbon emissions, and atmospheric concentrations of carbon dioxide reached 380 parts per million.
- More wood was removed from forests in 2005 than ever before.
- Steel production grew 10 percent to a record 1.24 billion tons in 2006, while primary aluminum output increased to a record 33 million tons. Aluminum production accounted for roughly 3 percent of global electricity use.
- Meat production hit a record 276 million tons (43 kg per person) in 2006.
- Meat consumption is one of several factors driving soybean demand. Rapid South American expansion of soybean plantations could displace 22 million hectares of tropical forest and savanna in the next 20 years.
- The rise in global seafood consumption comes even as many fish species become scarcer: in 2004, 156 million tons of seafood was eaten, an average of three times as much seafood per person higher than in 1950.

Key social issues can be listed as below:

(1)Food and Agriculture

- For the second year in a row, the world produced over 2 billion tons of grain (more than at any other time in history).
- Since 1997, wild fish harvests have fallen 13 percent. Yet total fish production continues to grow—to 132.5 million tons in 2003—bolstered by a surging aquaculture industry.
- World exports of pesticides reached a record $15.9 billion in 2004. Pesticide use has risen dramatically worldwide, from 0.49 kilograms per hectare in 1961 to 2 kilograms per hectare in 2004.

(2)Economic Trends

- In purchasing-power-parity terms, the global economy reached another new peak, with the gross world product hitting $59.6 trillion in 2005.
- Global advertising spending increased 2.4 percent to a record $570 billion in 2005. Nearly half of this spending was in the United States, with $56.6 billion alone going to the production and distribution of 41.5 billion pieces of mail advertisements.
- In 2005, steel production reached a new record of 1,129 million tons while aluminum production reached a record 31.2 million tons.

- Round-wood production hit a new record of 3,402 million cubic meters in 2004.
- In 2004, nearly 1,800 transnational corporations or their affiliates filed corporate responsibility reports, up from virtually none in the early 1990s. While this reflects growing transparency and commitment to social and environmental principles, 97.5 percent of the nearly 70,000 TNCs worldwide still do not file such reports.

(3)Health and Society

- World population added 74 million more people in 2005, reaching a record 6.45 billion.
- Five million more people were infected by HIV in 2005, while 3 million people died from AIDS-related illnesses.
- Infant mortality rates fell 7 percent over the last five years, from 61.5 deaths per 1,000 live births in 1995–2000 to 57 deaths per 1,000 live births in 2000–2005.
- Over half of the world's 7,000 languages are endangered, and more than 500 are nearly extinct.
- One billion individuals, or one in every three urbanites, live in "slums," areas where people cannot secure one or more of life's basic necessities: clean water, sanitation, sufficient living space, durable housing, or secure tenure.
- As of 2002, 1.1 billion people lack access to an improved water supply, and some 2.6 billion are thought to lack access to improved sanitation facilities.

6.2Social Perspectiveof the Lower Mekong Basin

The Lower Mekong Basin (LMB) is made up of Kingdom of Cambodia, Lao People's Democratic Republic (Lao PDR), Kingdom of Thailand, and Sociallist Republic of Viet Nam that has been agreed on the development of the Mekong River in the form of Mekong River Commission officially established in 1995.

- In 2010, the LMB had60 million people with the average population growth of about 1.5% per year. The socio-economic information indicated that:
- Approximately 75% of the population live in rural area with low density of 136 persons per km^2;
- Cambodia and Lao PDR has large number of young population (aged 0-14) compared to Thailand and Vietnam that trend to have older aged population;
- High literacy rate was found in Thailand and Vietnam while Cambodia and Lao are improving;
- All countries have Buddhism religious base;
- Infant mortality rate is high in Cambodia and Lao and are improving;
- Global hunger index level (2009) indicated alarming/high vulnerability in Cambodia, Lao and Vietnam.

6.3Study on Mekong Navigation

6.3.1Existing Condition

Navigation, trade and tourism, these 3 things go together and play role in economic development of the region. Normally, the navigation for trade and tourism is active from China (Kunming) to Thailand (Chiang Rai) and within an area in the southern part of the LMB (between Vietnam (Mekong Delta) and Cambodia.

Trading of approximately 300,000 tons of goods was performed on the route between Kunming and Bankok via Chiang Saen Port. Record during 2005 to 2008, the monthly average of cargo throughput and vessel calls in the port of Chiang Saen was more active from August to December each year.

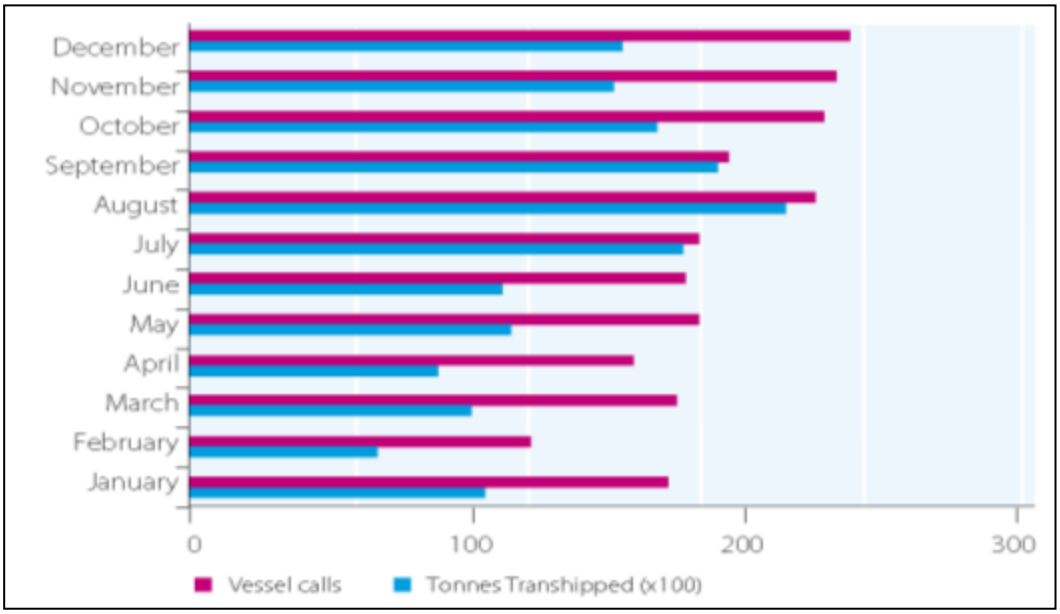


Figure 24: Navigation and Trades at Chiang Saen Port

In Lao PDR a range of 50 to 100 DWT vessels are operating through regional trade. Most of goods are timber, agricultural products, and construction materials. Thailand imports of goods from China include vegetables, fruits, agricultural products and fertilizers. The main exports from Thailand to China are dried longan, fish oil, rubber products and consumer goods.

6.3.2Concern on Mekong Navigation and Mainstream Hydropower

Two key concerns include:

- The Mekong mainstream hydropower development is expected to increase water levels during the dry season that benefits to regional navigation and trade on the Mekong River.

- Any proposed hydropower power dam on the Mekong mainstream required to include guidelines for planning, construction, and operation of navigation locks to compensate the raised-water head created by the proposed dams.

6.3.3Legal Agreement Framework for Mekong Navigation

Main principle legal framework and agreement related to the PLHPP include:

- Agreement (November 1994) between PR China and Lao PDR on Freight and Passenger Transport along the Lancang-Mekong River; and

- 1995 Agreement on the Cooperation for Sustainable Development of the Mekong River Basin (Article 9 on Freedom of Navigation, 5 April 1995, Chiang Rai)

6.3.4Regional Navigation Development Program

The MRC aims at improving navigation in the Mekong and its tributaries. The improvement of navigation on the Mekong River can boost trade and local economies throughout the basin, thus playing an important role in poverty alleviation. International navigation is one of the most important mandates of large river commissions.

The Mekong Navigation Program is established to analyses river transport systems and related activities in the Lower Mekong Basin, covering a network of 8,500 km of waterways. Within the basin both maritime shipping and inland water transport play significant roles in livelihoods and economic growth as direct access.

The strategies of Mekong navigation program are to:

- Facilitate coordination and cooperation in developing sustainable, effective and safe waterborne transport in a protective manner for the waterway environment.
- To increase the international trade opportunities for the mutual benefit of the MRC member countries.

The MRC Mekong Navigation Program also aims to combat poverty and helps its Member States to achieve the Millennium Development Goals by creating the opportunities to:

- Reduce shipping accidents
- Promote the potential of Mekong shipping for cargo and for tourism;
- Establish legal navigation frameworks between the countries;
- Transport the agricultural produce of remote farmers;
- Reduce transport costs;
- Facilitate public-private partnerships;

- Improve the waterways for navigation;
- Increase direct and trickle-down job opportunities

A number of navigation projects started in 2007, and some have already been successfully concluded. Amongst these is the project on Hydrodynamic and Morphological Impacts of Channel Dredging in the Tonle Sap Lake, completed in July, with a regional workshop held in September to finalize reporting. Initial results showed that if a narrow channel were dredged it would probably not require much maintenance and would therefore be stable. Dredging a year-round access route to Siem Reap would provide a major breakthrough for both tourism and trade, though a thorough environmental impact assessment will be required before any dredging is carried out.

In March and June, following detailed legal study and initial draft of a new Agreement between Cambodia and Viet Nam, the Navigation Program facilitated two meetings in Phnom Penh for implementation of the Agreement on Cross-border Waterway Transportation. Both Cambodia and Viet Nam are eager to formulate and implement this agreement, which will facilitate trade and transport between the countries and encourage traders from other nations to come to their ports.

To improve understanding on how other navigation agreements have been established, high ranking officials from Cambodia, the Lao PDR, Thailand and Viet Nam participated in a working visit to Belgium and the Netherlands. This trip also addressed issues of capacity building within implementation of the agreement for cross-border navigation.

The river stretch between Luang Prabang and Vientiane is quite difficult for navigation and only a handful of pilots able to negotiate the rapids. The MRC will make this route more accessible by introducing detailed river charts, engineering designs, and installing channel markers in danger areas. Tendering for the Condition Survey of Dangerous Areas for Navigation (hot spots) between Luang Prabang and Pakse in the Lao PDR and in Thailand started in October 2007.

For the Mekong stretch downstream of Luang Prabang, terms of reference for a study that will provide legal framework recommendations for cross-border navigation between the Lao PDR and Thailand have also been developed.

In 1995, Laos, Thailand, Cambodia and Vietnam established the Mekong River Commission (MRC) in an aim to assist in the management and coordinated use of the Mekong's resources. In 1996, China and Myanmar become dialogue partners of the MRC and the six countries are now working together to promote cooperation in all fields of sustainable development, management and conservation of water and related resources of the basin.

6.3.5Navigation forMainstream Hydropower Dam

As mentioned in MRC agreement (article 9 on freedom of navigation), on the basis of equality of right, freedom of navigation shall be accorded throughout the main stream of the Mekong River without regard to the territorial boundaries.

The hydropower development projects could pose barriers to navigation, but they also offer the possibility of providing more reliable and consistent water depths that will facilitate larger vessel capacities.

The only way to efficiently realize the benefits of inland waterway navigation in harmony with hydropower project development is the construction of navigation locks. The design, construction and operation of all ship locks along the river should be subject to common standards and guidelines for the whole Mekong River.

Recently, MRC finalized a Preliminary Design Guidance for Mainstream Dams in the lower Mekong Basin in order to ensure the consistent approach to the design of individual dams. The Preliminary Ship Lock Dimension is mentioned in this Guidance.

The important parameters that used for the preliminary dimensions including

- Benchmarking for international river and references
- Recommendations by PIANC
- Chinese waterway classifications and dimensions of planned locks at Guan Lan Ba dam.
- Economic analysis

The term preliminary is used by MRC due to the need to define the technical navigation accessibility of the upper Mekong River in association with planned hydropower development.

MRC will run a result of the optimization study through the hydraulic model to develop a longitudinal profile of the river base on least available depths. The extent of the river stretch between the limit of the tail-water and the upstream dam will be crucial in defining the optimum ship design.

It is suggested that, until the result of the Technical Navigation Accessibility are fully known, minimum requirements should not be lower than the following dimensions (Length:120 m, Width=12 m, and Depth 4 m). Furthermore, a parallel slot is to be reserved for a second lock to double the capacity during a future expansion. The head for one lock chamber is set to be 30 m. The tandem locks will be used rather than ship lift if head is higher than 30 m. It is also proposed to establish allow area for lock doubling in the future.

The intermediate objectives of formulation of standard Specification for design, construction and operation of Navigation locks are:

- To define the technical navigation accessibility of the Upper Mekong River in

- To prepare specifications for the design, construction and operation of the planned navigation locks.
- See Page 5-126 to 5-188, details of Navigation could be found in the section of Project Layout and Main Structure in FS approved in March 2017 as attached in this report.

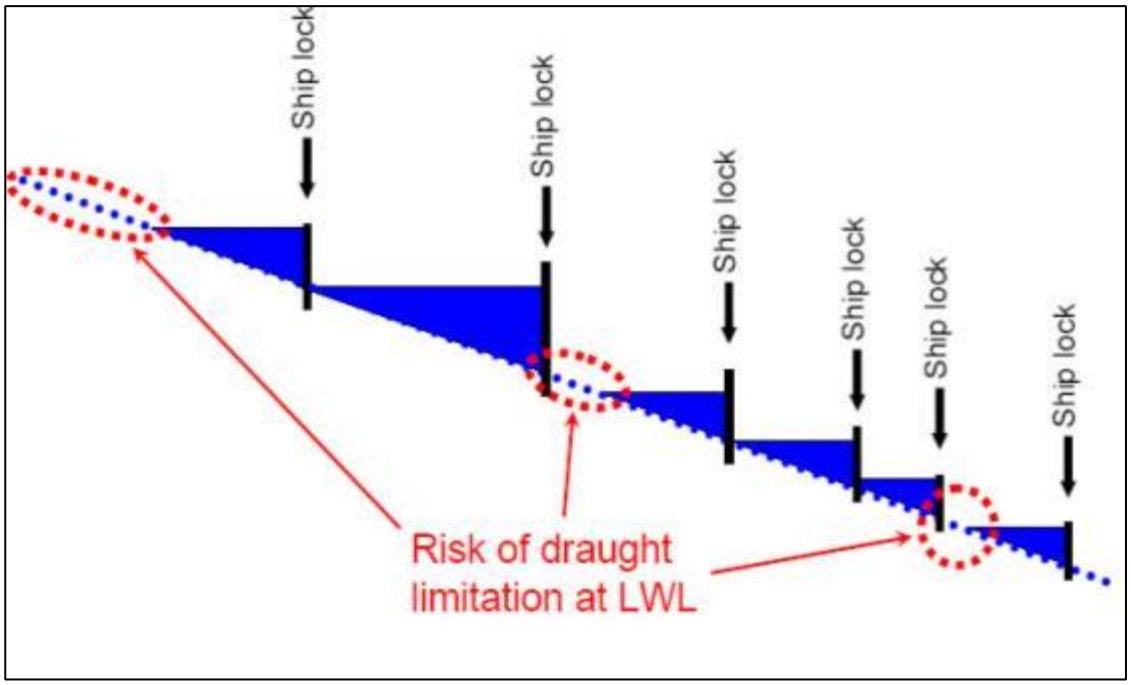


Figure 25: Risk of Draught Limitation at Low Water Level for Navigation Lock

Table 29: Proposed Navigation Lock of HPP on the Mekong River

HP project name	Total lift (m)	Number of chambers	Max unit lift (m)	Transit time -one line of lock (mn)
Pak Beng	30/39	2	15 / 20	30 /50 mn
Louang Prabang	50	2	25	50 mn
Sayaburi	30/39	2	15 / 20	30 /50 mn
Pak Lai	33	1 or 2	17 / 33	30 /50 mn
Sanakham	21	1	21	30 mn
Pak Shom	21	1	21	30 mn
Ban Koum	33	1 or 2	17 / 33	30 /50 mn
Strung Teng	17	1	17	30 mn
Sambor	37	2	19	50 mn

The nautical accessibility of the whole waterway will be assessed under different scenarios. The first one is the cascade scenario, where the cascade between Jinghong and Vientiane are in place. The second case is the stand-alone dam scenario, in which

only some of the proposed dams will be built. Finally is the scenario where no dams are built.

Accessing and quantifying the navigation accessibility, under different scenarios, will include important aspects as follows:

- Evaluation of the free-flowing stretches regarding the available water depth and navigability.
- Assess the air clearances. Assess the situation under the proposed bridge construction.
- Redefine the longitudinal profile of the river between Jinghong and the Khong Falls, after dam construction
- Determination of the optimum nautical accessibility, optimal channel design and optimal ship size.

Formulate specifications for the construction and operation of the planned navigation locks:

- Suggesting the re-determination of the maximum operating levels, if require and recommendations for lowest operating levels
- Re-determine the optimum lock dimensions based on the optimal ship size
- Recommendations to maintain navigation during construction
- Recommendations for the exact location of lock includes:
  - Ship entrance channel/alignment.
  - Formulate specifications for the construction and operation of the planned navigation locks:
- General principles for filling – emptying systems, gate
- selection and design for mooring devices
  - Recommendations for safety instructions (with regards to dangerous goods)
  - General principles for operation, including communication systems

6.3.6Prospects of Commercial Transportation on the Mekong River

The Mekong River has provided a means of transportation for thousand years. Recent efforts have focused on improving the commercial navigability of the water course, led to a large extend by China in the river's upper reaches, and the Asian Development Bank (ADB) in the lower Mekong. The ADB-backed GMS economic cooperation program, the China-Thai FTA and the proposed ASEAN-China FTA are all major factors contributing to efforts aimed at increasing navigability. Modern transportation infrastructure is essential for economic growth, yet incredibly precarious if hastily implemented.

Transportation on the river is presently segmented by natural barrier. Shipments entering from the South China Sea can only travel slightly upriver from Phnom Penh with the Sambor Rapids and Khone Falls hindering travel upstream into Laos. Navigation of the Lancang Jiang, as the Mekong is known in China, began in 1990

when China deployed five barges on a mission to chart the river downstream to Vientiane, Laos.

The economic Quadrangle Plan involving China, Laos, Myanmar and Thailand has further spurred development of the river as a commercial opportunity. China has initiated a program of dredging and removal of rapids, reefs and shoals in conjunction with plans for construction of a cascade of hydroelectric dams in Yunnan Province, several of which are already in operation. The stated goal is to eventually enable vessels of 500 DWT to ply the route between Simao Port in Yunnan and Luang Prabang, Laos, which some twelve other ports in between. Xiaowan, Manwan and other Lancang dams first and foremost aim to provide a cheap source of energy to fuel industry in Yuna and elsewhere. In addition, officials maintain they will stabilize downstream water levels, decrease currents and increase depth of the river which will all improve navigability. These projects initially had a negative impact on water levels and decreased currents to the degree that silt accumulation blocked river channels, though China contends conditions will improve as the reservoirs reach capacity.

Thailand has responded to increase river trade by improving facilities at Chiang Khong and construction of a new port at Chiang Saen, now known as Chiang Saen 2. The original Chiang Saen Port was located in an area that constrained growth and its cultural and historic importance prevented drastic renovations, therefore an entirely new facility was constructed. Thai manufactured products are generally considered to be of better quality than those made in China, but as consumers around the globe understand, Chinese goods carry a powerful price point incentive. In China, Thailand has found an outstanding market for its wide variety of exotic fruits and vegetables. However, Thai farmers have already felt the impact of cheap garlic arriving from Yuna, and they will continue to feel pressure until the market equalize.

Myanmar and Laos have also ramped up efforts to benefit from increased river trade. Myanmar's Wan Seng and Wang Pong ports are already entry points for cheap Chinese goods. China's Xishuangbanna Petroleum Company recently signed an MOU with a Lao company to import diesel and gasoline via Laos. This has spurred speculation that the sleepy Mekong village of Xiengkok will be transformed into a modern port. Although China already imports oil products from Thailand, shipping diesel and gasolline via Laos is attractive due to lower costs.

In case of Vietnam, According to the report from the Regional Economic Integration through improved Mekong Navigation in the 4th WWF in Mexico (2006), it is reported that between 20-25 million tons of cargo are transported per year in the Mekong Delta of Vietnam.

6.3.7Other Related Mekong Navigation Information

As discussed some in Section 5.3 (a), the international transportation in the Mekong River is mainly dealt with South China, and conduct mainly between the port of Chiang Saen in Thailand to the ports of Chiang Run and Seu Mao in China. From the end of 2001 to April 2003, the Chinese government announced the termination of goods

transportation between the two countries in order to improve the water channel and to further strict the import of products from Thailand. Nevertheless, the trade between the two countries continue to grow due to the increase in dried longan products. In general, the trade between Thailand and China increase rapidly, especially the export.

In early 2004, the exports from Thailand to China decreased due to the low water level in the Mekong river, thus, alternative means of product transportation were applied. The export products such as dried longan and animal products, showed a decrease as well as the fruits from China to Thailand.

Nevertheless, the transport of goods in Chiang Saen in 2005 showed an increase as illustrated in the first 6 months in 2005 is almost the same as in 2004. The information is showed in the ***Table***below.

Table 30: Information on Mekong Navigation and Trade in Thailand

Item	2004		2005	
	Full Year	*Month average*	*Full Year*	*Month average*
Number of ship (round)	1,700	141	1,128	188
Total amount of goods				
Imported (Ton)	*21,991*	*1,832*	*20,130*	*3,355*
Exported (Ton)	*52,423*	*4,368*	*54,130*	*9,012*
Passenger				
Arrival (Person)	*1,418*	*118*	*1,945*	*324*
Departure (Person)	*663*	*53*	*497*	*82*

Source: Department of navigation, Thailand

6.4Lao Socio-economicCondition

6.4.1Introduction

Lao People's Democratic Republic (Lao PDR) is located in the heart of the Indochinese peninsular, in Southeast Asia, at a latitude of 14 to 23 degrees north and longitude 100 to 108 degrees east.

Lao PDR shares a 505 km border with China to the north, 435 km of border with Cambodia to the south, 2,069 km of border with Vietnam to the east, 1,835 km of border with Thailand to the west, and a 236 km border with Myanmar to the northwest. The country stretches 1,700 km from north to South, with an east-west width of over-500 km at its widest, and only 140 km at the narrowest point.

Lao PDR covers a total of 236,800 square kilometres, three-quarters of which is mountains and plateaux. The country has three distinct regions.

The north is dominated by mountains that average 1,500 metres above sea level. The highest peak is the 2,800 metre Phou Bia in Xieng Khouang province. The Phou Luang (Annamite Chain) stretches from the southeast of the Phouane Plateau down to the Cambodian border. It has three large plateaux: Phouane Plateau in Xieng Khouang province, Nakai Plateau in Khammouane province, and Boloven Plateau in southern Laos, 1,000 m above sea level.

The plains region comprises large and small plains along the Mekong River. The largest of these is the Vientiane Plain, on the lower reaches of the Nam Ngum River. Also significant are the Savannakhet plain, on the lower reaches of the Se Bang Fai and Se Bang Hieng rivers, and the Champassak plain, which is on the Mekong River, stretching between the Thai and Cambodian borders. Blessed with fertile soil, these plains represent one quarter of the total area and are the "granaries" of the country.

The Lao PDR is criss-crossed by many rivers and streams. The Mekong River flows through 1,835 km of the country from north to south. Rivers and streams provide great potential for hydropower development. Over half of the power potential in the lower Mekong Basin is contained within Laos.

The Nam Ou river flows from Phonsaly to Luang Prabang for 448 km; the Nam Ngum runs 354 km from Xieng Khouang to Vientiane province; the Se Bang Hieng of Savannakhet province is 338 km long; the Nam Tha runs from Luang Namtha to Bokeo for 325 km; the Nam Sekong runs 320 km from Saravane and Sekong to Attopeu province; the Se Bang Fai runs between Khammouane and Savannakhet for 239 km; Oudomsay province's Nam Beng covers 215 km; the Nam Sedong flows for 192 km between Saravane and Champassak; the Nam Selanong in Savannakhet runs for 115 km; the Nam Kading of Borikhamsay province is 103 km long; the Nam Khanh runs for 90 km between Huaphanh and Luang Prabang.

Being a tropical country, the weather in Laos is influenced by monsoons. The weather in the mountains in the north and in the high range of the Annamite Chain bordering Vietnam in the east is semi-tropical. The difference in day and night temperatures is about 10 deg C.

Laos has around 2,300-2,400 hours of sunlight per year. The atmospheric humidity is usually 70-80%, and 75-90% of the precipitation is recorded in the rainy season, May to October. Rainfall in the dry season, November to April, accounts for only 10-25%. There is a sharp difference in rainfall between regions. For instance, in the Phou Luang (Annamite Chain), the annual average rainfall is around 300 millimetres. In Xieng Khouang, Luang Prabang and Sayaboury provinces, annual rainfall is 100-150 millimetres; in Vientiane and Savannakhet 150-200 millimetres of rainfalls every year.

Laos has an abundance of natural resources. Beneath the earth's surface, the mineral deposits include tin, iron, coal, zinc, copper, gold, silver, sulphur and sapphires. Although mining is still in its infancy, surveys show that the quantity and density of mineral deposits are quite high. On the surface, the country has a wealth of forests,

covering 47% of the surface. They comprise a variety of species, with many of high economic value such as Khagnoung, Khamphi, Dou, Eaglewood and Longleng.

The forest regions are also rich in non-timber products such as shellac, benzoin, cardamon, pine resin, rattan and medicinal plants, and there is a wide range of fauna, including elephants, tigers, bears, deer and a newly-discovered species of deer called Saola.

Such wealth represents a great potential for the development of the country, ensuring a brighter future and better living standards for its people.

6.4.2Macro Economics

The Government of Lao PDR's 8th Five-Year Plan (2016-2020) is a continuation of the 7th Five-Year Plan. The Plan is regarded as a measure for achieving socio-economic development, industrialisation and modernisation towards the year 2020.

The 8th National Socio-Economic Development Plan is the Lao PDR's guiding strategic document. It paves the way towards the graduation from Least Developed Countries (LDC) status and lays a strong foundation for the achievement of the National Strategy on Socio-Economic Development 2025 and the Vision 2030 as well as the Sustainable Development Goals *(Source: UNDP 2016).*

Lao PDR, a lower-middle income economy with a GNI per capita of $1,740 in 2015, is one of the fastest growing economies in the East Asia and Pacific region and the 13th fastest growing economy globally. GDP growth averaged 8 percent over the last decade. Use of the country's natural resources – mostly water, minerals and forests – contributed one third to growth. Construction and services also expanded, with growing regional integration boosting tourism and attracting foreign investment. The macroeconomic environment remains challenging, reflecting both domestic, and increasingly external risks, and needs careful management. Growth contributed to lowering the number of poor people to an estimated 23.2 percent of the population in 2012/13 from 33.5 percent a decade ago. However, poverty has been declining slowly compared with some regional peers.

The Lao economy is projected to expand at around 7 percent in 2017-19 supported by a healthy pipeline of power projects and growing opportunities for the non-resource sector resulting from closer ASEAN integration. In addition, some recovery in commodity prices can support mining and agriculture output, while improved connectivity facilitates tourism growth. However, the country continues to face a challenging macroeconomic situation. The fiscal deficit widened significantly in 2016 and brought public debt to close to 70 percent of GDP. The current account deficit narrowed in 2016, but is projected to widen as a few large infrastructure projects are launched, while foreign reserve buffers are low. Parts of the banking sector have weak capital buffers and deteriorating portfolios. Maintaining macroeconomic stability will require concerted

efforts to reduce the fiscal deficit, strengthen public debt management and address weaknesses in the financial sector.

As a member of the Association of Southeast Asian Nations (ASEAN), Lao PDR is increasing its integration into the regional and global economy, and served as the chair of ASEAN in 2016. Lao PDR has been a member of the World Trade Organization since February 2013.

Lao PDR has made good progress on a number of Millennium Development Goals (MDGs), including halving poverty, reducing hunger, and improving education and health outcomes. However, certain MDGs remain off track, most crucially on nutrition, with an estimated 44 percent of under-five children being stunted. Total fertility rates are high, with a high unmet demand for family planning. Lao PDR still has a high maternal mortality rate and limited skilled birth attendants and could also do more to place gender equality at the center of its national development plans. The Sustainable Development Goals (SDGs) provide a framework for the Government to monitor and evaluate the progress in its development plan implementation and commitments. Lao PDR is one of the first countries in the world to localize the SDGs into the national development plan. *(Source: World Bank, April 2017)*

6.4.3Foreign Direct Investment

Since 2005, foreign direct investments have sharply flowed into the Lao PDR with more than 180 million US dollars per year (Figure 7). It has mainly been coming from China and Vietnam that have been investing in the mining sector and from Thailand investing in hydro-power projects. Therefore, to facilitate the investments and make the country a more attractive place for investments, the government is trying to reform its foreign trade policy, with the primary objective to join the World Trade Organization (WTO). To achieve this, Laos has been working on the reform of its investment laws, following by the approval of the National Assembly of a new investment law that provides an equal treatment of domestic and foreign investment.

6.4.4 Inflation & Wage

The 2011minimum wage for Lao workers is 348,000 kip per month but, if allowances are included, a worker on the minimum wage can earn about 500,000 kip. The last increase to the minimum wage occurred in 2009, when it rose from 290,000 kip to 348,000 kip per month. The Lao Federation of Trade Unions wants to propose a minimum wage of about 700,000 kip per month, more than double the current wage. Some economists have expressed concern that raising the minimum wage in Lao PDR might cause even higher inflation. Higher fuel prices have caused food prices to rise in Vientiane. Because of rising food and fuel prices, authorities are negotiating a rise in the minimum wage for Lao workers. The Lao Federation of Trade Unions has stated the proposed wage rise is aimed at improving the livelihoods of workers in response to rising inflation. Some businesses and economists have voiced concern that raising the

minimum wage could lead to higher inflation as it would increase production costs and businesses would have to sell their products at higher prices.

6.4.5Banking & Currency Exchange

In September 2010, the Lao Government raised its interest-rate policy, from 4.0% to 5.0% for loans of less than 1 week. It phased out direct lending for off-budget infrastructure projects, which had been a cause of high rates of growth in credit. However, disbursement of central bank lending committed in 2009 continued to feed credit growth.

The central bank of Lao PDR also uses exchange-rate policy to address inflation, aiming to limit fluctuations in the Lao kip to 5% a year against major currencies. Last year (2010), the kip rose against the US dollar by 3.0% but fell by 5.0% against the Thai baht. The effectiveness of monetary policy is hampered by the widespread use of the US dollar. To promote use of the kip, the government has directed most of its revenue departments to accept only that currency and has asked wholesalers and retailers to use it for quoting prices. Such measures have helped to lower the level of dollarization to below 50% in 2010, from a peak of 79.0% in 1999.

6.4.6Fiscal Situation

Strong growth in government revenue, in part a result of high global prices for copper and gold, helped to rein in the budget deficit in fiscal year 2010. Growth in spending moderated relative to 2009, when the government had lifted outlays to cushion the impact of the global recession. The budget deficit, including grants but excluding off-budget spending, narrowed to an estimated 3% of GDP from 5.1% in 2009. Including off-budget spending, it was close to 5%. Mineral exports exceeded US$1 billion for the first time and electricity exports rose to $375 million. Shipments of clothing increased in value by about 14% to $184 million, mainly on better demand from Japan and the Republic of Korea. Merchandise imports rose by an estimated 13.5% to $2.8 billion.

6.4.7General Livelihood Resources

Within the radius of 10 km of the riparian villages, the livelihood resources consist of bodies of water (mainly the Mekong River and its tributaries), unstocked forest, bamboo forest, and grassland. River bank gardens are also found growing mainly maize/corns, beans and vegetables.

The people can access to nearby forests and harvest forest products for food and for other household uses or sometimes to sell, such as:

- Timber for housing at the rate of 5 m^3/household; traditional forest management permits villagers to take timber for also other domestic structures than the house such as rice storage, animal stabilization poultry houses.
- Firewood is collected from forests. Every household normally has storage of firewood under the house, to be used for cooking and heating in the cooler season. Fuel for fires is often collected from slash and burned forest or recycled from other uses.
- Charcoal making is common for cooking, boiling, heating and for sell.
- NTFPs collection of bamboo and rattan shoots, eagle wood with resins, wild vegetables, fruits, mushroom, medicinal plants, seeds and seedling. However, much of the exploitation of these resources is occurring at unsustainable levels. Poorer families turn to forests products for food security at times when rice is short or the crops fail.
- Hunting and trapping wild mammals, reptiles, birds and insets occurs even it is prohibited. Wild life is sold as well as consumed at home.

6.4.8Education

As shown earlier in Tables 3 and 4 nearly all villages in the study area have a primary school for the young people. However, secondary schools are limited but can be available mostly in the main towns, such as Paklay, Meun, Kenthao and Paklay.

The recent statistics (NSC, 2006) indicated that 13.7% and 14.5% of people of age 6 or above had no schooling(for Vientiane and Xayaboury, respectively). In general, percentage of females attended school was higher than males**.**

The statistics also indicated that there was very high percentage of people leaving school after finishing their primary education. The reason for the low attendance in secondary school was partly explained by the distant location of the schools. Most secondary schools are located in town. If parents could not afford a dormitory room and other required expenditures, youths have few options but to leave school and work in the rice fields or find employment elsewhere.

The literacy rate of people 15 years and above in Vientiane and Xayaboury provinces was higher than the whole country average (72.7%). The Xayaboury showed highest rate at 80.4%

Table 31: Schooling Situation of Population Aged 6 Years and Above

No.	Province	No. schooling	Attending primary school	Left school	No answer	Total
01	Vientiane	13.7%	31.1%	51.6%	3.6%	100.0%
	- Male	19.1%	28.9%	47.4%	4.6%	100.0%
	- Female	8.5%	33.2%	55.6%	2.7%	100.0%
02	Xayaboury	14.5%	27.8%	55.9%	1.8%	100.0%

	Male	19.0%	25.3%	53.5%	2.2%	100.0%
	Female	10.2%	30.2%	58.2%	1.4%	100.0%
03	Whole Country	22.8	28.4	46.7	2.1	100.0%
	Male	29.5	25.6	42.4	2.6	100.0%
	Female	16.1	31.3	51.1	1.6	100.0%

Source: NSC (2017)

6.5Tourism Study

6.5.1Tourism Development

The government of Lao PDR stated its policy on tourism development in the National Socio-Economic by Development Plan from 2016-2020. Tourism is one of eight priority development programs. For a newdestination like Lao PDR, it is necessary to build a comprehensive database for the purpose of tourism development planning. Tourism planning has been implemented with several processes and mechanisms. The national plan with respect to the tourism development in the study can be found here: *(http://www.latalaos.org/doc/Strategy2006.pdf)*. The national plan can be summarized as below:

a) Promote cycle (bicycle) tourism among northern provinces such as these routes:

- Huaphanh – Luang Prabang – Xiengkhuang –Luang Namtha
- Oudomxay- Luang Prabang
- Xayabouly- Luang Prabang – Oudomxay
- Bokeo –Luang Namtha – Luang Prabang
- Phongsaly – Huaphanh – Xiengkhuang
- Phongsaly – Oudomxay – Luang Prabang

b) Promote inland, waterway and airway tourism with provinces and neighboring countries such as:

- Inland travel with China
  - Huaykon – Muangneun – Pakaeng (Oudomxay to China)
  - Chiang Khong – Huayxay (Bokeo) – Boten (Luang Namtha) to China
  - Xiengkhuang –Luang Namtha –Oudomxay – Luang Prabang.
- Inland travel with Thailand

- Xiengkhuang –Luang Namtha – Bokeo- Chiang Khong – Thailand.

- Waterway travel with China
  - Mekong, China – Xiengkhuang – Golden Triangle – Houayxay – Paklay- Luang Prabang

- Waterway travel with Thailand
  - Xiengkhang – Houayxay – Paklay - Luang Prabang.

- Promote water travel along Mekong's tributaries where possible and along the existing ones, for instance the Namtha, Nam Ou and Namkhan rivers.

- Airway travel - Make use of Luang Namtha airport – Oudomxay, Huayxay to link with Luang Prabang and Vientiane Capital.

6.5.2 Tourism Network of Surrounding Provinces

The Figure below shows a schematic network of tourism destination in this region. The route starting from Paklay link to the surrounding tourism destination in this region is not significant accordingly to the road condition and the limit of border crossing.According to the Mekong River Cruising study of TAT (1997), not proposed the Mekong River in this section as the potential route for development. The existing activities on the Mekong were for accommodating only local tourists, but for future development the international tourists should also be taken into consideration.

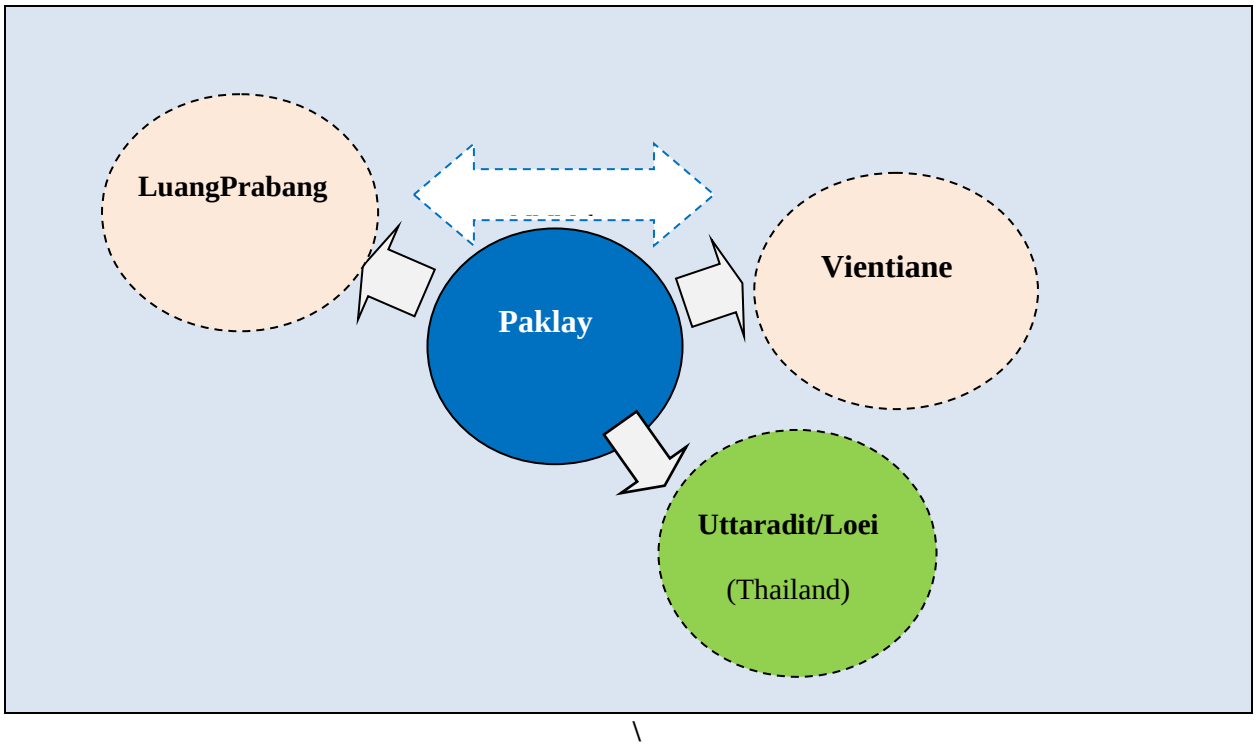


Figure32:Paklay Tourism Network and Linkage.

6.5.3 General Existing Condition of Tourism in the Area

6.5.3.1Provincial Tourism Situation of Paklay

Paklay HPP is located in the administrative boundary of Paklay district, Xayaboury Province. The tourism system in Paklay area is part of the Central Lao tourism system where can be connected mainly by tourists of Lao PDR and Thailand. At present, Paklay is not considered as interesting place among tourists due to its location being outskirt of the main tourism route. Paklay is considered as border linkage with Thailand by Loei and Uttaradit provinces via Thai-Laos border. According to the Paklay Tourism Official Information there are few number of international tourists record in this area.

6.5.3.2Tourism Attraction

Paklay HPP is located in the administrative boundary of Paklay District and Hongsa District, Oudomxay and Xayaboury provinces, which is situated in the both sides of the Mekong. At present, Paklay and Hongsa are considered as interesting place among tourists due to its location being inside the river tourism route. Hongsa and Muang Ngeun District are considered as border linkage with Thailand by Houai Kon-Muang Ngeun, Thai- Lao border checkpoint.

According to the tourism field survey in the Paklay project area, it was found that the potential tourist attraction (classified by the Paklay District Tourism Office) included historical, cultural and natural sites as summarized below:

- Fourteen of historical sites which include 11 old colonial buildings, 3 religion places, and an old town;
- Eleven of cultural sites which include 7old temples, 4 traditional sites;
- Twenty nine of natural sites including 15caves, 5 waterfalls, 8 ecological (forestry and mountainous) sites, and a hot spring.

It was also found that the main tourist attractions and motivation is the mountainous topography and some biodiversity of the area. However, there was no waterway tourism travel program provided for visitors. Even there are some potential Mekong waterway routes such as such as Paklay – Pha Leap – Donkhon (old temple) for development. At present the people in Paklay use Mekong for boating racing and Bounbang Fai, as the spirit traditional.

6.5.3.3Tourism Market

According to the Paklay Tourism Office report on number of tourist in Paklay, the number of tourist arrival to Paklay was recorded at 7,200 persons. Most of tourists came to the study area to visit Paklay city. The trend of number of tourist in the study area was expected to be rapidly increased in the near future when the Mekong bridge and cross border has been developed.

7.DOWNSTREAM ENVIRONMENTAL AND SOCIAL BASELINE STUDY

7.1Introduction and Objective

7.1.1Purpose

This Chapter aim to provide available environmental and social (E&S) information to be used in the stage of cumulative and trans-boundary impact assessment (CIA/TBIA) of which this CIA/TBIA will be performed later and probably be integrated other upper cascade hydropower dams on the mainstream into the assessment.

Since many downstream communities are dependent on the Mekong River mainstream for day-to-day living which includes water supply, navigation, cropping, tourism, fish cultures, etc, we need to have information of these as initial information for the CIA/TBIA

7.1.2Scope

Data collection and area to be included is based on the recent MRC's study that the changes in water levels could be exacerbated by the operational strategy of projects. The Peaking operation with maximizing turbine discharge may increase the rate of fluctuation of water levels. The 3-6 m fluctuation may reach to the downstream communities located 40-50 km away from the dam. Case of unplanned and emergency releases these peaking events, the impacts may be larger like 100 km. To ensure that the project has preliminary data on this issue, the study team decided to gather information at approximately 100 km from the proposed dam site.

7.1.3Methodology

The following methods were employed in gathering the downstream E&S data for the PLHPP.

- Review of related documents of the study area including district/sub-district general information, studies/researches on the Mekong Mainstream, etc;
- Discussions with senior district/sub-district administrators and other concerned stakeholders;
- Selected interviews with villagers residing on the right bank of the Mekong River;
- Survey by boats along the Mekong River;
- Ground surveys checking the village location and river-bank agriculture, water use and other economic activities from the Mekong.

7.2Downstream Socio-Cultural and Economics

7.2.1Population and Ethnicity

Riparian villages residing on both banks of the Mekong River were conducted. The survey showed that there are 5 villages on the right bank (belonged to Paklay and Sanakham districts of Xayaboury and Vientiane Provinces).

The ethnicity of households of these downstream communities comprises of Khmu (70%), Lao (25%), Hmong (5%).

The *Khmu* villages are found mostly in Paklay District in low mountainous areas and degraded forested valleys. The Khmu houses are built on low wooden stills, about 1 to 1.5 meters above the ground. The walls are made of bamboo mats without windows, the roof is covered with thatch. Traditional *Khmu* villages have a communal house, where young adolescent boys live and where men gather for important discussions or to work together on crafts.

Most of Lao Loum is found mixed with Khmu and Hmong in Ngeun and Hongsa districts of Xayaboury. The highest number of Hmong household was found at Ban Pakngum of Hongsa.

Table 32:Location and Population of Downstream Communities (Lao PDR)

No	Province	District	Village Name	No. of HH	No. of Population		Location		Elev. (mASL)
					Total	Female	River bank	Km from Dam	
1	Oudomxay		Pakngeuy	116	605	309	LB	*3*	
3			Paklay	271	1,311	650	LB	*14*	356
5			Houaythom	45	327	141	LB	*16*	361
6			Houaylao	39	304	159	LB	*34*	331
7		Paklay	Kewkoui	47	395	182	LB	*38*	480
8			Kokmaliow	11	60	32	LB	*76*	330
9			Houaykha	57	326	185	LB	*81*	333
10			Bor	64	462	244	LB	*81*	318
11		Nga	Hatteu	117	659	340	LB	*91*	314
12	Xayaboury		Houayngeuy	94	650	318	RB	*2*	
13		Ngeun	Pakhuaykhen	85	597	300	RB	*6*	
14			Pakngum	64	445	222	RB	*30*	339

15			Thaxoung	42	190	93	RB	*41*	328
16			Keang Ane	53	313	159	RB	*46*	321
17			Thanoun	56	278	147	RB	*54*	328
18		Hongsa	Kok Ek	71	373	188	RB	*72*	311
19			Kenghang Noy	65	378	186	RB	*86*	320
20			Pakhuaysing	90	493	304	RB	*98*	332
Total (2 provinces/4 districts)			**20 villages**						

7.2.2 Livelihood and Income

The livelihood of people relies on primitive agriculture where rice/maize farming and livestock is the household/village bank. The average per capita income of most people is comparatively under the poverty line ranging between USD 100 – USD 200per person per year.

The field survey found that the size of farmland per household consist of <0.25 ha low-land rice, <1.00 ha upland-rice, <0.60 ha garden/ perennial trees, and <1.00 grassland for animal. The survey also found that animal husbandry is one of household cash where they sell animal when they need urgent cash. The animal raising in the area includes cattle and buffaloes, pigs, poultry, and goats.

7.2.3 Infrastructure and Faculties

These downstream villages have limited infrastructures and supporting facilities such as roads, waterworks and electricity (except Paklay has electricity and has paved road connecting to Oudomxay civic centre). Also social service facilities are considered limited such as markets and electricity. Due to limited road service in most of villages, all villages use the Mekong and its main tributaries as means of transportation primarily by small boats. Some long-tailed speed boats and large boats are served as boat taxis and tourist cruises traveling to and from Houay Xay – Paklay – Luang Prabang.

Approximately 65% of downstream people have cottage bamboo houses while around 34% are wooden house with metal sheet roof. Only one percent has good quality two-storey wooden house with tile roof.

Table38: Typical House of Downstream Villages

House Type	Typical House	Characteristic for Each Type	Approx. % of total HH
1		Good Quality House: 2 stories *Roof – Tile, Floor – Cement/Wooden plank, Wall – Cement/Plank, Column - Cement*	1%
2		Medium Quality House: 2 Stories *Roof Tile/Metal sheet, Floor – Cement/Plank, Wall – Plank, Column - Cement*	34%
3		Poor Quality House: *Roof – Thatch, Wall/Floor – Bamboo, Column - Wood*	65%
Total			**100%**

Table 39: ***Infrastructure in Nga and Paklay Districts of Oudomxay***

No.	Name of District	No. of village	Community Infrastructure			
			Having access road	Having market	Having Electricity	Having primary school
01	Nga	68	17	10	10	53
02	Paklay	53	21	7	4	50
Total		**121 (100%)**	**38 (31%)**	**17 (14%)**	**14 (12%)**	**103 (85%)**

Table 40: ***Infrastructure in Hongsa and Ngeun Districts of Xayaboury***

No.	Name of District	No. of village	Community Infrastructure			
			Having access road	Having market	Having Electricity	Having primary school
01	Hongsa	45	29	4	15	38
02	Ngeun	25	12	4	11	20
Total		**70 (100%)**	**41 (59%)**	**8 (11%)**	**26 (37%)**	**58 (83%)**

a)

b) Household Economy

The data from interviews revealed that the household gross income of downstream riparian villages of Paklay and Meun is estimated at 585 $ and 499 $, respectively which is above the poverty line index of Lao PDR. The main gross income is from agriculture (cropping and livestock rearing) which estimated at 63% to 72% of total household income for Paklay and Meun villages, respectively. For downstream villages in Paklay, they have more opportunity in income generation from trading, employment and services.

Table 33:Estimated Average HH Income of Downstream Villages (Paklay)

District	Sources of Income	(Kip/month)	(Kip/year)
Paklay	1) From Agriculture	2,600,000	31,200, 010
	2) Livestock	410,000	4,930,000
	3) Sale of Forest Product	425,000	5,100,100
	4) Trading	516,666	6,200,000
	5) Services	351,670	4,220,040
	6) Laboring /Salary	181,500	2,178,005
	7) Handicraft	96,300	1,156,402
	8) Other	92,000	1,100,800
Total monthly income/HH (Kip)		**4,673,779**	**56,085,357**
Total monthly income/HH (US $)		**585**	**7,010**

Table 34:Estimated Average HH Income of Downstream Villages (Met)

District	Sources of Income	(Kip/month)	(Kip/year)
Meun	1) From Agriculture	2,450,000	29,400, 000
	2) Livestock	427,500	5,130,000
	3) Sale of Forest Product	166,692	2,000,310
	4) Trading	341,691	4,100,300
	5) Services	177,420	2,129,040
	6) Laboring /Salary	267,667	3,212,005
	7) Handicraft	103,850	1,246,202
	8) Other	225,066	2,700,800
	Total monthly income/HH (Kip)	**3,993,221**	**47,918,657**
	Total monthly income/HH (US $)	**499**	**5,989**

c) River-bank Gardening

Most of villages on the Lao practice riverbank gardening. The main crops are vegetables such as onion, chili, peanuts, etc. Some sweet corn and maize was observed in the Phalat village in Paklay. The average size for each village for this is ranged from 5,000 m^2 to 10,000 m^2 depending on slope and land availability. Bank erosions are normally observed in the area.

7.3Tourism

7.3.1Paklay Tourism

Paklay HPP is located in the administrative boundary of Paklay district, Xayaboury Province. The tourism system in Paklay area is part of the Central Lao tourism system where can be connected mainly by tourists of Lao PDR and Thailand. At present, Paklay is not considered as interesting place among tourists due to its location being outskirt of the main tourism route. Paklay is considered as border linkage with Thailand by Loei and Uttaradit provinces via Thai-Laos border. According to the Paklay Tourism Official Information there are few number of international tourists record in this area.

7.3.2Tourism Network

The Figure below shows a schematic network of tourism destination in this region. The route starting from Paklay link to the surrounding tourism destination in this region is not significant accordingly to the road condition and the limit of border crossing. According to the Mekong River Cruising study of TAT (1997), not proposed the Mekong River in this section as the potential route for development. The existing activities on the Mekong were for accommodating only local tourists, but for future development the international tourists should also be taken into consideration.

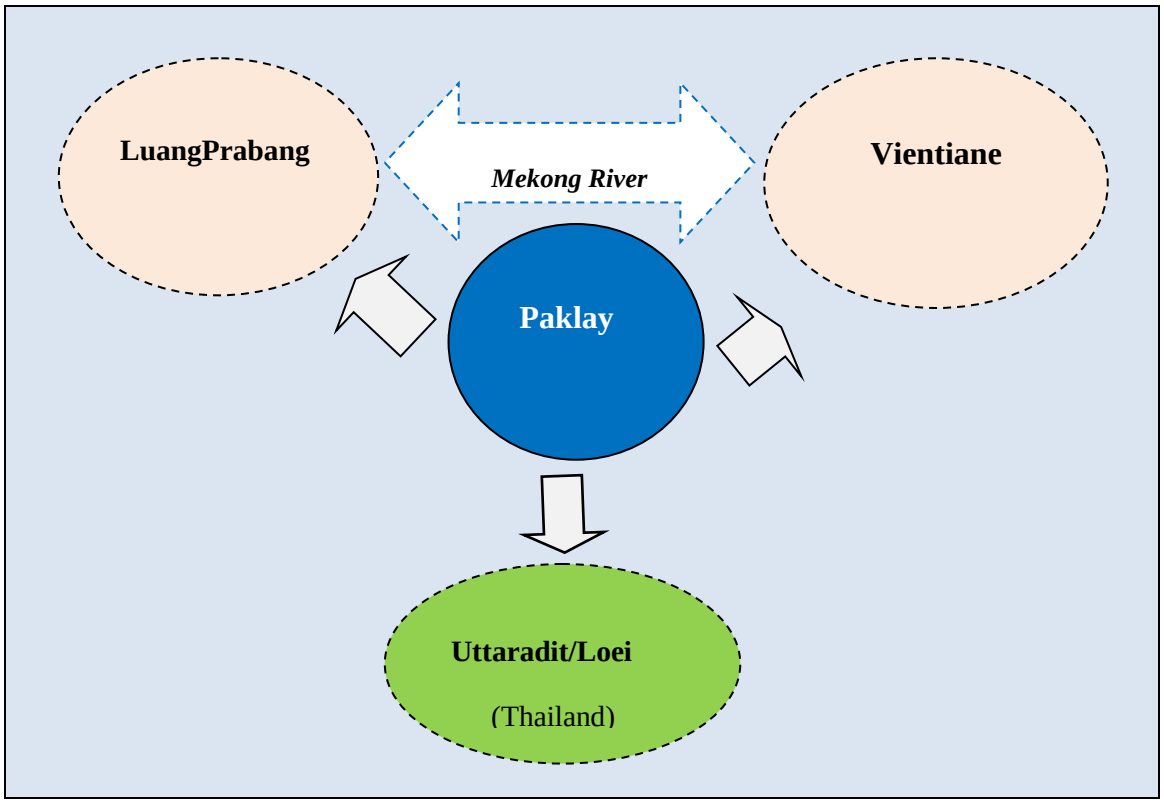


Figure 26:Paklay Tourism Network and Linkage.

7.3.3Attraction Resources

According to the tourism field survey in the Paklay project area, it was found that the potential tourist attraction (classified by the Paklay District Tourism Office) included historical, cultural and natural sites as summarized below:

Fourteen of historical sites which include 11 old colonial buildings, 3 religion places, and an old town;

Eleven of cultural sites which include 7old temples, 4 traditional sites;

Twenty nine of natural sites including 15caves, 5 waterfalls, 8 ecological (forestry and mountainous) sites, and a hot spring.

Paklay Town

Rural Paklay

Biodiversity Area

Boat Travel in Pak lay

Riparian Children

Fishing

Figure 27: General Spots for Tourists at Paklay Study Area

Paklay HPP is located in the administrative boundary of Paklay District and Hongsa District, Oudomxay and Xayaboury provinces, which is situated in the both sides of the Mekong. At present,

Paklay and Hongsa are considered as interesting place among tourists due to its location being inside the river tourism route. Hongsa and Muang Ngeun District are considered as border linkage with Thailand by Houai Kon-Muang Ngeun, Thai- Lao border checkpoint.

7.3.4Tourism Market

According to the Paklay Tourism Office report on number of tourist in Paklay, the number of tourist arrival to Paklay in 2011 was recorded at 7,200 persons. Most of tourists came to the study area to visit Paklay city. The trend of number of tourist in the study area was expected to be rapidly increased in the near future when the Mekong bridge and cross border has been developed.

7.3.5Mekong Waterway Tourism

Based on the recent tourism field survey along the Mekong River in the Paklay HPP project area, it was found that the main tourist attractions and motivation is the mountainous topography and some biodiversity of the area. However, there was no waterway tourism travel program provided for visitors. Even there are some potential Mekong waterway routes such as such as Paklay – Pha Leap – Donkhon (old temple) for development. At present the people in Paklay use Mekong for boating racing and Bounbang Fai, as the spirit traditional.

8.ASSESSMENT OF ENVIRONMENTAL IMPACT

8.1Overview of Approach and Methodology in Environmental Impact Assessment

8.1.1Introduction

The objective of this chapter is to describe the approach and methodology used for the identification and assessment of significant impacts that may result from the development and operation of the PLHPP. It addresses the EIA scoping process, the Study Area, and the impact identification matrix. Finally the chapter identifies the key potential (negative and positive) physical, biological and social impacts, predicts their Magnitude and Importance, assesses their Significance, and recommends feasible mitigation where required.

Project construction and operation may result in both direct and indirect impacts. An example of indirect project impacts would include rapid population growth which could result in increased pressure on local resources use such as the fishery, agricultural production, and forest and non-timber forest products (NTFP). In addition to impacts at the dam site area, the project's switchyard, transmission line, and access roads will also permanently affect land and resource use.

This EIA does not, in great detail, cover impacts of transmission lines or access roads as these are to be covered in separate Initial Environmental Examinations (IEEs) as required by the MONRE.

8.1.2Impact Area and Potential E&S Impacts

In thisChapter we addressed three layers of impacts that may occur due to the development of the PLHPPP:

- Global (Layer 3)
- Country and region (Layer 2)
- Project area (Layer 1)

For impact assessment, the figure below elaborates the 3 impact areas and key E&S issues to be used for the environmental assessment for the project.

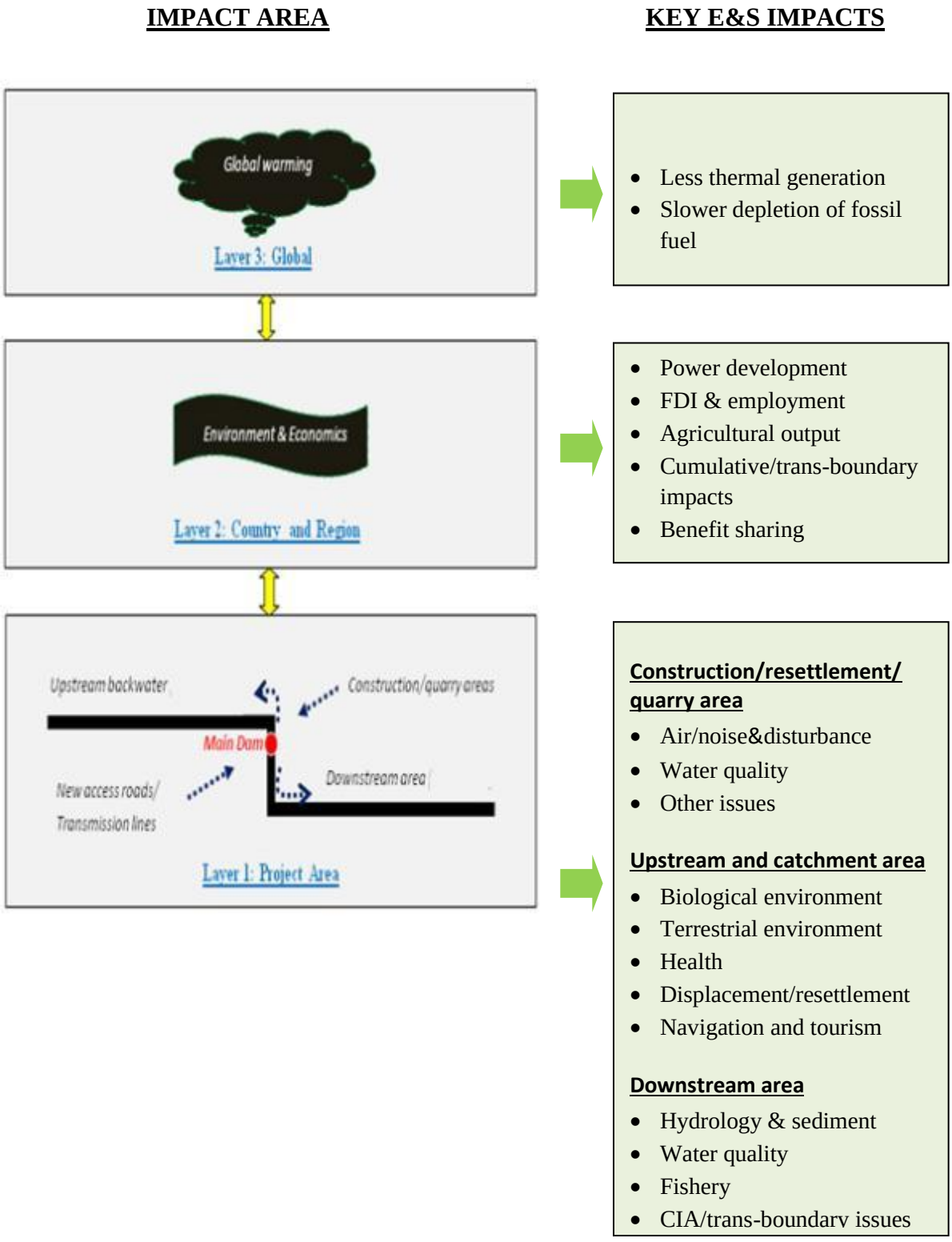


Figure 28: Identification of Impact Area and Key E&S Impacts

8.1.3Identification of Impact Avoidance

a) Selection of Water Retention Level

As a run-of-river hydropower station, increase of normal pool level of the reservoir ofthe Paklay Hydropower Station can help to enhance power generation benefit of theProject. Selection of normal pool level of the Paklay Hydropower Station is mainly limitedby upstream Sainyabuli cascade. The normal pool level of the reservoir for the PaklayHydropower Station planned in 1994 was 250.00m. According to feasibility study designof the Sainyabuli Hydropower Station, the downstream normal pool level of the dam site isabout 244.00m and downstream water level corresponding to full-load flow is about245.50m. When normal pool level of Paklay is 250.00m, it overlaps the tailwater ofSainyabuli Hydropower Station. At the end of 2008, French CNR was entrusted by the Laogovernment to review and demonstrate planning of the five cascades of Pak Beng~Sanakham within boundary of Laos. In September, 2009, CNR put forward the finalstudy report Optimization of Mekong Mainstream Hydropower which recommended that the normal pool level of Paklay should be 240.00m~245.00m. On August 26, 2009, theLao government gave a notice to the joint venture by letters requiring that the normal poollevel of the Paklay cascade should not be higher than 240.00m,so the design at this stage is carried out asper a normal pool level of 240.00m.

b) Selection of Main Dam Site

Since 2010 two alternatives schemes for dam site location have (lower and upper dam sites) have been compared. The criteria for comparison includes: cost, degree of environmental and social impact, ease of construction, etc. According to the comparison, the upper and lower dam sites have bothstrengths and weaknesses. Generally, the lower dam site scheme can utilize the waterpowerresources potential. But the population impacted by inundation in the lower dam sitescheme is larger than the population in the upper dam site, and thedifference is large. The immigration problem is related to the local people's livelihood andsocial stability, has a lot of uncertainties, and increases investment risk, thus, the upperdam site is recommended for the phase.

8.1.4Methodology in Assessing Impact

8.1.4.1Scoping

Initial scoping was done during the IEE. Additional detailed scoping was conducted for this EIA by the Biophysical and Social Team leaders in coordination with their respective teams and stakeholders. The objective of this scoping was to develop Discipline specific TORs, work plans, methodologies and schedules for the discipline specialist’s data collection activities and studies. This included identification of the specific type of information required for the impact assessment work.

All discipline specific time frames matched the overall time frame provided for the specialists input to the data collection, analysis, assessment, and reporting activities in the overall Project Work Plan and time frame.

Preparation for Participatory Stakeholder Consultation was initiated by the designated NCG specialist during the Preparation Phase of the ESIA. The first step was to prepare a project specific consultation program and participant specific materials. The participatory consultation

process was designed to verify the validity of the proposed scope and approach to the ESIA. Participants included representatives of the potentially affected people in the project area, NGO's, Government agencies responsible for the environmental approvals of the project and agencies that were requested to provide environmental and social baseline information. Feedback obtained during the consultations was recorded and summarized for inclusion in the EIA. Relevant feedback obtained was used to adjust the scope, approach and focus of the ESIA to meet relevant National and International guidelines.

8.1.4.2Identification of Potential Environmental and Social Effects

This section of the EIA describes the methodology used by the interdisciplinary PLHPP EIA study team to screen the project for potential physical, biological and socio-cultural impacts that may occur during the pre-construction, construction and operation phases of the project.

For the project area assessment an environmental and socio-cultural impact identification matrix (Figure below) was used during initial project scoping and consultations at the village level, to identify potential cause / effect (C/E) relationships that could result in environmental and socio-cultural impacts during the construction and operation of the proposed HPP. The matrix is a valuable tool and guide as it provides a clear, systematic, rigorous and effective method of screening the project for potential cause / effect relationships that could result in significant environmental impacts.

While a matrix is sometimes developed and used to do a preliminary characterization of C/E relationships (according to a specific legend in the matrix), the present study uses the matrix simply to identify potentially significant cause effect (C/E) relationships between project components / activities and various key physical, biological and socio cultural components. It serves as check list for the identification and subsequent assessment of potential project impacts.

The top rows of the matrix identify the principal project components and activities which are known to have had potentially significant environmental impacts in past projects.

The left hand columns of the matrix provide a checklist of the principal physical, biological and socio cultural components of the environment that may be affected by project construction and operation.

Cause/effect relationships and potential impacts that may result from project infrastructures or activities affecting environmental components, are indicated with an (X) in the body of the matrix. Blanks in the body of the matrix indicate there is no likelihood of a significant cause / effect relationship or impact.

The cause/effect relationships and impacts which are most likely to result from project components or activities affecting specific environmental components are also identified with an (X) in the matrix.

ENVIRONMENTAL & SOCIAL COMPONENTS				HYDROPOWER PROJECT ACTIVITIES																
					PRE CONSTRUCTION			CONSTRUCTION						OPERATION			ANCILLARY DEVELOPMENT		
					Land Acquisition	Clearing	Access Roads	Construction of Dam and Infrastructure	Quarries, Borrow and Storage areas	Diversion Works	Labour Force & Camps	Waste Disposal	Hazardous Materials	Change in Flows / Regulation	Dam Failure	Decommissioning	Illegal / Unplanned Activities	Transmission Lines	New Resettlements
PHYSIOCHEMICAL	ATMOSPHERE		Air Quality				x	x											
			Noise				x	x											
			Climate																
	WATER RESOURCE		Hydrology						x				x	x					
			Level						x				x	x					
			Siltation / sedimentation		x	x	x	x					x	x			x	x	
			Flooding (Local)			x							x	x			x		
	WATER QUALITY		Surface Water Quality **		x	x	x	x		x	x	x					x	x	
			Surface Water Quantity **			x													
			Ground Water Quality **																
			Ground Water Quantity **																
	LAND SOILS & EROSION		Soil compaction																
			Soil quality			x													
			Drainage			x													
			Erosion		x	x	x							x	x			x	x
			Flood Plains / wetlands																
	GEOLOGY & SEISMICITY		Subsidance																
			Slope stability		x	x								x	x			x	x
			Seismicity																
BIOLOGICAL / ECOLOGICAL	AQUATIC		Fish species			x	x							x	x				
			Other species												x				
			Habitats			x								x					
			Ecology											x					
			Endangered / protected Spp / habitats			?	?							?	?		?	?	?
	TERRESTRIAL		Wildlife		x	x	x				x						x	x	x
			Other species		x														
			Habitats		x	x	x				x								
			Ecology		x		x				x						x	x	x
			Endangered / protected Spp / habitats		?		?				?						?	?	?
HUMAN VALUES	HEALTH & SAFETY		Public Health & nutrition**								x	x	x						x
			Waterborne diseases								x								x
			Parasitic Disease								x								x
			Communicable Disease								x								x
	SOCIAL & ECONOMIC		Land use		x	x	x											x	x
			Agriculture / forestry		x	x	x												
			Mineral resources & exploration																
			Transportation			x													
			Navigation																
			Employment**		x		x												x
			Education**																
			Buildings & existing infrastructures																
	AESTHETIC & CULTURAL		Aesthetics or Landscapes		x		x							x					
			Sense of Community**																
			Archaeological / Religious Places																

Figure 29: General Impact Matrix for Local Project Area

8.1.4.3International Standards for Assessing Impact Significance

Serious guidelines for Impact assessment, including those proposed by MONRE, ADB, World Bank, IUCN and the "Equator Principles, require: 1) explicit and transparent identification of a project's potential physical biological and social effects, 2) analysis of the Magnitude and Importance of the anticipated effects and 3) an assessment of their SIGNIFICANCE and 4) recommendation of feasible and cost effective mitigation, compensation and enhancement measures.

The methodology outlined below was used and implemented in the following Impact Assessment sections; it fulfills these objectives and has proven effective in many previous ESIA's for several important reasons:

1) The methodology provides a common, systematic and rigorous frame-work that enhances the effectiveness of the many individual discipline specialists participating in the Impact Assessment each of whom has a different approach, and perspective and contributes different data.
2) The methodology ensures a thoughtful, systematic, rigorous and transparent identification of potential project effects and an analysis of their Magnitude and Importance.
3) Identifies and briefly describes any additional mitigation enhancement, compensation or institutional measures that are not included in the project description but that will be cost effective and are to be developed and included in the EMMP / SMMP.
4) Most importantly the methodology provides decision makers with a clear and concise Assessment of Impact Significance and identifies required mitigation and costs.

8.1.4.4Impact Assessment Methodology

Each Impact for the PLHPP will be measured using the methodology and terminology below:

A) Impact Assessment Title

B) Introduction/Concerns

Explains generally or theoretically how the specific aspect of the project may result in changes to the specific Physical, Biological or Social parameter being discussed. Changes can be positive or negative.

C) Project Aspects and Mitigation

Describes the actual activity of the project that may result in significant changes to Physical, Biological or Social aspects of the environment. After that, a description of any relevant mitigation already included in the project description will added.

D) Magnitude

Describes or quantifiesthe amount, extent or size of the potential loss or change in physical, biological, social environment under discussion. Compares the change or loss with the amount, extent or size of the resource in that will remain unaffected.

E) Importance

Describes or quantifies the ecological, economic or socialvalue of the resource or parameter that will be lost or changed. Note that Impact assessment is not a strictly objective endeavour. The EIA must consider the relative importance or value stakeholders assign to the predicted environmental effects. This requires integrating a value judgement into the impact assessment. Value systems that are used to judge the relative importance of predicted effects include: ecological, (critical vs other habitat, bio-diversity, sustainability), economic (monetary), and social / legal (aesthetic, cultural or compliance considerations).

F) Duration

Describes how long the impact will exist. For example the impact might last during the construction period only or during the entire operation period. Duration is described as follows: Short, when the impact occurs over a limited period of time, generally corresponding to the period of construction, the start-up period, a single season, etc; Medium , when the impact occurs for a prolonged period of time but not the life of the project; Long ,when the impact occurs for the life of the project or is permanent

G) Positive or Negative

Defines whether the Impact is Positive or Negative.

H) Significance

Assesses the total Impact Significance using the previous steps (A-G) as Low, Moderate or High

8.2Summary of PLHPP Impacts

Below are two tables summarizing the project's Global, Regional, National and Project Area Impacts. The first table is for the Construction Period of the hydro dam and the second is for the Operational Period. This summary is followed by a detailed description of each impact in further sections.

Table 35: Summary of Potential Impacts from the Project – Construction Period of Project

Area of Impact: Country and Region				
Name of Potential Impact	**Duration of Impact**	**Positive or Negative Impact?**	**Required Mitigation**	**Significance of Impact**
Impact on Foreign Direct Investment	Medium Term	Positive	No special mitigation required.	Positive Impact of High Significance
Impact on Employment and Income	Low/Medium/High	Positive	Hire Lao nationals according to Lao PDR Law.	Positive Impact of High Significance
Impact on Agricultural Output	Medium Term	Negative	Provide adequate farmland to affected persons.	Negative Impact of Highto low Significance
Cumulative Impacts	Long Term	Negative/Positive	Cooperation between hydro projects. Maintenance of river's flow regime through proper dam design and operation.	Negative or Positive Impact ofModerate Significance
Trans-boundary Impacts	Long Term	Negative/Positive	Perform Transboundry Environmental Impact Assessment. Perform regional consultations. Maintenance of river's flow regime through proper dam design and operation.	Negative or Positive Impact ofModerate Significance
Impact on Benefit sharing	Long Term	Positive	To be determined	Positive Impact with Moderate – High

				Significance
Area of Impact: Project Area(quaries, spoils disposoal areas, dam site, resettlement sites,upstream area)				
Impact on Water Quality	Short Term	Negative	Installation of waste water treatment plant for worker camps. Safe disposal of vehicle maintenance oils. Safe storage of chemicals and disposal of used containers. Attention to concrete shuttering to prevent accidental spillage of rainy cement into water courses. Prevention or washing cement mixing equipment in water courses. Attention to good earth moving practice when working near water courses. Removal of surplus vegetation in the reservoir area prior to impoundment. Monitoring of water according to Lao Environmental Standard: "Agreement on the National Environmental Standards, 21Feb2017 – No 81/GOL"	Negative Impact with Moderate – High Significance
Impact on Land and Soil	Short Term	Negative	All earthwork(borrow pit material extraction; quarry work, road building, etc., will be undertaken in sections with rehabilitation undertaken in stages to minimize erosion. Such rehabilitation shall include the following: Regrading slopes to minimize erosion Replacing stockpiled soil cover Replanting grass, shrubs, and trees Installing sediment runoff control devices Providing ongoing erosion monitoring Impacts on temporarily acquired land will be minimized by comprehensive rehabilitation work. Spoils, waste, hazardess materials etc. will be disposed of according to Lao PDR law.	Negative impact of ModerateSignificance.

Impact on Terrestrial Environment	Shot Term	Negative	Formulate the detailed forest clearing plan linked with salvage logging and biomass clearing plans, particularly in the proposed reservoir area, aimed at giving space and routes for wildlife to escape during construction. During construction, all project workers and staff including contractors will be prohibited from the hunting, buying or trading of wildlife. As stated in the Wildlife and Aquatics Law and other regulations concerned, hunting and trading of conservation species, especially from the prohibited and controlled list (List-1 and List-2) will be strictly banned. Strict rules against wildlife hunting and poaching will be imposed on project staff, workers, and all contractors engaged in the Project with penalties levied for anyone caught carrying and using firearms, animal snares or traps. Camps should not be sited near or on the sensitive and high biodiversity areas or water courses. Rubbish disposal and sanitation systems should also be planned and provided properly in the campsites.	Negative impact of Low Significance
Impact on the Fishery	Medium Term Term	Negative/Positive	Implement a fish hatchery program that will raise and release important fish into the project area Design and install a fish pass that meets or excedes MRC's guidelines. Institute conservation measures and mangement.	Negative/Positive Impact with Moderate – High Significance

Table 36: Summary of Potential Impacts from the Project – Operational Period

Area of Impact: Global				
Name of Potential Impact	**Duration of Impact**	**Positive or Negative Impact?**	**Required Mitigation**	**Significance of Impact**
Impact on Project on Climate Change	Long Term	Positive	Adequately clear all vegetation the will be submerged	Positive Impact with Moderate Significance
Impact on depletion and use of fossil fuels	Long Term	Positive	No special mitigation required.	Positive Impact with Low Significance
Area of Impact: Country and Region				
Name of Potential Impact	**Duration of Impact**	**Positive or Negative Impact?**	**Required Mitigation**	**Significance of Impact**
Impact on Rural Electrification	Long Term	Positive	Supply some portion of electricity generated to Lao PDR. Expand rural electricity distribution.	Positive Impact with Moderate Significance
Impact on Regional power grid	Long Term	Positive	Continue to expand and connect Lao PDR's power grid.	Positive Impact with Moderate Significance
Impact on Foreign Direct Investment	Long Term	Positive	No special mitigation required.	Positive Impact with High Significance
Impact on Employment and Income	Long Term	Positive	Hire Lao nationals according to Lao PDR Law.	Positive Impact with High Significance
Impact on Agricultural Output	Long Term	Positive	Provide convenient transportation conditions . Provide training	Positive Impact of High Significance
Cumulative Impacts	Long Term	Negative/Positive	Cooperation between hydro projects and governments.	Negative/Positive Impact of High Significance

			Maintenance of river's flow regime through proper dam \operation.	
Trans-boundary Impacts	Long Term	Negative/Positive	Perform Trans-boundary Environmental Impact Assessment. Perform regional consultations. Maintenance of river's flow regime through proper dam operation.	Negative/Positive Impact of High Significance
Impact on Benefit sharing	Long Term	Positive	To be determined	Positive impact of Moderate Significance
Impact to the Mekong River's existing Flow Regime	Long Term	Negative/Positive	Perform regional consultations. Maintenance of river's flow regime through proper dam operation. Prove the dam's affect on stream flow using MRC accepted software modeling.	Low and Negative Impact during rainy season with Moderate Significance and Low and Positive impact during dry season with Moderate significance.
Impact to the Mekong River's existing SedimentRegime	Long Term	Positive	Perform regional consultations. Maintenance of river's flow regime through proper dam operation. Prove the dam's affect on Sediment flow usingMRC accepted software modeling.	Positive impact during dry season with Moderate significance.
Area of Impact: Project Area and Upstream of Dam Site				
Impact on Terrestrial Environment	Long term	Negative	Development of a Wildlife Management Plan in connection with the Forest	Negative Impact with a Low Significance.

			Management Plan for the project area especially in the catchment area where the habitat is still remaining and abundant. Establishing an appropriate program to monitor the effects of the project on biodiversity and ecological resource use, and use the data obtained to adjust the Project's Wildlife Management Plan. Hunting will be controlled and illegal hunting will be prohibited. Species and population surveys have to be conducted continuously during the operation phase to mitigate the impacts on wildlife in the area.	
Impact on the Fishery	Long Term	Negative/Positive	Implement a fish hatchery program that will raise and release important fish into the project area Design and install a fish pass that meets or excedes MRC's guidelines. Institute conservation measures and mangement.	Negative impact of moderate significance for certain long range migratory species and positive ipact with moderate significane for certain non-migratory or short range migratory species.

8.3Global Impact

8.3.1mpact of project on climate change

a) Introduction/Concerns

There is a large body of study and research that offers alternative ways to help reduce global warming. These include:

- Taking good care of forests since CO_2, a major greenhouse gas, can be absorbed by trees. If a country fosters the growth of its forests and does not allow them to be cut down indiscriminately, global warming will be slowed down.
- Promoting energy efficiency, when less energy is used, the less global warming has a chance to take hold.
- Developing alternative sources of energy which emit little or no greenhouse gases. Using them will help curb global warming. Hydro-power, solar energy, and windmills can be used to take the place of burning gas, or coal for electricity.

b) Project Aspects and Mitigation

Project Aspects

The PLHPP plans to export electricity to Thailand where Thailand's power generation is mostly based on fossil fuels with natural gas and lignite contributing to more than 50% of the total electricity generated. The economy's electricity generation is projected to increase annually at a rate of 5.5 percent, from 111 TWh (or equivalent to 1012 watts) in 2002 to 504 TWh in 2030 which is less than half the growth rate of 14.1 percent observed before the financial crisis in 1997.

Thailand's total CO_2 emissions from the energy sector are projected to increase from 193 million tons of CO_2 in 2002 to 734 million tons of CO_2 in 2030. The electricity sector will be the major contributor accounting for 40 percent of total CO_2 emissions in 2030, or 294 million tons CO_2. Thailand has an agreement to import hydropower electricity from Lao PDR in the amount of 7,000 MW by 2020. The PLHPP is expected to sell the

electricity produced to Thailand. Over a 25-year operation of the PLHPP dam total potential avoided emissions are calculated at 51,846,217.5 tons CO_2.

Mitigation

- Sell Electricity to Thailand as planned
- Clear Biomass before Inundation

c) Magnitude

The potentially avoided amount of GHG is substantial though compared to the entire global situation relating to greenhouse gasses the magnitude of this impact is not huge. Therefore, the magnitude of the impact is considered low to moderate.

d) Importance

Slowing down the increasing level of greenhouse gas is very important worldwide. The importance is placed at the high level.

e) Positive or Negative?

Positive

f) Significance

This is a positive impact and the overall significance of it is put at moderate to high because it will last for the entire operational period of the project and have a global effect.

8.3.2Impact of Project on depletion and use of fossil fuels.

a) Introduction/Concerns

The burning of fossil fuels contributes to green house gases and there is a finite amount of fossil fuels on the planet.

b) Project Aspects and Mitigation.

Project Aspects

The PLHPP will reduce Thailand's and Lao PDR's demand for fossil fuels (and wood fuel) .

Mitigation

- Sell Electricity to Thailand as planned
- Clear Biomass before Inundation

c) Magnitude

Compared to the fossil fuel use in the entire world the magnitude is considered quite low.

d) Importance

It is necessary to reduce fossil fuel usage through the world. The Importance is considered moderate.

e) Duration

The duration is Long

f) Positive or Negative?

Positive

g) Significance

The Significance is considered low and positive

8.3.3Impact of the project on Lao PDR and the entire region

a) Introduction/Concerns

At the country level, the creation of PLHPP may support country and regional development. These positive impacts of power development include rural electrification and sub regional inter-connected grid, employment and income from economic activities generated.

In contrast, the negative impacts are concerned with the loss of 1,770 tons of agricultural production of the fertile lowland rice farming area to be inundated.

Also, there are cumulative and trans-boundary impacts to consider from a number of planned cascaded hydropower projects on the Mekong mainstream to be developed in other locations and from downstream bio-physical changes of the Mekong River as compared to the case of having no projects on the Mekong River.

Another important issue relates to the benefit sharing of the project's resources and earnings. It includes economic growth and the reduction of poverty if the support systems for these issues are well organized and focused.

b) Project Aspects and Mitigation

Project Aspects

In regard to the economy of Lao PDR and the region, the inflow of Foreign Direct Investment (FDI) during the construction stage, including foreign exchange earnings, and from hydropower during the operation phase will support the economic development in Lao PDR and neighboring countries. A number of employment opportunities will be available and purchases of construction materials will occur.

It is noted that a side impact from high demand of labor forces and construction materials may lead to the rising rate of wages and increased prices for construction materials.

Mitigation

- The electricity interconnection among Lao PDR, Cambodia, and Viet Nam, through regional initiatives needs to be implemented. A number of hurdles still need to be overcome, such as lack of transmission facilities affecting transfers, regulatory protocols, cross-border tariffs, etc. These gaps need to be filled among the Lower Mekong River countries.

- Since there will be less low land fertile area, the GOL has to concentrate on the improvement of the agricultural productivity of land remaining to secure food for rural inhabitants. This can be implemented with comprehensive agricultural research and development.

- In the construction phase, as the labor force requirement is large (more than 3,000 people), there is a good chance for the PLHPP to give priority to Lao people to be hired as laborers (especially those are directly affected due to inundation) including the local sub-contractors.

- There will be a need to conduct the "cumulative and trans-boundary impact assessment - CIA/TBIA" in a separate volume covering areas from China down to Mekong delta in Vietnam. The study will be used for regional consultation of the

project by addressing the regional perspective of Mekong mainstream development.

- The benefits of the project may include electricity, irrigation, navigation, tourism and especially upstream fishery management. Since large volumes of project benefits will occur after commissioning, the country benefit sharing mechanism should be set up as well. At a minimum, the project affected people should receive benefits to make their life better off.

Importance/Magnitude/Significance

- Rural Electrification - Hydropower development that supports rural electrification and a sub-regional inter-connected power grid are considered to be positive impacts with high importance and moderate magnitude. The duration of the impact is moderate to long term. Overall this is a positive impact of Moderate Significance.

- Foreign Direct Investment (FDI) – FDI, employment and income, is a positive impact to all developing countries. The importance of this impact would have to be considered high. The magnitude is also high since the total investment will be about 1,800 million US $. Overall this is a positive impact from moderate to long term duration and a High Significance.

- Agricultural production - without the project, the riverbank/valley rice paddy area of approximately 300 ha can produce a yield of glutinous rice of some 1,100 tons per year. With the project, this amount of rice is expected to be lost, or at least it cannot be grown in the inundated area. The Magnitude of this is moderate according to the hectares lost and the importance is considered to be high. However, in operation period, there will be more roads constructed and the transpotion conditions will be improved obviously, it is benefit for agricultural production trade. Overall this is considered both long term duration for a negative impact of High Significance in contruction period and a positive impact of High Significance in operation period.

- Cumulative and trans-boundary impacts - are considered to be negative and positive impacts of long term duration. The importance and magnitude are considered high and likewise the Significance is High.

- All issues with regards to benefit sharing are not clear yet because of the following: policy process of the GOL, limited lowland fertile area, and some external factors with regards to political, environmental and social policies in each country. The importance, magnitude and significance of this positive impact is considered to be Moderate.

8.4Project Area Impacts

8.4.1Impact on Air Quality

1) Construction Phase

a) Introduction/Concerns

Impacts on air quality will mainly occur during the construction of the proposed project. The principal impacts on air quality during the construction will mainly be associated with ambient dust emissions from earth work activities, such as the moving of earth materials, and the construction of the dam site, switchyard, roads and other related facilities. Fugitive or ambient dust emissions may also arise from stockpiling of materials, such as topsoil and spoils. Other point sources of air pollution may come from several sources including compressors, electricity generators, a stone and rock crushing plant and cement or concrete mixing plants.

The blowing dust from construction sites usually consists of suspended particulates with diameters of < 2 μm, 2-10 μm, and > 10 μm. But the most danger to human health is the dust with a diameter of less than < 2 μm as it can go into the lower part of human lung system. Also, matter of bigger size is less dangerous because its weight causes it to settles to the earth more quickly. Temporary stock piles of earth are often a significant source of dust. With the conditions of wind speed of 3 m/s or greater, dry weather and no environmental protection measures, daily average TSP at 150 m downwind of the earth pile can reach 0.49 mg/m3.

b) Project Aspects of the Project on Air quality and Mitigation

Project Aspects

During the construction, a large temporary and a smaller permanent land occupation will beginand these activities will require drilling, blasting and crushing, and may need to be transported to the construction site.

There will be exhaust gases from diesel electric generators, vehicle engines and other construction machinery; mainly hydrocarbons (HC), carbon monoxide (CO) and nitrogen monoxide (NO) and particulate matter (PM) will be generated. The toxic gases will affect the workers directly involved in the labor on the construction site.

Lao PDR National Environmental Standard No. 81/GOL for ambient air quality and exhaust emissions from new and old vehicles is shown in the Tables below.

Table 37: National Standard for Ambient Air Quality

Parameter	Symbol	Average Times				
		Hours			1 month	1 year
		1	8	24		
Carbon Monoxide	CO	30	10.26			
Nitrogen Dioxide	NO_2	0.32	-			
Sulphur Dioxide	SO_2	0.78	-	0.30		0.10
Total Suspended Particle	TSP			0.33		0.10

Table 38: Emissions Standard for New Vehicle

Type of Vehicle	Standards			
	Particulate Matter (PM), mg/Km	Nitrogen Oxide (NO), mg/Km	Hydrocarbon (HC), mg/Km	Carbon Monoxide (CO), mg/Km
Gasoline	-	150	200	2300
Diesel	50	500	-	640

Table 39: Emissions Standard for New Vehicles

Type of Vehicle	Smoke, SHU	Equipment	Measuring Technique
Diesel Engines	50%	Filter System	Measure while parking the car at load by quick acceleration the engine to maximum rpm
	45%	Opacity System	
	40%	Filter System	Measuring while the car steadily running on roller at 60% of maximum power rpm
	35%	Opacity System	

Mitigation

Dust generation at the construction site may have significant impacts on human health, especially for workers in the area, thus adoption of the good practices for the construction of the project are necessary and appropriate mitigation measures to suppress dust emissions need to be in place in order to limit dust generation during construction for all subproject activities including the washing of roads and trucks. It is recommended that water trucks need to be used to wet the roads, according to a daily schedule and taking into consideration weather conditions. When construction takes places during dry and windy days, water will be sprayed on earth piles and exposed surfaces to suppress dust regularly. The frequency and schedule of water spray needs to be established according to the site and location of sub-activities. A regular program for washing roads on the left and right bank also needs to be established. Aggregate preparation and storage areas and concrete mixing plants

should be located away from nearby residential areas and downwind of the prevailing wind. If necessary, dust suppression equipment needs to be installed in stone crushing and concrete-mixing plants. Proper maintenance of vehicles and diesel equipment, and avoidance of unnecessary running of vehicle and equipment engines will also result in reduction of gas and dust emissions. Regular field inspections will be conducted by the contractor's onsite environmental and local government officer. Records of public complaints need to be established. In case of violations or community complaints about dust and smoke pollution, the contractors will be ordered to take corrective actions within a required amount of time.

c) Magnitude

Air Quality will be adversely affected in all construction areas and from the use of trucks throughout the area, especially near the project's access roads. Construction activities will also create dust near villages residing near to construction site and to the quarry site. The magnitude of this impact should be moderate because though several areas are affected, they are not heavily populated.

d) Importance

Clean air is important to everyone's health but the quality of the air should not change severely for most local residents. Though many people will be affected by the increase of dust in the air the most affected individuals will be construction workers who should be taking the correct precautions (wearing masks). Therefore, the importance of the impact is considered to be moderate.

e) Significance

The Significance of construction on Air Quality is negative and should be at a moderate level; it will last from a few years only in constructionperiod.

8.4.2Impact on Atmosphere: Noise Quality

1) Construction Phase

a) Introduction/Concerns

Noise is commonly defined as unwanted sound and it can also be considered as a type of pollution. Exposure to high intensity noise for a long period can cause temporary or permanent hearing loss. In addition, noise pollution may also cause psychological and sociological effects on the human body such as annoyance, sleep interference and effects on performance.

b) ProjectAspects and Mitigation

Project Aspects

Under the new National Environmental Standard, No. 2734/PM-WREA , dated 7 December, 2009 (see Table 49), the average noise level in the ambient environment within 24 hrs should not higher than 70 dBA. In small or medium sized industries located in urban areas and high density communities, the noise level between 6:00 AM -22:00 PM shall not exceed 70 dBA and between 22:00PM-06:00 AM is limited to 50 dBA.

Table 40: National Environmental Standard and IFC's Guideline on Noise Level

Criteria	Applicable to	Day-time	Night-time
IFC Noise Level Guidelines (2007)	Residential, institutional, educational	55 dB (A) (one hour average)	45dB(A) (one hour average)
	Industrial, commercial	70 dB (A) (one hour average)	70 dB (A) (one hour average)
Lao PDR standards for ambient noise 2017	Not defined	70 dB (A) (24 hour average)	70 dB (A) (24 hour average)

The construction of PLHPP will involve many project activities: use of transport; construction of coffer dam, power house, switch yard, camps, maintenance and machinery repair shop, access roads and transmission line; explosion and excavation of rock and earth material; rock crushing and processing; cement mixing plant; compressor and diesel generator use.

These main sources of noise emission can be grouped accordingly: point source, ambient sources or mobile sources. Point sources of noise emission relate to rock crushing and processing, cement and mixing plant, compressor station and diesel generator while rock explosion, excavation and transportation of materials can be categorized as mobile sources.

Generally sound intensity level and the affects to humans by point and mobile sources may vary depending on the type of activities and exposure period. The reference of sound intensity is shown in Table below.

Table 41: Sound Intensity and Protection Measures

Activities	**Sound Pressure Level, dBA**	**Protection Measures**	**Additional Remarks**
Living room without TV and radio	40	Not required	Quite noticeable
Office	60-65	Not required	Noisy
Average Street traffic and heavy trucks movement	80-85	Not required	Noisy and intolerable for conversation
Air Compressor Operation	95-110	Ear Protection Required for Sustain Exposure	
Stone Crushing	98-120	Ear Protection Required for Sustain Exposure	
Cement Mixing	80-100	Ear Protection Required for Sustain Exposure	

The noise level during the construction will vary but will not exceed 85 dBA and it is predicted that the noise level from the sources, or within 1 km of them, should be approximately 45-49 dBA; 2km from the source the level should be about 40-43 dBA.

Mitigation

To prevent and minimize the noise impacts during construction and comply with national noise level guidelines, some applicable measures shall be identified and implemented including the following:

- Identify the noisiest equipment and activities.
- Schedule suitable working time for noisiest equipment and trucks.
- Limit working time and speed of transport and allow only necessary equipment on construction sites.
- Regularly perform inspections and maintenance of equipment and trucks.
- Provide baffles and noise insulating material for specific equipment as necessary.
- Provide mufflers or ear plugs for employees who work in a high level of noise.
- Position any high pressure or noisy equipment far from villages or employee camps. equipment such as generators, air compressors, etc.
- Reduce noisy activities, especially at night time.
- Avoid transporting materials past villages.

c) Magnitude - The highest noise measurement during construction should be 85 dBA. This will mostly affect construction workers who can wear ear protection if required; in any case noise levels of 85 dBA do not require ear protection. Villagers will be affected very little because within 1 km of the noise source the level should only be 45-49 dBA which is a safe and relatively low level. So, the magnitude of the noise is low to moderate and usually temporary in duration.

d) Importance

The importance of the noise generated is considered to be low because it will affect few villagers, and the construction workers who will be experiencing stronger noise levels will be provided with ear protection if required.

The magnitude of the noise is low to medium and of short duration while the importance is low (as described above). Therefore, the Significance of this impact is low to medium and short in duration.

c) Recommendations

This impact is quite manageable. It is only necessary to see that the mitigation steps stated above are implemented. A technician should be assigned the job of monitoring noise levels and implementing mitigation measures.

8.4.3Impact of on Water Quality

1) Construction Phase

a) Introduction/Concerns

Most ofthe constructin activities can affect the water quality, increasing the total solids and sediment in the Mekong River. Significant increases of oils and chemical spills may also create negative impacts on water quality at the areas around the construction site and at downstream area.

The water quality may be affected during the construction period as follows:

- Change in pH, primarily due to contamination with concrete.
- Increase in Biological Oxygen Demand (BOD) concentration from construction camp sites and temporary construction offices. This cause could occur from untreated wastewater and insufficiently treated sewage water. Therefore, mitigation measures must be strictly implemented during the construction period.
- Oil contamination from maintenance and equipment or from machine use.
- Accidents including oil spills and other similar products contamination.
- The rock fill quarry will be within the reservoir boundary, thus restricting physical change to an area that will be surface water drained during rainy season.
- Dry ups during the filling of the reservoir.

b) Project Aspects and Mitigation

The construction of PLHPP will involve the construction of camps, a cofferdam, diversion structures, a powerhouse on the riverbed, switchyard, sluice gates, navigation lock, fishpass, access roads and other structures. The construction of these

structures will involve the following: clearance of forest and topsoil; ground leveling; waterbed digging; excavation; the removal of overburden layers over the river bed which are mainly composed of silty, fine sand; construction of navigation lock.

A diversion of water in different stages will be applied to minimize downstream water supply impacts. During the earlystage of the diversion period, the cofferdam only narrows the original river course and will not affect the downstream water supply conditions. During the laterstage of the river closure period, the elevation of water level will continuously increase and the elevation of closure gap will significantly increase when the closure gap is closed up. And the river water will run through the sluice gate.

The average rainfall in the area is about 1,300 mm with about 76% of the rainfall falling during the rainyseason. The maximum discharge occurs from February to March where the average flow in the Mekong River at the project area is about 1,100-1,200 m3/sec and the lowest flow recorded is 700 m3/sec. The dilution factor from the flow is very high.

Mitigation measures include the following:

- Installation of waste water treatment plant for worker camps.
- Safe disposal of vehicle maintenance oils.
- Safe storage of chemicals and disposal of used containers.
- Attention to concrete shuttering to prevent accidental spillage of wet cement into water courses.
- Prevention or washing cement mixing equipment in water courses.
- Attention to good earth moving practice when working near water courses.
- Removal of surplus vegetation in the reservoir area prior to impoundment.

c) Magnitude

Certainly any pollution of the water around the project area could have an effect over a wide area, especially the downstream locations. So the potential magnitude of change is high

d) Importance

Clean water is very important and many people downstream use the water .

The assumption of this report is that during the construction of coffer dam impact will be minimized through adoption of best practices for cofferdam construction and a strict implementation of mitigation measures throughout the construction period. Since correct mitigation steps will be taken, it can be concluded that the construction of the cofferdam and its removal, as well as other construction activities will be of moderate importance.

e) Significance

The significance of this negative impact on water quality is predicted to be moderate/high with a short to medium duration.

8.4.4Impact on Land and Soil

1) **Construction Period**

a) Introduction/Concerns

The potential impact during construction on soil could result from the following:

- Loss of topsoil.
- Failure to rehabilitate borrows areas and temporarily acquired land.
- Soil erosion and siltation.
- Soil contamination by fuel and lubricants.
- Disposal of excess earthworks.

b) Project Aspects and Mitigation

Three details of mitigation measures are shown below:

1) To minimize the potential impact on soil from the activities of the stone quarries, cofferdam quarries, and borrow pit material extraction, an environmental protection point of view will be used along with economical rationality and quality guarantees.

2) Borrow pit material extraction will be undertaken in sections with rehabilitation undertaken in stages to minimize erosion. Rehabilitation shall include the following:

   - Regrading slopes to minimize erosion
   - Replacing stockpiled soil cover
   - Replanting grass, shrubs or trees
   - Installing sediment runoff control devices
   - Providing ongoing erosion monitoring

3) impacts on temporarily acquired land will be minimized by comprehensive rehabilitation work.

4) oil erosion and siltation will be minimized by preventive measures implemented on a case-by-case basis, such as planting shrubs and grass and appropriately engineered storm-water diversions.

5) Construction of the access road could result in increased soil erosion, which will be minimized by appropriate road engineering, including appropriate road compaction and runoff design.

6) Soil contamination will be prevented by installing oil separators at wash-down and refueling areas, and installing secondary containment at fuel storage sites.

7) The largest potential negative impact is related to waste rock disposal and materials mining. Excavated rock and aggregate will be used in construction to the maximum extent possible.

The Amended Forestry Law, No 06/NA (Dec. 2007) is an important guide to mitigation measures.

c) Magnitude and Importance

Magnitude – as described above there will be much land/soil affected so the magnitude of this impact is high

Importance – loss of healthy soil or improper removal and storage of it is very serious so the importance of this impact moderate to high.

d) Significance

The significance of construction on soils and topsoil is moderate to high and negative.

e) Recommendations

Loss of topsoil will be avoided by stripping and storing topsoil (where present) prior to construction and reusing it appropriately.

2) Operational Phase

a) Introduction/Concerns

During operation, potential impact to soil could occur from spillage of hazardous wastes and materials, including hydrocarbons and localized scour at the water discharge outlet.

b) Magnitude

The magnitude of this impact is high since the area of backwater is kilometers and erosion could occur along the newly created riverbank.

c) Importance

The main problem during operation would be erosion and this fact is already being used in project design. For example, residents who live near possible erosion locations would be relocated away from the riverbank area (in the RAP); therefore importance is put at low.

b) Significance

The significance of this impact will be low to moderate and the duration will be for the life of the project.

8.4.5Impact from Solid Waste Material

1) Construction Phase

a) Introduction/Discussion

Improper disposal of waste materials, especially organic waste material or domestic waste, can cause substantial environmental damage which could seriously pollute soil, water and air unless good practice on these are arranged.

b) Project Aspects and Mitigation

Project Aspects

The solid waste that will be generated during the construction of the project will be waste from construction material and domestic waste. Amount and quantity of solid waste material from construction activities and camps as well as offices varies.

Mitigation

- Any waste slag stored in the reservoir area should be far away from water inlets during the construction period and should not occupy the main channel during the flood period.
- All these off-site disposal areas should be constructed according to the best practices of solid waste management and approved by the government authorities. No on-site landfills shall be developed.
- Hazardous waste will be collected and stored on-site in approved facilities according to relevant standards. Hazardous waste will then be removed from the site to approved hazardous waste disposal facilities.

c) Impact Assessment

Solid waste materials could have adverse impacts on the surroundings riparian vegetation, aquatic fauna as well as human being if improper disposal. Since the land use on the two sides of PLHPP is traditionally held, so spoil dump locations are critical to local residents and will be located so as to avoid damage to the extent possible.

It will be necessary to have an appropriate disposal sites for solid waste in the Project Area. It will also be necessary to monitor and control the disposal during the construction and operation periodfor preventing the pollution to the Mekong River water and near-by. The significant of the impact is potential minor. With these

application of mitigation, the solid wastes residual impact of the project on land use and Mekong river can be mitigated.

2) Operation Phase

a) Introduction/Concerns

Improper disposal of waste materials, especially organic waste material or domestic waste, can cause substantial environmental damage which could seriously pollute soil, water and air during the project operation.

b) Aspects of the project

In this phase, domestic and industrial wastes from the hydropower plant and accommodation facilities will be disposed of in off-site approved municipal and hazardous waste disposal sites.

As mentioned in the project description, the land area in the vicinity of dam site will be used for office and living facilities, warehouses, E&M equipment assembly yard, auto repair workshop, materials make up area, machinery depot, concrete batching plant, quarry sites, disposal areas, roads, and so on. These facilities will generate some solid wastes that need proper disposal and management.

c) Impact Assessment

Similar to the construction periodbut with smaller amounts of waste, the solid waste materials could have adverse impacts on the surroundings riparian vegetation, aquatic fauna as well as human beings if improperly disposed of. Since the land use on the two sides of project is traditionally held, so spoil dump locations are critical to local residents and will be located so as to avoid damage to the extent possible.

From the above reasons, appropriate disposal sites are required for solid waste headwork compound area including residential and office and related working shops. It will also be necessary to monitor and control the disposal during the construction and operation phases in order to prevent pollution to the Mekong River water and near-by. The significance of the impact is potentially minor. With these applications of mitigation, the solid wastes residual impact of the project on land use and the Mekong River can be mitigated.

d) Recommendation

A construction material handling and disposal protocol that includes spill responses should be prepared and implemented as part of each site's environmental supervision procedures.

8.4.6Sewage and Wastewater

Construction Phase

a) Introduction/Concerns

Water used for project activities maybe pumped into the river. This may increase pollution to the natural environment in the project area.

b) Project Aspects and Mitigation

The water will be used in various construction activities including the following: rock excavation; concrete pouring and curing; concrete batching system; aggregate screening system; production of other plants; construction (including housing).

Domestic water means the water used for sanitation, washing, cleaning. Discharge of domestic wastewater or sewage can be considered as a point source pollutant. Any untreated discharge of domestic sewage from point sources into the environment and any bodies of water can lead to the deterioration of the water quality and surrounding environment.

c) Impact Assessment

Domestic sewage contains the following: high nutrients of nitrogen and phosphorus; pathogenic organisms; suspended solids; oxygen demanding material; biodegradable organic matter (COD and BOD). Excessive concentration of biodegradable organic material can lead to a depletion of the dissolved oxygen level in the water, and nutrients of nitrogen and phosphorus can lead to the large growth of algae. Pathogenic organisms include viruses, protozoa, and bacteria excreted by a diseased person or animal. When discharges go directly into surface water this may pose impacts on aquatic life as well as humans.

d) Recommendation

It is recommended that all sewage must be collected and treated by high efficiency septic tanks and make sure that the discharge of treated effluent meets the national environmental standards; sewage will need to be monitored to ensure no harmful to the natural environment in the project area.

Operation Phase

The PLHPP is a run-of-river hydropower plant. The transformation of water flow due to impoundment will not occur. Therefore, the PLHPPwill not cause any significant impact or changes to the downstream discharge. Also, it will not cause a significant impact on water use downstream.

The existing water quality of Mekong River is generally of good quality. Nevertheless, the water level in the upstream area will be higher than the existing condition. To maintain the minimum water flow in the downstream section of the river and to minimize the impacts on flora and fauna, it is suggested that an automatic hydrological forecasting system be established. This system will provide a communication interface connecting the hydrologic forecast system of Mekong River and the dispatching center of the PLHPP, thus the fluctuation level of the water flow in the upstream area and downstream will be minimized.

The reservoir will not act as a storage reservoir and will have a very short residence time which will be only slightly longer than the pre-impoundment condition. However, the movement of sediments may be somewhat affected and while the majority will pass the structure it is expected that some may accumulate in front of the dam. The dam has been

provided with a series of low opening gates that are intended to flush sediments away from the turbine intakes. When these are operated it is likely that there will be a flush of sediment through to the downstream aquatic environment. The consequences of this have beenrecognized in theMRC publication on Preliminary Design Guidanceand a section is devoted to management of sediments released from run-of-river dam sites.

8.4.7Geology & Seismicity

a) Introduction/Concerns

The general concern is about dams cause earthquakes that related to the extra water pressure created in the microcracks and fissures in the ground under and near a reservoir. When the pressure of the water in the rocks increases, it acts to lubricate faults which are already under tectonic strain, but are prevented from slipping by the friction of the rock surfaces. This may related to the conventional storage dam but the run-off-river scheme may has very few problem on this issue.

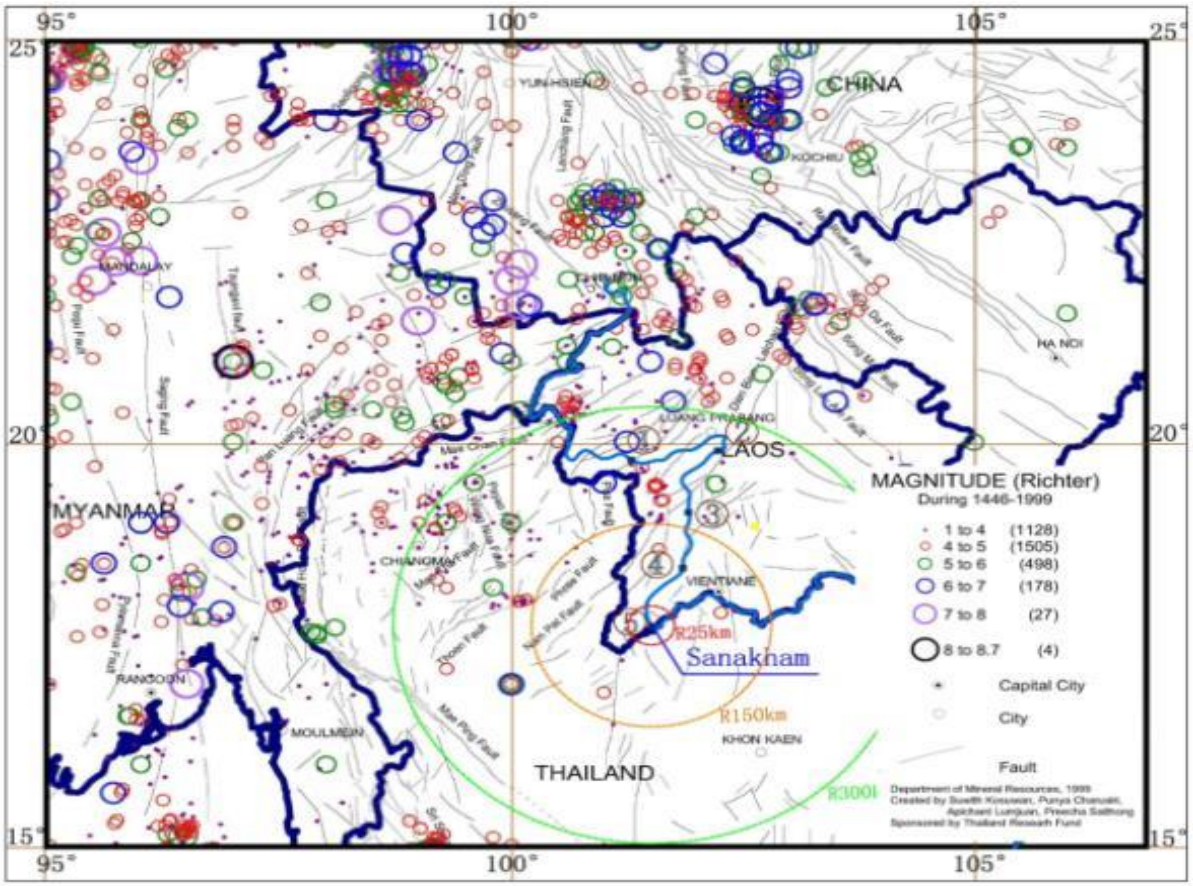
b) Project Aspects and Mitigation

The highest altitude is in the north, which is known as "India Sina Ridge." The eastern mountainous area is the Truong Son Ra Mountains on the border with Vietnam. The western part of the country is marked by the Mekong River and its coastal plain to the low hilly area that borders with Thailand. So overall, Laos is a region of high elevation in the north and low in south with a slope from east to west.

The highest point in project area is about 460 m, and the lowest point is the Mekong River.The elevation is less than 200 m, and the relative height difference is up to 260 m. It is in the south end of the Hengduan Mountains, with the Luan Shan mountain range in the south. In general the elevation is low in the southwest and high in the northeast. The overall landscape is characterized by a hilly topography with relatively wide and low depositional basins between the mountains. The mountain region is in roughly a NE - SW direction, and is consistent with the North East Line folds and fracture lineament, suggesting that the topography is controlled by regional tectonics. On both banks of the Mekong River in the region are three levels of terrace development, of which terrace I is the most developed, and the elevation is at EL.13 m ~ 20 m, and the width is 300 m - 1300 m. The main composition is silt and silty clay, with a small amount of gravel at the bottom. It is not the standard

features of the dual structure. I and II grade terraces are mostly erosion terraces, the height is about 30m ~ 60m, and the surface is usually covered with Qel-dl.

Within 25 km of the project area, there is no obvious evidence of earthquake activity in the last 553 years, although there are several faults running NNE; also, there is no historical record about a strong earthquake greater than 6 magnitude. Thus, from the regional geological tectonics and crustal activity point of view, PLHPP site is a relatively stable region.



Source: Department of Mineral Resources, 1999.

Figure 30: Historic earthquake distribution of Project Area in 553 years (1446-1999)

Tectonics

The general fracture strike is NNE ~ NE (see Figure 4.2.2). The fracture is formed by two main fault zones and a number of broken sub-fractures; all zones are distributed with a 30 km wide range, and extend out of the near-field zone at the south and north ends.

Nam Pat Fault at the west of near-field area: attitude is NE 35 ° SE ∠ 85 ° ~ 90 ° (partial tilting toward North West), width of fault rupture zone is 10m~50m, include mainly the

fragmented rock, mylonite, sheet rock, with a total extension length of more than 300 km (extending southwest into Thailand, northeast across the border of Laos into Vietnam), and pass from the town of Paklay of the reservoir. The distance straight to the dam site is about 30 km.

Nam Duk Fault at the east of near-field area: the attitude is NE 10 ° SE ∠ 80 ° ~ 88 ° (partial tilting toward North West). Width of fault rupture zone is 5m ~ 15m, including mainly the fragmented rock, mylonite, sheet rock, with a total extension length of more than 80km (extending southwest into Thailand, and northeast with intersection with the Nam Pat fault). The meeting point is also near the town of Paklay, and the distance straight to the dam site is about 20 km or so.

According to the analysis of the characteristics of the fault geometry, structure, substances and landscape performance, the nature of faults are different in different directions and parts, mainly normal faults and reverse faults.

Most of the fractures are cemented, highly weathered on the surface. The vertical crustal movement since neo-tectonic times has been modest. The Mekong River is relatively wide, and passes through the low bedrock mountains. As a major fault zone, the development of linear landscape of Nam Duk Fault and Nam Pat Fault parts at the near-field zone is moderately poor.

According to the fault activity survey, the activity of two regional faults is poor in Quaternary. The continuity of the main fracture topography is reflected in the local site outside of Paklay and near-field. In accordance with the 8 groups of test results of the fault year using the ESR (electron spin resonance) year dating year method, the fault activity was more than 380,000 years ago. Only in the local area outside of the near field there are activities of middle Pleistocene of Quaternary. The latest activity of two regional main faults and branch faults near the dam site in the near-field region (25km range) show that it is between the early and middle Pleistocene of Quaternary. The dam site's tectonic construction is relatively stable, and the new construction activity is relatively weak. There is no strong devastating seismic structure.

The Nam Duk Fault and the Nam Pat Fault regional have little effect on the project site, and there was no destructive earthquake in recent history. The maximum intensity of future destructive tectonic earthquakes is estimated at about 5.5 degrees using the Richard scale.

The venue has no limestone and the structure is stable, and the maximum reservoir induced seismicity is not more than 3.5 degrees. The greatest impact of both on the site is up to degrees. The branch faults are at least 1000m away from the site. The fracture zone section is nearly vertical, and there is no ability and consequences of horizontal dislocation of construction activities. Measures against breaking near the site may not be considered in the project.

Although there is distribution of two regional faults: Nam Duk Fault and Nam Pat Fault in the near field zone around the site, judging from its location, historical earthquakes situation, etc., the activity should not be strong; there is no regional fault or historical earthquake within 5km of the dam site. According to the existing norms of China, it belongs to the regional tectonic zone of stability.

Magnitude and Importance of Importance

Magnitude – Earthquakes can cover a large region but there is no historical record to indicate an earthquake is likely in the project area

Importance – The dam will be built according to the strength required for the seismic activity this region. Therefore, this impact should be of low importance

Significance

The significance of this impact is low due to the unlikelihood of an earthquake occurring; the duration will be for the life of the project.

Recommendation

The height of dam in this project is a low dam, so the regional tectonic seismic activity has little effect on the project.

8.4.8Impact on Aquatic Environment

1) Construction Phase

a) Introdiction/Concerns

The construction of main workmay result in deterioration of water quality that could lead to the creation of some impacts on the aquatic ecological system as well as to the destruction of habitat, spawning and feeding grounds. There will be a blockage of fish migration due to dam construction. Also, there could be a serious impact on endangered species. Theoretically there might not be an adequate minimum flow downstream from the dam. Upstream of the dam, the habitat will change from free flowing to an impounded area.

b) Project Aspects and Mitigation

Transformation of the habitat from a river with rapids into to standing ecosystem due to impoundment will not occur for PLHPP due to the run-of-river design. Fish species which live in running water habitat will not be negatively impacted to the new conditions. There are number of species which appear in schools such as Henicorhynchus spp. Cirrhinus spp. with a short life span and a fast rate of reproduction; normally their abundance in the catch appears to follow the level of floods from the upstream.

The creation of a barrage without any reservoir stagnant effects will improve the overall natural fish production capacity of the Mekong River in the project area, especially in the dry season; based on the information of the water quality and the existing aquatic organisms, species diversity and their quantities, a positive impact on fish biomass will occur for species that do not have long distance migration patterns. The increasing volume and regulation of the water level would be a benefit for many aquatic living organisms. After impoundment, fisheries activities would have to be adapted to using new fishing methods and gear.

c) Impact assessment

With the project on this type and size, it is assumed that seasonal siltation (draining of water from the catchment area, and agricultural zones during the rainy season) and long term degradation (deforestation of catchment areas) will have negative impacts on the aquatic environment. During the construction period, the water quality in the river will be affected by the construction work in the project area. Increased turbidity is expected to be generated which will affect the living conditions of plankton and benthic organisms. At the downstream site, there are confluences with tributaries; the fisheries here need to be managed properly to prevent incorrect exploitation and promote sustained fishing practices.

Different species should be affected at different degrees and different trophic levels, with those directly feeding on plankton among the most affected. According to the fish species survey, the majority of fish found abundantly in the Mekong Hydroelectric Power Project area of the rheophilic type which feed mainly on plankton and bottom sediment. The reduction of plankton and benthic fauna during construction period is believed to be insignificant since the level of plankton density is already low and the effect of siltation and water turbidity will only occur during the construction period; the aquatic organisms will recover in the short time.

With regards to fish populations, the study on species composition and their abundance in the project area indicated that the fish populations in this stretch of river are already low and the number of species is relatively small, the change in hydrological conditions will not affect resident species that are able to live in impounded condition. Fish species with long distance migration patterns and those that spawn in rapids or submerged vegetation are likely to be affected. The study used six sampling stations; the majority of families except Cyprinidae were represented by only 1-3 species.

Transformation of the habitat from a river with rapids into to standing ecosystem due to impoundment will not occur for PLHPP due to the run-of-river design. Fish species which live a running water habitat will not be negatively impacted to the new conditions. In the Mekong River, there are number of species that form in schools such as Henicorhynchus spp., Cirrhinus spp. that have a short life span and a fast rate

of reproduction; normally their abundance in the catch appears to follows the level of flood from the upstream.

The creation of a barrage without any reservoir stagnant effects will improve the overall natural fish production capacity in the Mekong River in the project area, especially in the dry season. Based on the information of the water quality and the existing aquatic organisms, species diversity and their quantities, a positive impact on fish biomass will occur after impoundment.

The increasing volume and regulation of the water level would be a benefit for the aquatic living organisms. After impoundment, fisheries activities would have to adapt to using the new fishing methods and gear.

In sum, this may be an effect of high importance and medium to high magnitude, leading to a significant impact. The potential impact will be negative at a moderate level during construction period.

2) Operation Phase

a) Introduction/Concerns

Operation of project will cause changes to freshwater ecosystem, altering flows, interrupting ecological connectivity, and fragmenting habitats. This will adversely affect fisheries, aquatic biota and aquatic biodiversity.

b) Project Aspects and Mitigation

The project will create a tail-water-pond and the backwater will be extended to 81 km upstream from the main dam. The land to be submerged includes arable land, orchard, woodland and homestead. These areas will be transformed from land to fully water in the peak rainyseason while some part of them will be appeared in the dry season.

c) Impact Assessment

The information above showed that the dam will impede upstream fish migration, downstream conditions will not change significantly. The following issues may have an impact on aquatic biodiversity.

After a number of years of operation and because the upstream fish migration route has been blocked (migration cycle links cut), fish will return in far fewer numbers on an annual basis. If tail waters are available as spawning habitat, and fish are releasing buoyant or semi-buoyant eggs / larvae, these will pass through the dam's turbines. Hydraulic shear pressures created internally within the turbine housing will result in very high mortality rates for eggs and larvae and result in very poor recruitment to downstream fish populations beyond the PLHPP.

Almost all species are exploited to one degree or another, and at various stages of their life-cycle. Some "white fish" species are short-lived, and because they can complete their life-cycle within at least one calendar year, they can take high levels of fishing pressure and their populations, perhaps as isolated genetic stocks, will always survive. Disturbance to aquatic habitats by hydropower dams represent a risk to the long-term sustainability of fisheries. Long-lived, late maturing larger "white fish" species are potentially at far greater risk than the smaller short-lived, early maturing "white fish" species.

The most important impact of dams on the Mekong will be on long distance migrants that move up the Mekong to breed, some as far as China. The Mekong giant catfish (Pangasianodon gigas) is believed to be a long distance migratory fish. Research has found that there are different and isolated stocks of this fish such as those found in Tonle Sap and other deep pools in the Mekong River. This fish has succeeded as a cultured fish in Thailand by using the brood-stock from an upstream pond, but it still is in the list of CITES.

Therefore, the negative impacts that the PLHPP will have on Fisheries and Aquatic Resources (FAR) will depend on many factors and variables. Not least of these will be the construction sequence of the 5-dam cascade projects are to proceed. Dams disrupt the continuity and linearity of riverine systems, and greatly impact migratory fish populations in a negative way. Without seasonal fish migrations, and the fisheries that rely on them, livelihoods and food security for riparian communities will be compromised to various degrees, and depending on circumstances may be serious.

As the upstream pond will be created with different flow condition, the following impact may occur to aquatic biodiversity.

1) Loss of habitats with rapids / riffles and deep pools throughout the entire river stretch from the dam to the upper reservoir tail water. Considerable reduction in spawning / production areas and dry season habitat for rheophilic Mekong species (require flowing water) and certain more sedentary type fish species. Fish production of some real riverine species over the impounded area will be less than under pre-impoundment conditions over one calendar cycle.

2) The fish species composition of the upstream pond will be different to that of the pre-impoundment riverine species population. Some species that are able to adapt to the reservoir conditions may develop to the point where they dominate the fish population including the possibility of the proliferation of predatory species which may impact on non-predatory fish populations.

3) Impact on spawning and recruitment to reservoir fish populations. Certain riverine species will adapt to reservoir conditions.

4) Proliferation of exotic species such as Tilapia (Oreochromis spp.) that are farmed in net-cages or in earth ponds have much less consumer appeal. If the PLHPP is to proceed, then landings of introduced species will need to be monitored and assessed. Common Carp (Cyprinus carpio) that produce adhesive eggs laid on various substrate material may become a very important part of the fishery.

d) Magnitude and importance of change

Not all fish species caught in the project area are threatened by the mainstream dam. Some species have only limited migrations over short ranges which may not be impaired by dam structure whilst other are highly adaptable to habitat modifications including impoundment.

The species most likely to be impacted will be those that undertake significant (passive and active) migration between critical (spawning, feeding, and refuge) habitats to complete their life cycle or to exploit seasonal variations in habitat quality and availability.

The impact on the aquatic biology and fish population is an effect of medium to high importance with high magnitude.

e) Significance

The potential impact will be a negative affect at a moderate level for upstream and low level at downstream.

f) **Recommendation**

It is possible to have a project fishpass facility to mitigate the migratory of fish(The monitoring facilities will be constructed along with project construction, and the specific operation and management measures will be refined in the subsequent design). The maintaining downstream flows and upstream migration is crucial to the sustainability of fish populations.

The fish transport mobile unit with large container with aeration system will set up for collected the fish from downstream or pond of fishpass way cross to upstream.Adoption of aquaculture within the headpond area would be a partial solution to the loss of migratory species.

8.4.9Impact on Terrestrial Environment

1) Construction Phase

a) Introduction/Concerns

Besides the transform land especially from woodland arable into water body will lost some habitats for terrestrial flora and fauna, the noise/vibration disturbance expected to be created from construction activities as well. The in-migration of construction workers to the project area may at risk to the nearby local village forest for seeking wild food.

b) Aspects/Mitigation of the project

During the construction period of approximately six years, a large workforce will come to the project area (number to be determined). Construction activities include the use of heavy equipments and blasting.

During construction, the loss of habitat and the reduction or cutting off of river flow there can be a negative impact on terrestrial and aquatic life. Also, noise, dust and vibration caused by construction activities, particularly blasting, can disturb and impact almost all of the wildlife species. The ecological instability generated by the flooding of a large area and the resulting movement of large numbers of animals can have an impact on public health and cause crop

damage. Crop pests can become a more serious problem for a short period in fields close to the reservoir.

There is likely to be some migration of noise-sensitive wildlife away from the source of the disturbance, resulting in the localized decrease in the numbers of some species. Owls, flying squirrels and bat colonies are particularly affected by the introduction of night time noise vibration. In addition, during the construction phase there may be increased hunting pressure by the workforce.

In addition to negative concerns mentioned above there can be an improved management of ecological resources by the local community due to project initiatives. An increased knowledge of the local ecology due to wildlife and fauna surveys (as part of the initial impact assessment and ongoing monitoring) should be useful. There will also be the potential to reduce the human pressure to wildlife in the surrounding project area and protect pockets of undisturbed forest. The Project could provide a water source for the wildlife; the reservoir itself may serve as a source of water during the dry season or drought to wildlife living within the area. In addition, new habitats for some species would be created. The project could stimulate the local economy in the long-term by attracting businesses and ecotourism through sight-seeing and bird and wildlife watching if there is a good and sustainable management plan on forest and wildlife conservation. The local people's awareness of forest and wildlife conservation should also improve with adequate training.

Mitigation:

During the construction, in order to minimize the impacts on wildlife, a number of steps must be taken; management and mitigation measures will be as follows:

- Supporting local conservation initiatives concerned with the protection of high-value habitat, or endangered wildlife species.
- Minimizing the impacts of wildlife hunting by the appropriate location of project facilities, protection of high-value habitat and effective site rehabilitation.
- Establishment of a Environmental Management Office within the project to work closely with the government authorities concerned and to be responsible for wildlife protection as well as conducting wildlife rescue especially during reservoir filling or reservoir impoundment.
- Formulate the detailed forest clearing plan linked with salvage logging and biomass clearing plans, particularly in the proposed reservoir area, aimed at giving space and routes for wildlife to escape during construction.

- During construction, all project workers and staff including contractors will be prohibited from the hunting, buying or trading of wildlife. As stated in the Wildlife and Aquatics Law and other regulations concerned, hunting and trading of conservation species, especially from the prohibited and controlled list (List-1 and List-2) will be strictly banned. Strict rules against wildlife hunting and poaching will be imposed on project staff, workers, and all contractors engaged in the Project with penalties levied for anyone caught carrying and using firearms, animal snares or traps.
- Environmental education and awareness programs will be conducted for project staff, project workers and in local villages. For Project staff and workers, this will improve the awareness and understanding of the importance of forest resources for local communities; also, they need to be made seriously aware of prohibitions and penalties regarding hunting, wildlife trading and the collection of other forest resources.
- In order to minimize noise and vibration impacts, it is recommended that the Project should minimize the noise and vibrations generated by project construction by ensuring that all machines or equipment incorporates industry standard noise reduction systems and comply with applicable noise standards as mentioned in the section above.
- All project workers and staff including all contractors at the project area will not be allowed to bring any hunting tools into the forested areas. All related laws and regulations concerned will be disseminated to all project workers, staff and all contractors involved.
- As mentioned above, salvage logging and vegetation clearance in large areas of the inundation should be done in area by area or plot by plot in order to give spaces and ways for wildlife to escape during clearance and construction.

2) Operation

a) Introduction/Concerns

The creation of the long reservoir along the Mekong River will create some small fragmented forest areas and block the movement of wildlife particularly mammals. Additionally, the other permanent constructions and infrastructure including access roads will impact the regional movement of wildlife species.

Fragmentation and reduction of wildlife habitat could affect on the population of wildlife. Some wildlife species can be illegally hunted easier than before by local villagers and project staff due to better access to forest areas because of new roads and the reservoir. Resident and migratory birds which use the forest habitats as feeding, resting and nesting sites could be affected

On the other hand, in terms of positive impacts, the project would provide a water source for the wildlife. The reservoir itself may serve as a source of water during the dry season or drought to wildlife living within the area. In addition, new habitats for some species would be created. The project could stimulate the local economy in the long-term by attracting businesses and ecotourism through sight-seeing and bird and wildlife watching if there is a good and sustainable management plan on forest and wildlife conservation. The local people's awareness of forest and wildlife conservation should also improve with adequate training. Improved roads (not all from the project) and infrastructure within the area are also likely to stimulate local trade and business activity especially income for local people.

b) Project Aspects and Mitigation

The results of field reconnaissance survey, villager interviews and the incorporation of the available secondary data identified more than 50 species within and around the project area. Among these, are mammals, reptiles, amphibians and bird species.

There is currently no indication of significant numbers of owls, flying squirrels or bat colonies being present; however, due to the mountainous terrain nearby the project area and the presence of caves along the escarpment of the mountain, the presence of such wildlife, especially flying squirrels and bats, cannot be discounted. In terms of

wildlife trails, from the field survey we found that no wildlife trails have been identified in the vicinity of the project area.

Narrow wildlife habitats areas, wildlife trails and food-sources of wildlife and birds will be affected within and around the project areas.

Among the total forested area to be cleared for project purposes, particularly the reservoir, a large portion of the project area is within a proposed protection forest which will cause a loss of natural forest resources, wildlife habitats, biodiversity and natural ecology.

There are some species classified under the “Prohibited List” (or “List 1”) or “Controlled List” (“List 2”) that need special consideration.

Prohibited List (List 1) species are the rare and endangered species which have a high value or special importance for various reasons including economic value, social value, educational scientific research; it’s illegal to hunt these species except for research and breeding purposes and they must be managed, inspected, preserved and controlled.

Controlled List (List 2) species are also beneficial for economic or social reasons, environmental reasons, and the livelihood of multi-ethnic people or for educational scientific research; they must be managed, inspected, preserved and controlled. These species cannot be hunted, except for some customary use by local people.

c) Impact Assessment and Recommendation

During the operation period, in order to minimize the impacts on wildlife, a number of steps must be taken; management and mitigation measures will be as follows:

Supporting local conservation initiatives concerned with the protection of high-value habitat, or endangered wildlife species.

Minimizing the impacts of wildlife hunting can be arranged by the appropriate location of project facilities, protection of high-value habitat and effective site rehabilitation.

Establishing an appropriate program to monitor the effects of the project on biodiversity and ecological resource use.

Hunting will be controlled and illegal hunting will be prohibited. Species and population surveys have to be conducted continuously during the operation phase to mitigate the impacts on wildlife in the area.

A habitat restoration program will be developed in the areas disturbed by the contractor.

Area utilization of local people could disturb wildlife populations as well as add hunting pressure. Local people should be prohibited from earning their living in the forest particularly in the watershed area.

In the constructionarea there should be a prohibition against having fruit orchards, houses or buildings; also, fisheries should be strictly controlled in the watershed area surrounding of the reservoir.

Educational programs on wildlife conservation will be implemented in the communities of the Project by contractor.

Under the WCMU (WMPC), work closely with government authorities concerned to develop a Wildlife Management Plan in connection with Forest Management Plan in the catchment area where the habitat is still remaining and abundant.

Implementation of an appropriate program to monitor the effects of the project on biodiversity and ecological resource use which will affect wildlife.

Under the WMPC and in collaboration with district and provincial authorities concerned, develop and assist in land use planning to minimize the project related in-migration of people to the area. This will minimize exploitation of forest resources and wildlife and maximize employment opportunities for local people.

Conduct periodic monitoring of key wildlife species within and around the project area and downstream of the project area to assess whether any additional mitigation or management measures are required. In particular, a detailed survey will be conducted

to assess the distribution and status of the rare and endangered species and investigate whether any species specific mitigation measures are required.

8.4.10Navigation and Tourism

a) Introduction/Concerns

Concern is made on dam that it may create an obstacle for the movement of navigation between upstream and downstream area while tourism is considered a by product benefit from project development.

b) Project Aspects and Mitigation

The large navigation by ship and trading of goods was found in the upper part of the Mekong between Kunming (China) and Chiang Rai (Thailand) but very few here in the PLHPP project area. Most navigation include passenger logistic between both banks of the Mekong and some small scale fishing by small boats.

c) Impact Assessment

The raised water level in the upstream Mekong River channel (with back water extending to 81 km) will benefit to navigation and tourism in the upstream area of the PLHPP main dam. This is because of water level in the dry season will be higher with slower velocity that suitable for navigation and may create the water sport tourism.

d) Recommendation

In the long term, improve navigation (through the proper design of ship lock) and support tourism development at the dam (to water sport tourism in the upstream pond) shall be made and follow the MRC agreement in 1995.

8.5Downstream Area

8.5.1 Impact on Hydrology & sediment

Potential Impact on the Hydrology and Water Level

The Additional Hydrology of Paklay Hydropower Project hava been studied to identified the Minimum Flow During the Dry Season (E-flow) which appoved by Water Resources Department, MONRE as attached to this Report The filling of the reservoir is anticipated to start by the end of the first year as soon as the dam wall is high enough. From an environmental point of view, the seasonal patterns of the lows

downstream should be maintained as far as possible, even if the actual flow rate is considerably reduced. Minimum rainyseason flows are approximately 1/3 of the average. Releases downstream should be modified according to the season, so that the peak flows are reduced to one third of average monthly flow rates. The environmental flow assessment that was carried out as a pre-construction activity will provide the data for developing a hydrological model for filling the reservoir that maintains environmental integrity.

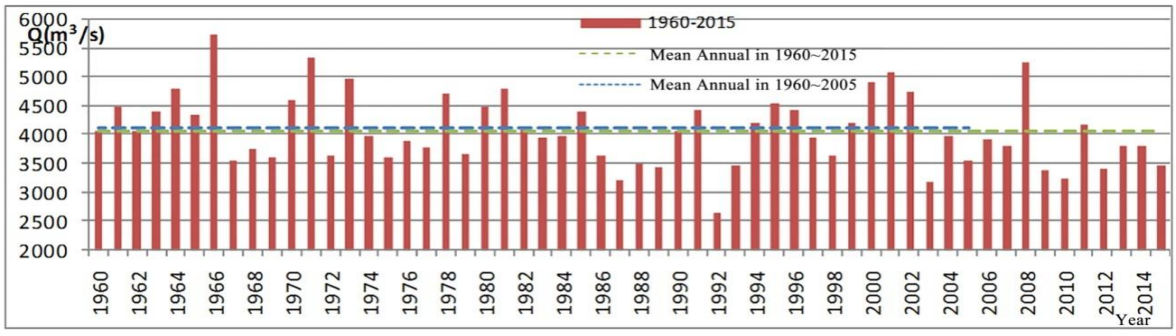
Environmental flow studies should be carried out during the first two years of the construction period to develop knowledge about appropriate flow regimes necessary to maintain the health of the river, its ecosystems and its productivity. This should be agreed between the developer and provincial authorities in consultation with local communities dependent upon the river.

The EFA will be do further study after construction and before impoundment.The project EMO will use EFA as tool to maintain the hydrograph as close to the natural conditions of the river during the various stages of implementation and operation of the project and the hydrological data will be kept record for monitoring. The independent review of flow release regime that should be detailed in the next steps. The project developer should be aware of the budget to cope with this issues therefore the specific TOR must be identify in ESMMP-CP and ESMMP-OP.

The monthly mean annual flow of the dam site is 4060 m^3/s and the corresponding annual runoff is 128 billion m^3 based on the statistics of monthly average flow in 56 years from 1960 to 2015. Refer to Table 2 for mean monthly flow at the dam site. Mean Annual Flow at dam site is shown in Fig.13.Mean monthly Flow at Dam Site as show in the table below.

Unit:m^3/s

Month	January	February	March	April	May	June	July	August	September	October	November	December	Year
Q	2550	2220	2030	2000	2090	3050	5320	5480	8440	5770	4040	3020	4060
%	3.59	2.70	2.31	2.37	3.49	6.62	13.63	21.14	19.14	12.13	7.86	5.03	100



Column of Mean Annual Flow at Dam Site

Impact due to the construction period

Overall the construction of run-of-river dams as a cascade rather than as series of reservoirs has removed many of the issues associated with reservoirs. This means that the river hydrology is not seriously altered and sediment movement is not seriously compromised since the river can return to its pre-impoundment flood regime allowing sediment to pass through the series of small run-of-river reservoirs. Run-of-river dams will also have a virtually unlimited lifetime as there is no reservoir to silt up. This makes good use of the resource for the generation of energy from a clean process using a renewable resource.

Impact due to the Dam operation

In normal conditions i.e. without floods, the surface of the reservoir can be considered as being level, since the backwater slope is very low. All the flow is turbine. The gates are closed until the input flow reaches the installed capacity of the powerhouse. During operation the following conditions will prevail within the reservoir. There will little change in the river's discharge regime as in-stream run-of-river projects operate as inflow = outflow. However, in a cascade situation with small reservoirs the normal hydrograph will be slightly attenuated and transposed due to the increased storage contained within the reservoirs. Overall there will be little impact on the flow regime with the most apparent effect being during low flows and the least effect during flood flows when the reservoirs will cease to act as storage reservoirs.

During high flows and floods, the upstream slope of the water level surface increases and is most pronounced at the head of the reservoir. As run-of-river dams have large gates these are progressively opened so that at no time is the flood level allowed building above the normal flow top water level. Otherwise, if the same regulated water level is maintained and a flood occurs this would build on the top water level and result in an increased backwater level with increased inundation hazard. However, gates must be opened slowly to avoid excess downstream flows and destabilization of banks of the reservoir.

Run-of-River Concept

Run-of-river hydropower projects have limited storage capacity so they have little overall impact on the river's hydrology as flow into the reservoir = flow out of the reservoir. Reservoir height is maintained by the operation of the very large gates that are provided with

these structures so that at no time is height of the flow allowed to increase above its normal level. i.e. the height of a 20 yr flood is the same as the “before” flood height.

- Run-of river dams have the following characteristics
- Storage capacity of the impoundment is negligible compared to river flow volumes, especially flood volumes. .
- There is no significant active storage in comparison to the storage of the reservoir at top water level.
- In normal operating conditions (input flow less than powerhouse capacity), drawdown is limited to small variations in the head pond.
- Output flow from the dam is equal to the input flow upstream of the reservoir.
- Where flows fall below the powerhouse design, run-of-river storages can be used for peaking.
- Some peak flood mitigation is possible if the event is limited in time and intensity.

Mitigation:

The only possible realistic mitigation measure is to develop aquaculture within the surrounding villages and this will need to be investigated further during the EIA.

It will not be possible nor is it is necessary to attempt to mitigate these minor changes.

Recommendations

The main beneficial impact arising from the PLHPP Project will be the improvement in boat navigation due to greater depth of water for longer periods. The inclusion of ship locks in the dam will allow vessels up to 500 t to pass the dam site. The reservoir will also provide a safer place for local people to fish and access the other side of the reservoir for longer periods.

Potential Impact on the Sedimentation

Construction will only take a few years and construction impacts are easily controlled providing an adequate Environmental Management and Mornitoring Plan (EMMP) has been developed. The main impact that was identified was the need to carry out work within the river channel to prepare the dam foundations whereby the downstream water may be compromised by sudden release of sediment disturbed by the activities. The construction work will need to be stopped if the downstream turbidity increases above a critical level.

Measures to reduce the sediment inflow into the reservoir area from construction should be applied as soon as construction commences. Erosion and sediment movement control will be undertaken as part of the soil conservation and erosion protection control program. During earthmoving, attention should be paid for soil erosion and sedimentation, to minimize the area disturbed and rehabilitate disturbed areas as quickly as possible. Particular care will need to be taken while operating during the rainyseason that excavation areas are minimized. Protection and diversion banks may need to be constructed above particularly susceptible areas while sediment control basin or river may be need below large excavated areas. Top-soils are to be stripped before any excavation commences and stored for site rehabilitation works. Sediment arising from construction sites will need to be monitored regularly and should be made in the future planning.

Impact due to the Construction period

These major sources of construction related impacts on water quality will be from erosion of disturbed areas required for the construction activities , from the wastewater discharge at the construction camp, and from contaminated water.

Excess in sediment load in water may occur at the early stage of construction, when earth works start. Pre-diversion construction works, excavation works at dam site, quarrying works, sand borrowing in river bed, creation of spoil areas too close to the river bank or with unstable slopes, all these activities may have significant impacts on water sediment load.

Also, high sediment loads may reach the river at the beginning of the rainy season, when heavy storms wash out unstable slopes of spoils or bare soils in the construction sites or camps, or along the access roads and construction site. In any case, strict respect of construction standards regarding slope, drainage and sedimentation ponds around disposal sites must be required from the contractor.

Impact due to the Operation

Run-of-river systems will have little overall impact on altering the sediment discharge with some expected build up of rapidly settling sediments at the top of the reservoir. Fine suspended sediments will probably continue as before with little settlement in the reservoir due to the short residence times. However, as the dam will operate as a cascade the overall impact on sediment being retained within the cascade system will be enhanced and this may

result in larger amounts of sediment being stored within all reservoirs which may only be mobilised when the river returns to its pre-existing situation during floods when all the dam gates are open.

Denial of sediment to a river results in an unsatisfied carrying potential which may be satisfied by the river collecting sediments from other available areas with fine readily entrainable materials such as sand, silt and clay deposits that may be situated alongside or within the river channel. Entrainment of materials depends on the velocity of the flow, the higher the discharge the greater the carrying capacity. This is a power relationship and normally as flow increase the carrying capacity rises as the square of the velocity. During dry seasons the river will operate as a river with some potential for erosion but this will be limited due to low velocities. During the rainyseason and as flow velocity increases so too will erosion capacity. Part of this will be met from bedload and higher suspended sediment concentrations carried within the flow and part will need to be met naturally from deposits that are already moving within the river channel.

It appears unlikely that the construction of dams will seriously exacerbate the current situation which is already subject to the forces of natural erosion. The Mekong has over many years created its current channel geometry to fit within the existing flow regimes and as neither the flow regime nor the sediment supply is going to be markedly changed it is expected that the downstream situation will remain relatively stable.

However, in the upstream situation i.e. within the reservoir, bank channels will now either be totally or partially inundated by the reservoir. It is highly likely that where these consist of fine deposits these will slump and collapse into the reservoir and this will continue until a new reservoir side slope results which is in equilibrium with the reservoir's hydraulics.

For the largest floods all gates are completely opened allowing the water level in the reservoir to be close to the pre-existing natural flood level. Thus the reservoir will cease to exist and instead it will be replaced by the pre-existing river conditions. This will remove any project exacerbated inundation flood hazard, as the reservoir now returns to a pre-existing river situation this will also allow accumulated sediments to be passed through the reservoir as before. Thus there will be little alteration to the sediment supply of the river.

Mitigation:

- Monitoring of downstream situation for any unusual erosion
- Undertaking precautionary bank stabilisation in the reservoir on susceptible areas that will be close to settled areas.

Recommendations

The basis for these obligations must be developed during the preparation of tender documents during the Detailed Design stage of the Project.

8.5.2Impacts on Water quality

a) Concern

Key issue of water quality to downstream will be during construction. The following sections assess the water quality condition by focusing in the construction period.

b) Aspects of project

The water quality could be affected during the construction period as follows:

- Change in pH, primarily due to contamination with concrete.
- Increase in Biological Oxygen Demand (BOD) concentration from construction camp sites and temporary construction offices. This cause could occur from untreated wastewater and insufficiently treated sewage water. Therefore, mitigation measures must be strictly implemented during the construction period.
- Oil contamination from maintenance and equipment or from machine use. Also, accidents including oil spills and other similar products contamination.
- The rock fill quarry will be within the reservoir boundary, thus restricting physical change to an area that will be surface water drained during rainy season.
- Dry ups during the filling of the reservoir.

c) Impact Assessment

A diversion of water in different stages will be applied to minimize downstream water supply impacts. During the earlystage of the diversion period, the cofferdam only

narrows the original river course and will not affect the downstream water supply conditions. During the laterstage river closure period, the elevation of water level during the closure period will continuously increase and the elevation of closure gap will significantly increase when the closure gap is closed up. During the second stage diversion period, the river water will run through the sluice gate.

The average rainfall in the area is about 1,300 mm with about 76% of the rainfall falling during the rainyseason. The maximum discharge occurs from February to March where the average flow in the Mekong River at the project area is about 1,100-1,200 m3/sec and the lowest flow recorded is 700 m3/sec. The dilution factor from the flow is very high.

d) Recommendations

The magnitude of impact during the construction of coffer will be minimized through adoption of best practices for cofferdam construction and a strict implementation of mitigation measures throughout the construction period.

Since correct mitigation steps will be taken, it can be concluded that the construction of the cofferdam and its removal will be of medium importance, medium magnitude and of a medium time period to the water quality and water supply of downstream areas.

During the construction and demolition of the cofferdam, it is recommended that a water quality monitoring program shall be regularly performed and appropriate techniques and measures for the demolition of the cofferdam are implemented accordingly. Appropriate mitigation measures for the control of sediment shall be in place and strictly implemented.

8.5.3Fishery Impacts

a) Introduction/Concerns

General key worries is that the proposed PLHPP Dam may create obstacles for the movement of migratory fish species and may impact to downstream fish species and number.

b) Project Aspects and Mitigation

Transformation of the habitat from a river with rapids into to standing ecosystem due to impoundment will not occur for PLHPP due to the run-of-river design. Fish species which live in running water habitat will not be negatively impacted to the new conditions. There are number of species which appear in schools such as *Henicorhynchus* spp. *Cirrhinus* spp. with

a short life span and a fast rate of reproduction; normally their abundance in the catch appears to follow the level of floods from the upstream.

The creation of a barrage without any reservoir stagnant effects will improve the overall natural fish production capacity of the Mekong River in the project area, especially in the dry season; based on the information of the water quality and the existing aquatic organisms, species diversity and their quantities, a positive impact on fish biomass will occur for species that do not have long distance migration patterns. The increasing volume and regulation of the water level would be a benefit for many aquatic living organisms. After impoundment, fisheries activities would have to be adapted to using new fishing methods and gear.

b) Impact Assessment

There was no inland aquaculture activities found to be operating in the project area based on both observation and discussions with local government officials and residents. Capture fish were generally more expensive than culture fish. At Paklay morning market, very few capture fish were sold with higher price than cultured fish as Pa duk (Hybrid *Clarias* species) and Nile tilapia (*Oreochromis niloticus).*

c) Recommendation/Summary

During the operation period, with the increasing amount of water for the living of aquatic organisms, the dynamic of trophic level in the aquatic ecosystem will be relatively stable to existing plasticity of food preference by each group. An increase in biomass of fisheries resources according to the increasing of water body cause the positive impacts to the aquatic ecosystem.

It is expected that even there will be significant change on the aquatic ecology but there will be no significant change on spawning activities of fish. The flow of water pass barrage site in every season will be not changed. During rainyseason, the water flow should be proper evaluated to determine the effective tool for sustaining fish biodiversity. They are the local species that generally thrive in upstream portion of the river where water current is quite strong. However, the project component will include fishpass facility therefore the impact of barrage to fishpass will be minimized.

The possible use of a proposed fishpass. The maintaining downstream flows and upstream migration is crucial to the sustainability of fish populations.

The fish transport mobile unit with large container with aeration system will set up for collected the fish from downstream or pond of fishpass way cross to upstream. Adoption of aquaculture within the headpond area would be a partial solution to the loss of migratory species.

9. PUBLIC INVOLVEMENT IN THE ESIA PROCESS

9.1 Introduction

Nowadays public participation issues became more important, this Chapter reports progress and tentative plan for public involvement for the PLHPP. In fact, public involvement for hydropower projects in Lao PDR is usually initiated at the village level, and then proceeds with consultation meetings at the district, provincial and national levels. The project consultants in cooperation with the project developers are responsible for all consultation meetings, including all expenditures such as transportation for participants, accommodation, and payment for those attending the meeting. The Mekong Paklay study team has realized this issue and has conducted consultation meeting in each village during the ESIA process.

9.2 Objective & Scope

The consultation aims to introduce the proposed project to stakeholders, inform them as it develops, and identify their views and concerns. The objective is to incorporate stakeholder concerns and local knowledge in the design and execution of the project, and avoid/ reduce potential conflicts to the possible extent. This approach fosters stakeholders' engagement and contribution to the project, enhances its acceptability and encourages realistic expectations as to what the project will deliver to them.

Key purposes of the consultation program are to:

- Identify problems, concerns and needs
- Inform stakeholders about the project
- Obtain feedback
- Learn from local knowledge and understanding
- Evaluate alternatives
- Promote ownership and enhance social acceptability
- Avoid or resolve conflicts
- Demonstrate commitment of the project proponent in addressing issues raised during consultations.

Scope of consultation will focus on four main components:

- *Information Collection* - involving collecting information on the environmental and social baseline conditions of the study area to determine key sensitive receptors.

- *Information Dissemination* - involving disclosure of information about the intended activity, project objectives and their outcomes in order to enable meaningful consultation.

- *Consultation* - involving an interactive, two-way flow of information, views and ideas between stakeholders and the project proponent, China SINOHYDRO Overseas Investment Company.

- *Participation* - defined as a voluntary process in which stakeholders and project proponents come together to share, negotiate and control the decision-making process in project design and management, it builds on the consultation component.

The consultation process will involve, but will not be limited to:

1) Formal meetings with government authorities, institutions, individuals, specialists and any NGOs identified;

2) Meetings with opinion leaders, community representatives (village committees or councils).

3) Household survey questionnaires, aimed at the local population within the project area. The survey questionnaires are a fundamental component of both the RAP and the SIA as they provide the basis for identifying impacts and developing management and mitigation measures that are specific to the local conditions.

9.3 Identification of Key Stakeholders

9.3.1 MRCS & Lower Mekong Riparian Countries

The regional agreement on Cooperation for the Sustainable Development of the Mekong River Basin (1995) was already on board. In addition to Mekong River Commission Secretariat (MRCS), four countries need to be consulted on the E&S issues of PLHPP on the Mekong Mainstream include:

1) Cambodia
2) Lao PDR
3) Thailand
4) Vietnam

The road map/agenda for intra-country consultations requires suggestion and guidance of the MRCS.

9.3.2 Central GOL Bodies

The central government concerning hydropower development can be listed as follows:

- Lao's National Mekong River Commission
- Ministry of Natural Resources and Environment (MONRE)
- Ministry of Energy and Mines
- Ministry of Agriculture and Forestry
- Ministry of Planning and Investment
- Ministry of Finances
- Ministry of Health
- Ministry of Labor and Social Welfare
- Ministry of Information and Culture
- Any other relevant departments identified in consultation with JV/NCG

9.3.3 Provincial/District GOL

Similar to those at the national level, the provincial and district administration and related key authorities include:

- Provincial/District Cabinet Offices
- Provincial/District Energy and Mines Offices
- Provincial Natural Resources and Environment Office
- Provincial/District Land Management Office
- Provincial/District Agriculture and Forestry Offices
- Provincial/District Planning and Investment Offices
- Provincial/District Health Offices
- Provincial/District Labor and Social Welfare Offices
- Provincial/District Information and Culture Offices

9.3.4 Village Leaders and Affected People

Some experience for hydropower development in Lao PDR showed that project impacts come to the villages especially those who are the project affected people including village leaders and vulnerable group of people.

- Cluster Village Heads of the project affected
- Village heads in each of the project affected villages
- Key village informants, including village teachers, village elders, spiritual leaders and health-care workers
- Directly and indirectly affected families in project area
- Gender and vulnerable groups (including ethnic minority group)
- Key village interest groups including landowners, land users, identified vulnerable groups, guardians of cultural and spiritual sites etc.

9.3.5 Non-Governmental Organizations

- Lao Women's Union
- Lao National Front
- Lao Front for National Construction
- Lao Youth Association
- Other NGOs as listed in an Appendix to this document

9.4 Consultation with GOL Provincial & District Authorities

Consultation with GOL stakeholders will involve a series of formal meetings and discussions. The purpose of the interviews at national, provincial and district levels will be to inform the stakeholders of the proposed project, to discuss the associated environmental, social and resettlement issues as well as to gather any relevant secondary data. The consultations with district and provincial stakeholders will also discuss the most practical and feasible mitigation measures in the opinion of these stakeholders. It is expected the majority of these interviews will be undertaken by NCG and the local consultant team. Consultation at these levels is an important step in the protocol of working in the local area. It is a courtesy to inform the relevant government bodies and leaders of the intention to conduct surveys and interviews in the Paklay and Met Districts.

The consultations/meetings will take the form of semi-structured interviews in which a short presentation about JV and the purpose of the EIA, SIA and RAP tasks. This will be followed by discussions about the role and responsibilities of the government office in general; it's specific role in relation to the Paklay HPP; any requirements in relation to construction and operation of the project; opinions about the positive and negative impacts of project and suggestions for JV and NCG. A series of such meetings are envisaged with the central and provincial line departments, agencies, MONRE etc. During these meetings, the key issues and

concerns raised by the stakeholders will be recorded for inclusion in the RAP, SIA and management plan.

9.5 Consultation with Villages & Local Communities

Village Level Participation

Members of the communities in the vicinity of the project area participate through village meetings, interviews with representatives of the local villages and as part of the household surveys. The survey is used to develop a baseline socio-economic profile of the local communities. Information is sought on the level of awareness of the project, concerns and expectations of the project. Individual household interviewees and social dialogues are used to document the profile of communities, the range and extent of impacts both at the household and community level. Specifically the village level consultations will be held for the following purposes:

- Gather information on the profile of the community and the possible social impacts of the project on community structure, local resources and livelihood patterns. Some specific "focus group" were conducted in some villages
- Assess the scale of resettlement, loss of assets and livelihood (individual and community) and explore options for the most suitable livelihood restoration and asset replacement measures, including resettlement site options.
- Identify key environmental concerns of the communities, especially related to the diversion of water, impacts on land use, and construction activities.

Figure 31: Consultation at Village Level in the Project Area

District and Provincial Level Participation

A series of formal meetings and discussions with district and provincial authorities have been performed. The purpose of the interviews at national, provincial and district levels were to inform the stakeholders of the proposed project, to discuss the associated environmental, social and resettlement issues as well as to gather any relevant secondary data. The consultations with district and provincial stakeholders also discussed the most practical and feasible mitigation measures in the opinion of these stakeholders. The majority of these interviews were undertaken by NCG and the local consultant team. Consultation at these levels was an important step in the protocol of working in the local area. It was a courtesy to inform the relevant government bodies and leaders of the intention to conduct surveys and interviews in the project districts.

The consultations/meetings employed the form of semi-structured interviews and the purpose of the EIA, SIA and RAP, TBESIA & CIA tasks. This was followed by discussions about the role and responsibilities of the government office in general; it's specific role in relation to the PLHPP; any requirements in relation to construction and operation of the project; opinions about the positive and negative impacts of the project and suggestions for Sinohydro and NCG.

Many of such meetings were envisaged with the central and provincial line departments, agencies, MONRE etc. During these meetings, the key issues and concerns raised by the stakeholders were recorded for inclusion in the reports.

Figure 32: Participation of District Authorities

Technical and Site Visit Level Participation

All stakeholders from GoL, Villageers , Project Developer and Consultants are together to check the project site and discuss vila local people then come for technical consultation to listen the project information and seeking the mitigation to reduce the impact and to ensure that the developer will follow the rulres and regulations.

Figure 33: Participation for Technical Consultation

National Level Participation

The official national consultation will be conducted after the final draft (TBESIA $ CIA, EIA, SIA, EMMP, SMMP, RAP) and after the district/provincial consultation on these draft reports. During the course of the study many Central GOL authorities including the National Lao Mekong Committee have been contacted and cooperated.

Figure 40:National Consultation Meeting

9.6 Consultation with Other Stakeholders

In addition to the GOL and local communities mentioned, it is anticipated that other stakeholders including the construction contractors, NGOs and other civil society organizations will be consulted over the course of the EIA, SIA and RAP consultation program.

Consultation with these stakeholders will take the form of *ad hoc* meetings similar to those described for the GOL. These consultations will assess the issues and concerns of these stakeholders on the project and its different activities. Construction contractors and NGOs may also be invited to participate in an impact assessment workshop as part of the ESIA.

The PLHPP is a Mekong Mainstream development project, so it requires regional consultation in 3 countries, Cambodia, Thailand and Vietnam. The key issues will be concerned with cumulative impact assessment and trans-boundary impact issues. All of these are included in the Paklay ESIA study course.

At the minimum, the following key aspects that need to be included in the regional consultation:

- Impact area
  - Upstream/catchment
  - Downstream
  - Construction/quarry sites
  - Country
  - GMS

- Global
- Etc.

- Issues
  - Water resource development
  - Socio-economic development
  - Fishery
  - Hydrology
  - Sediments
  - Displacement/Resettlement
  - Navigation
  - Tourism
  - Climate Change/Global warming
  - etc.

a) MRCS

Both MRCS in Phnom Penh (Cambodia) and Vientiane (Lao PDR) were officially visited with many meetings on the transboundary issues such as hydrology and sedimentation, fisheries, navigation, and other environmental and social aspects.

Concerns about transboundary issues have been considered since the First Summit of the Mekong River Commission (MRC) took place in Hua Hin, Thailand, on 5 April 2010. Regional Prime Ministers, political leaders, MRCs Dialogue Partners, The People's Republic of China, The Union of Myanmar, and range of experts in the field of transboundary water resources management attended. This conference summarized challenges for trans-boundary river basin organizations in a changing world as follows:

- Benefit sharing means "the process where riparian cooperate in optimizing and equitably dividing goods, products and services connected directly or indirectly to the water course or arising from the use of its water."
- Increased involvement of civil society stakeholders in planning activities and decision making processes is increasingly recognized as an essential part of sustainable development, and which may yet require additional emphasis to be effective.
- As relevant examples the Yangtze and Zambezi basins have developed mechanisms for the synchronization of dam operations and flood releases to optimize water use from existing and future systems. These experiences offer valuable lessons for the Mekong.
- Collaboration involves technical and policy issues that address long-term, short-term and real-time planning and operations.
- As an example from this region, the MRC's integrated water resources management based development strategy provides a framework for managing the "development space" in the basin. The "development space" is not just a volume of water that can be used, but a space for development and management of water and related resources, shaped by sustainable boundaries, e.g. acceptable transboundary impacts and basin-wide procedures.

– Basin organizations need to find sustainable financing mechanisms to support the core functions for management of the basin. *(MRCS, 2011)*

Figure 41: Meetings with MRC on Trans-boundary Impact Assessment

The results of meetings can be summarized as follows:

- The study team was warmly welcomed by the MRCS. All parties met at the MRCS in accord with the 1995 Mekong Agreement in which the TBESIA framework aims to facilitate MRC cooperation to support the protection of the environment, natural resources, aquatic life and conditions, and the ecological balance of the Lower Mekong River Basin and prevention and cessation of harmful effects resulting from development projects/activities.
- All parties agreed to support the study team on data and information and other suggestions for the transboundary study.
- Suggestions on hydrological and sedimentation scenarios/modeling (based on HecRecSim software) and a fishery survey were made by the MRCS senior staff and advisors.
- Since the project is within the Lao territory, any official contacts should be passed through the Lao National Mekong Committee.

List of contacted persons at the MRCS are as follows:

1) Mr. Xaipadeth Choulamany (Env. Program), MRCS Phnom Penh, Cambodia
2) Mr . Peng Bun Ngor, Fishery, MRCS Phnom Penh, Cambodia
3) Mr. Bounphet Phommachanh, Navigation, MRCS Phnom Penh, Cambodia
4) Mr Anthony Green, Senior Modeling Advisor, Information and Knowledge Management Program, Technical Support Division, MRCS Phnom Penh, Cambodia
5) Dr. Inthavy Akkharat, Hydrologist, MRCS Phnom Penh, Cambodia
6) Ms. Ornanong Vonnarart, Hydrologist, MRCS Phnom Penh, Cambodia
7) Dr. Vithet Srinetr, Environment Program Coordinator, Environment Division, MRCS Vientiane, Lao PDR
8) Nguyen Van Duyen, Environmental management Specialist, MRCS Vientiane, Lao PDR

b) Thailand

The riparian provinces including Loei, Nong Khai, Nakhon Phanom, Mukdahan, and Ubon Ratchathani were visited in particular the riparian districts located wihin 5 km corridor. Official meetings were conducted in Chiang Khan, Pak Chom and Muang Mukdahan. The following governmental agencies were contacted:

- Riparian District Administration Offices;
- Riparian Sub-district Administration Offices;
- Provincial Statistical Offices;
- Tourism Authority of Thailand;
- Academic and non-governmental institutions.

The study team had a good chance to present and exchange knowledge and ideas on the "Role of Hydropower Dams in Water Resources Development" at Rajabhat University, Thailand on 2 December 2011. Attendants from various agencies discussed the role of hydropower in flood protection and other related issues.

Concerns about baseline information, monitoring, and post evaluation of hydropower dams related to methods and techniques were also included in the meeting.

Figure 34: Meeting at Rajabhat Thailand

c) Cambodia

Three governmental agencies were visited and the meeting included:

- Ministry of Environment (MOE), Environmental Impact Assessment Department, Royal Government of Cambodia;
- Ministry of Industry, Mines and Energy (MIME), Royal Government of Cambodia;
- Ministry of Planning, Royal Government of Cambodia;
- MRCS at Phnom Penh Office.

The study team informed the agencies visited about objectives and provided information about the mainstream projects and the Paklay HPP, the type of data required, and exchanged information and ideas concerning the feasibility stage of mainstream hydropower development. The gathering of social data and information was done at the same time as the visits.


Figure 35: Meetings with MOE *(left)* and MIME *(right)* in Cambodia

The MIME has plans for 14 hydropower dams to be operated in 2020. Many projects are proceeding as public-private partnership where NGOs need participation in the decision making process.

d) Vietnam

The plans for visiting Governmental Agencies in Hanoi and University of Can Tho have been postponed because of the need of official communication between countries. However, the meetings with local and international NGOs have been done (see next Section).

9.7. Dialogues with International NGOs

A number of dialogues with NGOs, locally and internationally, have been conducted and positions and voices listened to. The following meetings with some results were conducted.

a) NGO Forum on Cambodia

The "NGO Forum on Cambodia (NFOC)" is a network of national and international organizations working for social justice and sustainable development in Cambodia. In October 2009, the NFOC, Probe International, has published a document entitled "Powering the 21st Century, Cambodia with Decentralized Generation – A primer for Rethinking Cambodia's Electricity Future". This document addressed 6 main issues, namely:

- Cambodia's Electricity Sector;
- Rethinking Cambodia's Power development Strategy;
- A Better Strategy for Powering 21st Century Cambodia;
- Central generation vs. Decentralized Generation;
- Promotional Policies, Financial Incentives, Common Barriers;
- Powering 21st Century Cambodia with Decentralized Generation.

These can be done through introducing explicit and enforceable rules encouraging decentralized generation including: building a superior electricity system; adding

capacity in smaller, more affordable increments; and using locally available resources and the best generating technologies.

Other conclusion is related to political issue that the Cambodia's political leaders have to choose between the last century's model of power generation and the public interest.

On 23 March 2011, the NFOC has sent a letter to the Chairman of Cambodia National Mekong Committee to inform about the negative impacts of the proposed Xayaburi Mainstream Dam such as fishery, ecosystem and bio-diversity, transboundary, agriculture, and livelihood of which the project require to do more research and EIA study since the previous EIA was addressed only 10 km downstream of the project where considered not enough.

List of contacted NFOC persons are as follows:

- Ms Chea Phallika, Hydropower & Community Rights Project Coordinator, The NGO Forum on Cambodia
- Ms Im Phallay, Environmental Program Manager, The NGO Forum on Cambodia

List of non-government persons related to environment and tourism:

- Dr Ngy Laymithuna, Cambodian Environment Limited, Phnom Penh
- Mr John Pilgrim, Resettlement Specialist, Korea Consultants International
- Mr Ea Sophy, Resettlement Specialist, Korea Consultants International
- Mr Kriengkrai Krueysai, Hotel and Tourism Professional, Phom Penh

b) Vietnam Save the Mekong Coalition

The meeting with active NGOs in Vietnam was conducted to listen to their views on transboundary issues of mainstream hydropower dam development. At the Centre for Biodiversity and Development (CBD) in Ho Chi Minh City, there is a river coalition network with International Rivers which has recently expressed their views on Xayaburi Dam (in Lao PDR) and Son La and Yali dams (in Vietnam).

This NGO is part of "Save the Mekong Coalition" that have written a letter to Australia's Minister of Foreign Affairs expressing their concern with the Xayaburi Dam and the grievous failure of its PNPCA process. As the process has been funded by the Australian Government, the signatories called on Australia and other donors to use its leverage to call for an improved process and a delay in decision-making.

List of key contacted persons of Vietnam NGOs are:

- Ms Pham Thi Hong Van, Environmental Activist, International Rivers Coalition/Journalist, Mekong Delta Provinces
- Mr Lam Dinh Uy, Environmental Scientist, Center for Biodiversity and Development, Ho Chi Minh City

- Dr Dao Trong Tu, Executive Director, Centre for Sustainable Water Resources Development and Climate Change Adaption, Hanoi, Vietnam
- Ms Nguy Thi Khanh, Coordinator of Vietnam Rivers Network, Centre for Sustainable Water Resources Development, Hanoi, Vietnam

Other nongovernmental persons contacted during the field surveys in Vietnam included:

- Mr Nguen Trong Khang, Tour Operator, My Tho Tourist
- Mr Le Van Nhu, Tour Guide, My Tho
- Ms Bao Yen Tran Thi, Tour Guide, Can Tho
-

c) Development NGOs in Lao PDR

The involvement of international and local NGOs in Lao PDR are found different than those in Cambodia and Vietnam where most of NGOs are supporting the country development in many aspects such as livelihoods, health, education, and tourism. Below are some results of meeting with NGOs in the Lao PDR. Since the key project area is located in Oudomxay and Xayaboury provinces. The following local and international NGOs have been met with and to discuss their possible aid to the project.

1. Community Health Development

Name of NGO: Croix-Rouge Francaise (CRF)

Name of Project: LRC/FRC Community Health Program (Phase II / 2008 2011)

Program objective: Improving the sanitary conditions of vulnerable rural communities in Xayaboury and Vientiane Provinces

Expected results:

- Water supplies and sanitation systems are available for all
- Appropriate related hygiene behaviors are adopted by the family members
- First aid and primary health care are effectively provided by the Village Health Volunteers
- Health status for children is improved as the District Health Department implements the “Child Survival Strategy” (WHO/UNICEF)

Place of implementation: Khob, Hongsa and Xienghone districts of Xayabouri Province and Maet, Kasy, Vang Vieng and Hom disctricts in Vientiane Province.

Beneficiaries: 60 villages for an estimated population of 32,000

Program duration: 40 months, from April 2008 to August 2011

Total budget: 2,626,702 Euro

Financial support: French Red Cross 46% ; EU 28%; French MoFA 26%

Primary implementer: Lao Red Cross

Lead technical assistance: French Red Cross

Associated partners: Ministry of Public Health – Institut Francophone de la Medecine Tropicale (Vientiane)
Contacted person: Mr Arounphone, French Red Cross, Xayaboury

2. Tourism Development

Name of Agency:

German Development Service (Deutscher Entwicklungsdienst - DED)

Activities:

The German Development Service (Deutscher Entwicklungsdienst – DED) Laos is supporting Lao PDR by providing advisers with professional experience. In Oudomxay four advisers, one junior adviser as well as four volunteers are engaged in the rural development, vocational training as well as in the tourism sector. The Provincial Tourism Department is cooperating with the DED since 2004. At the moment, an adviser, a junior adviser as well as a volunteer are supporting the PTD on improving sustainable tourism. The DED now is called GIZ.

Contacted persons:

Mr Siegfried Moser, GIZ - German Development Service, Advisor Tourism Development Oudomxay

9.8 The Prior Consultation Process

The Pak Lay hydropower project is proposed on the Mekong mainstream in Pak Lay district, Xayaburi province, in north-western Lao PDR. The proposed project sits downstream of the currently under-construction Xayaburi hydropower station and is 241 kilometers upstream of Vientiane, the capital city of Lao PDR.

The run-of-river dam will operate continuously year-round and produce 770 megawatts of electricity, designed with 14 turbines or generators, each producing 55 MW. Designed to discharge the flow of 6,101 m^3/s, the power plant is intended mainly for power generation for domestic supply.

The project's total investment cost is estimated at USD 2,134 million with the construction expected to start in 2022 and the commercial operation to begin when the construction finishes in 2029. Power China Resources Ltd is named as the developer, according to the official notification documents from Lao PDR.

On 13 June 2018, the Lao government, through its Lao National Mekong Committee, notified the Mekong River Commission Secretariat of its intention to undertake the formal process of Prior Consultation on the Pak Lay hydropower project. The notification includes the detailed description of the planned project for the MRC Secretariat to review and take further action to inform the other member countries about the project's scope and other requirements under the prior consultation process.

The MRC's Joint Committee Working Group (JCWG) on the Procedures for Notification, Prior Consultation and Agreement (PNPCA) convened its first meeting on 8 August 2018 to hear and discuss several key issues that require advanced proper attention and common understanding and agreement to ensure successful implementation of a six-month Prior Consultation process of the proposed project with an aim of increasing the joint benefits and cooperation among the member countries and MRC Secretariat.

The MRC has scheduled two regional stakeholder forums – one in September this year and another early next year – and a field visit to the project site to exchange and share information, investigate the site, and discuss and document legitimate concerns.

The Commission is now implementing the Prior Consultation process, officially starting on 8 August 2018. The consultation is conducted by the MRC Joint Committee (JC), a higher governance body comprising one senior government official at no less than head of department level from each member country, with technical and administrative support by the MRC Secretariat and the joint working group.

The Prior Consultation is part of the MRC's procedural rules on cooperation on water use of the Mekong mainstream governed by the PNPCA. Under the Procedures, any infrastructural project using the mainstream water during the dry season within the same basin, as well as during the wet season between two basins, must undergo the Prior Consultation process. Applicable projects include large-scale irrigation and hydropower development which may cause significant impacts on the environment, water flow and quality of the Mekong mainstream.

In the Prior Consultation process, with technical and administrative support from the MRC Secretariat, the notified member countries will review technical aspects of the proposed project, assess any potential transboundary impacts on the environment and livelihoods along the riparian communities, and suggest measures to address those concerns. The member countries aim to come to an agreement on how the consulted case should proceed. It is not meant to approve or disapprove the proposed project.

This process normally lasts six months, but it could be extended further, if required, by the Joint Committee. The Prior Consultation is one of the three procedures required for the development of different types of water-use projects in the lower Mekong basin as specified in the PNPCA established under the 1995 Mekong Agreement.

Region Forum 20 Sep2018

The result of PNPCA (Statement of Pak Lay HPP - 4April 2019) is attached to SIA Report part of Public Consultation.

Appendices

Appendix 1: Paklay-Hydrology-Final FS-20170320

Appendix 2: Paklay-Project Layout and Main Structures-Final FS-20170320

Appendix 3: Summary Technical Review Report

Appendix 4: Paklay-Hydrology Report Jan 2020

POWERCHINA RESOURCES LTD.
No. 428, Unit 39 Ban Phonthan,
Saysettha District Vientiane Capital
Lao PDR
Telephone: (00856) - 21- 419075
Fax: (00856) - 21- 419075

National Consulting Group (NCG)
No. 012, Kaysone Road, Ban Phonexay, Xaysettha District
Vientiane, Lao PDR
Email: sdncclaos157@yahoo.com
Telephone: 856-21 261882