Lao People's Democratic Republic
Ministry of Energy and Mines

THE PREPARATORY SURVEY
ON
XE KATAM HYDROPOWER PLANT PROJECT
IN
LAO P.D.R

FINAL REPORT

October 2015

Japan International Cooperation Agency

The Kansai Electric Power Co., Inc.
NEWJEC Inc.

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SUMMARY

SUMMARY

1. PROJECT LOCATION

Figure 1.1-1 shows location of the project and Figure 1.1-2 shows location of the project (expanded version).

The power station will be constructed at the site located on Bolaven Plateau in Champasak Province, 80 km east of Pakse, the second largest city of Laos. Power generated utilizing Xe Katam River, one of branches of Xe Namnoy River will be connected to Pakxong Substation via transmission line. Good access from the existing road is available.

Figure 1.1-1 Location of the Project

(Source: Prepared by JICA Study Team)

Figure 1.1-2 Location of the Project (Expanded)

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2. PROJECT OUTLINE

For this Project, MOU concerning development was executed with the government of Laos in 2004. Since 2007 when exclusive development right (Project Development Agreement: PDA) was awarded by the government of Laos, development has been continued.

Because import of electricity from neighboring countries became exceeding the export and electricity supply/demand in Laos has continued to be tight since 2007, the business plan was changed from sale to Thailand to sale to domestic market in Laos as strongly requested by the government of Laos in 2008.

As a result, viability of the Project became significantly severe due to change of a buyer of electricity who will purchase the electricity at much lower unit price in domestic market. Consequently, type of power generation, method of procurement, etc. have been repeatedly investigated aiming at the project scheme which allows for business development at low cost and at high speed.

Figure 1.2-1 shows the outline of the Project as in 2006.

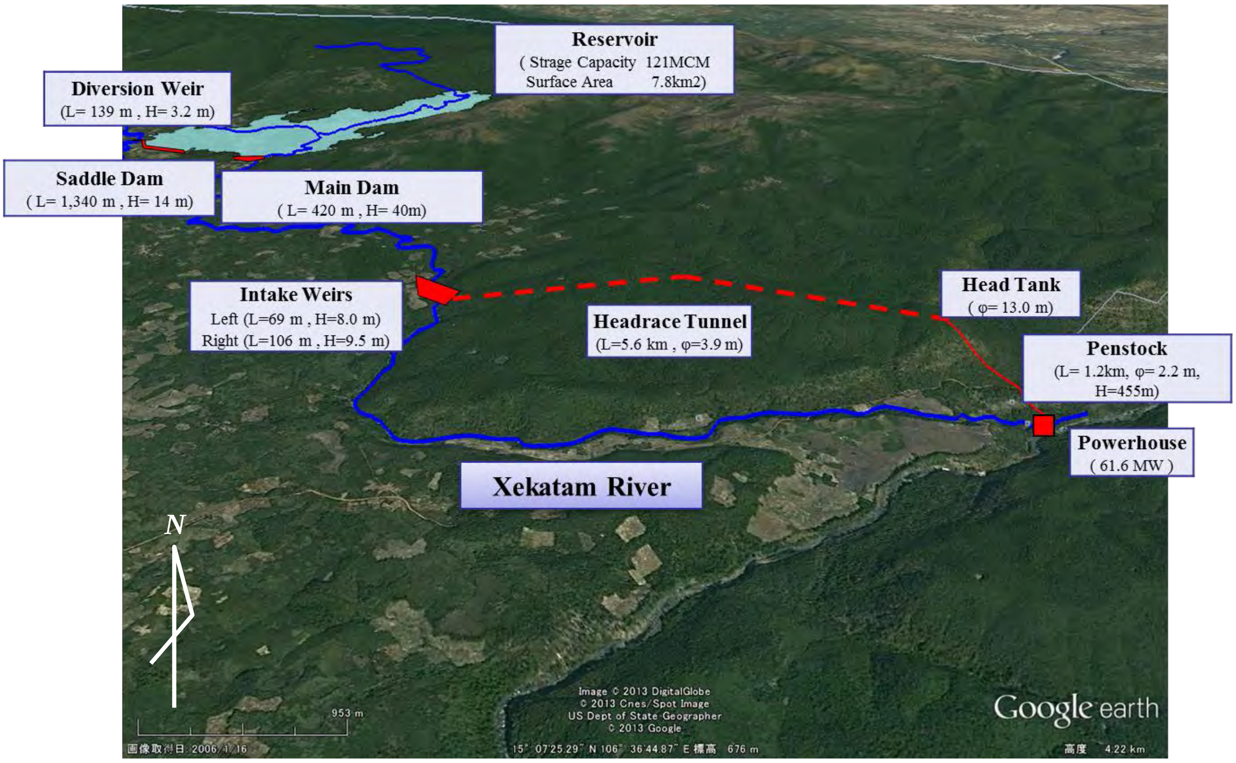

Figure 1.2-1 Outline Map of the Project as in 2009

(Source: Prepared by JICA Study Team)

The main specifications in 2006 were as follows:

- Power generation type: Dam Waterway
- Turbine type: Pelton
- Maximum output: 60.8 MW
- Maximum flow: 16 m^3/s
- Effective height: 455 m
- Annual power generation: 380 GWh
- Effective storage capacity: 115 million m^3

As in 2006, it used to be planned as a conventional hydro power with a dam. In the survey this time, however, a run-of-river hydro power was also studied from the viewpoint of financial viability as well as reduction of environmental load to surroundings.

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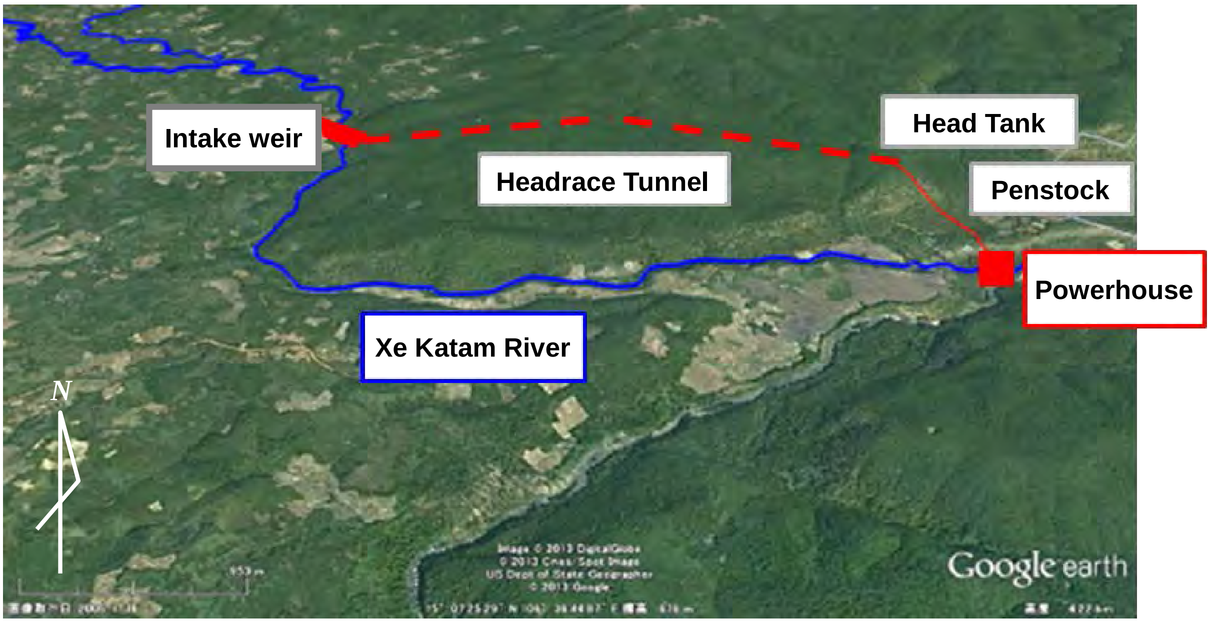

Figure 1.2-2 Outline Map of the Project

(Source: Prepared by JICA Study Team)

The outline specifications of the Project are as follows. As a result of optimization study of turbine output, the turbine type was changed from Pelton to Francis.

For details of the project specifications, refer to Chapter 4.

- Power generation type: Run-of-river type
- Turbine type: Francis
- Maximum power output: 81 MW
- Maximum flow: 20 m^3/s
- Effective height: 457 m
- Annual power generation: 299 GWh

Main facilities of dam waterway type and run-of river type are as follows:

Table 1.2-1 Main Facilities of Dam Waterway Type and Run-of-River Type

Dam waterway Type	Run-of-River Type
- Diversion weir	-
- Saddle dam	-
- Main dam	-
- Quarry site, Borrow pit	-
- Intake weir	- Intake weir
- Settling basin	- Settling basin
- Headrace	- Headrace
- Water tank	- Water tank
- Penstock	- Penstock
- Power station	- Power station
- Transmission line (Power station – Pakxong substation)	- Transmission line (Power station – Pakxong substation)

3. RESULTS OF STUDY ON THE PROJECT

3.1 TECHNICAL

Geological survey and hydrologic analysis relating to the facilities which are only required for dam waterway type (main dam, saddle dam, diversion weir, etc.) and common facilities (intake weir, headrace, power station, etc.) were conducted in "Survey" and comparative investigation was conducted in "Design".

As a result of this survey, it was decided that power generation type should be run-of-river type and accordingly neither main dam nor saddle dam would be constructed.

3.2 ENVIRONMENTAL AND SOCIAL CONSIDERATION

Environmental and Social Impact Assessment (ESIA) was developed in compliance with JICA Guideline for Environmental and Social Consideration (April 2010) and applicable laws, regulations, guidelines and standards of Lao PDR.

Terrestrial flora and fauna survey found some 200 species of plants, 12 mammals, 14 birds, 3 reptiles and 53 fishes. Some of the species are considered rare and endangered to some extent, but no critical issues have been found. Part of the Project is located in the Xe Katam Provincial Protected Forest. Around 50 ha of forest will be impacted.

Two (2) villages will have direct impact caused by the construction and operation of the power facilities and 15 villages (out of which two (2) villages are duplicated) will have direct impact by transmission line. Major impacts are land acquisition and impact on fishery.

One (1) house is required to relocate under transmission line ROW, 26.1 ha of land owned by 80 households and 3 companies are to be acquired for permanent use which consists of power facilities, transmission line and access road. 28.9ha of land has an impact of temporary use during construction and transmission line ROW.

Compensation and Community (Ethnic People) Development Plan was established. It includes, among others, entitlement matrix, compensation policy, community development plan, ethnic people development plan, vulnerable group development plan, gender development plan and grievance redress procedures.

13 stakeholder consultation meetings were held to obtain opinions from project affected people, village authorities and other stakeholders. An executive summary of ESIA, namely result of survey, evaluation of impact and proposed mitigation measures including entitlement matrix and community development plan were presented. Stakeholders generally accepted the ESIA.

The Preparatory Survey on Xe Katam Hydropower Plant Project
in Lao People's Democratic Republic

FINAL REPORT

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Abbreviations

Symbol	English
ACSR	Aluminum Conductor Steel Reinforced
ADB	Asian Development Bank
AIDS	Acquired Immune Deficiency Syndrome
amsl	above mean sea level
AP	Affected People
ASR	Alkaline-Silica Reaction
BLT	Build, Lease, Transfer
BOO	Build, Own, Operate
BOT	Build, Own, Transfer
CA	Concession Agreement
C.A.	Catchment Area
CC	Compensation Committee
cct	Circuit
CEAR Insurance	Construction & Erection All Risks Insurance
CEMMP	Contractor's Environmental Management and Monitoring Plan
CFRD	Concrete Facing Rockfill Dam
CIGRE	Conseil international des grands réseaux électriques
CITES	Convention of International Trade in Endangered Species of Wild Fauna and Flora
COD	Commercial Operation Date
COD	Chemical Oxygen Demand
CRIEPI	Central Research Institute of Electric Power Industry
CSG	Cemented Sand and Gravel
DAF	Department of Agriculture and Forestry in province
DEB	Department of Electricity Business in MEM
DLUP	Department of Land Use and Planning
DESIA	Department of Environment and Social Impact Assessment in MONRE
DO	Dissolved Oxygen
DOE	Department of Electricity in MEM
DOF	Department of Forestry in MAF
DONRE	District Office of Natural Resource and Environment
DSCR	Debt Service Coverage Ratio
DWG	District Working Group
EC	Environment Committee
ECO	Environment and Community Office
EDL	Electricité du Laos
EGAT	Electricity Generating Authority of Thailand
EIA	Environment Impact Assessment
EIRR	Equity Internal Rate of Return
EMMP	Environmental Management and Monitoring Plan
EPA	Ethnic People Assessment
EPC	Engineering Procurement Construction
ESIA	Environmental and Social Impact Assessment
FIDIC	Fédération International des Ingenieurs - Consdeil
FIRR	Finance Internal Rate of Return
Fm.	Formation

Symbol	English
F/S, FS	Feasibility Study
FY	Fiscal Year
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMS	Greater Mekong Sub-Region
GNI	Gross National Income
GNP	Gross National Product
GOL	Government of Lao PDR
GPS	Global Positioning System
GRC	Grievance Resolution Committee
HC	Head Contractor
HH	Household
HIV	Human Immunodeficiency Virus
Hz	Hertz
IEC	International Electrotechnical Commission
IEE	Initial Environment Examination
IFC	International Finance Corporation
IPP	Independent Power Producer
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standard
JPY	Japanese Yen
KANSAI	Kansai Electric Power Co., Inc.
kV	Kilo-Volt
kVA	Kilo Volt Ampere
kW	Kilo Watt
Lao PDR	Lao People's Democratic Republic
LFNC	Lao Front for National Construction
LURC	Land Use Right Certificate
m^3/s	Cubic Meter per Second
MAF	Ministry of Agriculture and Forestry
Marine DSU Insurance/ Marine ALOP Insurance	Marine Delay in Start-Up Insurance, Advance Loss Of Profits Insurance
MEM	Ministry of Energy and Mines
MIC	Ministry of Information and Culture
MOF	Ministry of Finance
MOH	Ministry of Health
MONRE	Ministry of Natural Resources and Environment
MOU	Memorandum of Understanding
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
MW	Mega Watt
NAFRI	National Agricultural and Forestry Research Institute
NATM	New Austrian Tunneling Method
NBCA	National Biodiversity Conservation Area

Symbol	English
NEF	New Energy Foundation
NLMA	National Land Management Authority
NPAD	National Protected Area Division
NSEIA	Natural, Social and Environmental Impact Assessment
NSEDP	National Socio-Economic Development Plan
NSEMMP	Natural, Social and Environmental Management and Monitoring Plan
NTFP	Non Timber Forest Product
NGO	Non-Governmental Organization
O & M	Operation & Maintenance
ODA	Official Development Assistance
OPGW	Optical fiber Ground-Wire
PAP	Project Affected Person
PDA	Project Development Agreement
PDEM	Provincial Department of Energy and Mines
PDP	Power Development Plan
PEA	Provincial Electricity Authority
PONRE	Provincial Office of Natural Resource and Environment
PPA	Power Purchase Agreement
PPF	Provincial Protect Forest
PPP	Public-Private Partnership
ROW	Right of Way
SCADA	Supervisory Control Data Acquisition
SCM	Stakeholder Consultation Meeting
SHA	Share Holder’s Agreement
SIA	Social Impact Assessment
SMMP	Social Management and Monitoring Plan
SPC	Special Purpose Company
SPT	Standard Penetration Test
SS, S/S	Substation
TGCR	Technical Guideline on Compensation and Resettlement
TOR	Terms of reference
TPES	Total Primary Energy Supply
TR	Technical Report
UCS	Unconfined Compression Strength
USBR	U.S. Bureau of Reclamation
USD	United States Dollar
UXO	Unexploded ordinance
VC	Village Committee
WB	World Bank
XKHC	Xe Katam Hydropower Company (project company)

CHAPTER 1

OUTLINE OF THE SURVEY

CHAPTER 1 OUTLINE OF THE SURVEY

1.1 Project Background/Past Activities

Due to the strong economic development in recent years, the domestic electric demand in Laos showed high growth. In 2014, maximum electric power demand (or peak demand) was 908 MW and electric power consumption per year was 4,221 GWh. Peak demand grew by approximately 4 times and electric power consumption grew by approximately 5 times in the last decade.

After 2015, high growth rate of peak demand is expected as 15% per year while electric consumption, as 17% per year. It is also expected that annual growth rate of electricity consumption in the southern region of the country will reach to as high as approximately 16% which is same as that of average of whole Laos, because steady economic growth is expected. In order to properly respond to such demand increase, prompt enhancement of electricity supply system is required.

Table 1.1-1 Summary Electricity Energy Consumption and Peak Load Record

Area/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average Growth Rate	
												2004-2008	2004-2014
Energy Consumption (GWh)													
North	153.0	170.0	229.0	284.0	341.0	415.0	558.0	714.0	870.0	1,172.7	1,290.0	22.2%	23.8%
Vientiane Captal	500.0	556.0	721.0	770.0	850.0	902.0	983.0	1,028.0	1,184.0	1,294.2	1,423.6	14.2%	11.0%
South	250.0	284.0	450.0	589.0	598.0	602.0	613.0	658.0	814.0	1,370.5	1,507.6	24.4%	19.7%
Total	903.0	1,010.0	1,400.0	1,643.0	1,789.0	1,919.0	2,154.0	2,400.0	2,868.0	3,837.4	4,221.2	18.6%	16.7%
Growth Rate	10%	12%	39%	17%	9%	7%	12%	11%	20%	34%	10%	-	-
Peak Load (MW)													
North	55.6	67.8	86.0	95.0	105.8	128.8	158.0	201.0	216.0	219.8	234.4	17.4%	15.5%
Vientiane Captal	75.8	81.5	93.0	104.0	140.0	208.6	249.0	260.0	300.4	332.0	343.7	16.6%	16.3%
South	118.0	142.0	153.0	165.0	175.0	179.0	183.0	187.6	190.1	212.0	330.2	10.4%	10.8%
Total	249.4	291.3	332.0	364.0	420.8	516.4	590.0	648.6	706.5	763.8	908.3	14.0%	13.8%
Growth Rate	11%	17%	14%	10%	16%	23%	14%	10%	9%	8%	19%	-	-

Remark: The datum in horizon 2005 to 2009 is including of Sepon Gold/Copper mine and Mahaxai Cement Factory.

(Source: Prepared by JICA Study Team based on “Power Development Plan (PDP 2015-2025), Appendix 1-12, EDL, 2014”)

Table 1.1-2 Summary of Demand Forecast for the Whole Country

Descriptions	Units	2015	2020	2025	Growth Rate (%)	
					2015-2020	2015-2025
Energy Demand (Excluding system losses)	Gwh	6,485.4	17,693.0	30,929.9	22.2%	16.9%
System Losses	GWh	929.3	1,982.6	3,443.5	-	-
	%	12.53%	10.08%	10.02%		
Energy Demand (Including system losses)	GWh	7,414.7	19,675.6	34,373.4	21.6%	16.6%
Peak Load	MW	1,370.9	3,345.0	5,592.9	19.5%	15.1%
Load Factor	%	61.7%	67.1%	70.2%	-	-

(Source: Prepared by JICA Study Team based on “Power Development Plan (PDP 2015-2025), Table 2.1-5, EDL, 2014")

Table 1.1-3 Summary of Electricity Demand Forecasts for Southern Area

Descriptions	Units	2015	2020	2025	Growth Rate (%) 2015-2020	Growth Rate (%) 2015-2025
Energy Demand (Excluding system losses)	Gwh	909.7	1,840.6	3,877.6	15.1%	15.6%
System Losses	GWh	104.8	192.0	384.6	–	–
	%	10.33%	9.45%	9.02%		
Energy Demand (Including system losses)	GWh	1,014.6	2,032.6	4,262.2	14.9%	15.4%
Peak Load	MW	191.8	360.8	677.4	13.5%	13.4%
Load Factor	%	60.4%	64.3%	71.8%	–	–

(Source: Prepared by JICA Study Team based on "Power Development Plan (PDP 2015-2025), Table 2.1-4, EDL, 2014")

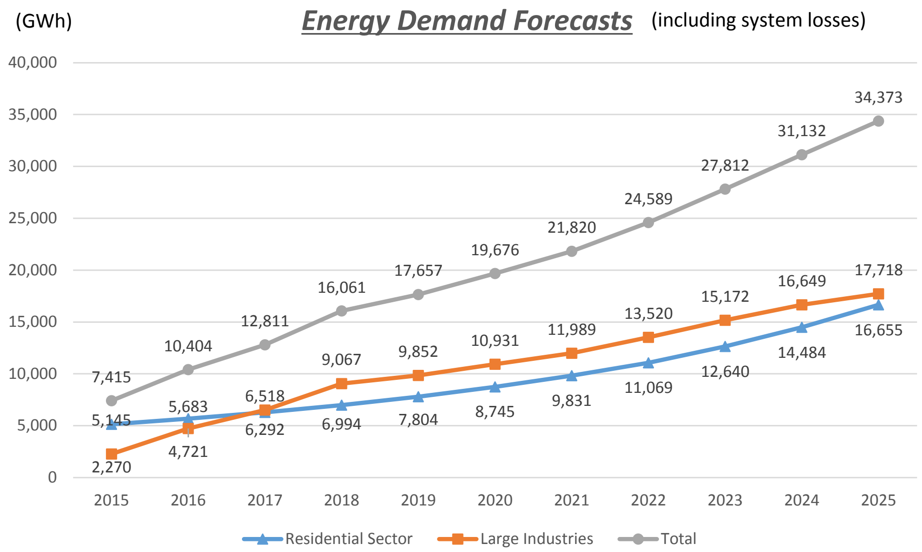

Figure 1.1-1 Expected Electricity Consumption by Sector (Whole Laos)

(Source: Prepared by JICA Study Team based on "Power Development Plan (PDP 2015-2025), Appendix 2-19, EDL, 2014")

The electric power in Laos is supplied mainly with hydroelectric power generation utilizing the rich hydropower resources and through system power exchange with neighboring countries (Thailand, China, and Vietnam). The state-owned Electricite du Laos (hereinafter referred to as "EDL") and independent power producers (hereinafter referred to as "IPPs") are in charge of the domestic electric power development. The introduction of IPPs will increase in the future according to the announced policy of the Government of Laos (hereinafter referred to as "GOL") to actively promote the electric power development by IPPs especially after 1990's. However, most of the IPPs in Laos sells its electricity to Thailand and barely contributes to ease the domestic electric power supply and demand. As a result, the development of IPPs for domestic market is urgently required.

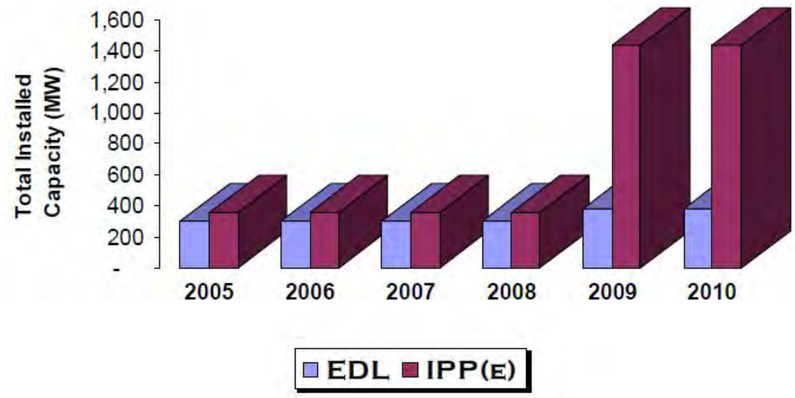

Figure 1.1-2 Historical Trend of the Installed Capacity

(Source: EDL Power Development Plan (PDP 2010-2020), Part I Present Status, August 2010)

In the 7th National Socio-Economic Development Plan (NSEDP) of Laos, the goal of annual economic growth rate of no less than 8% and graduation from least developed country (LDC) status by 2020 are laid out and one of the important policies is an electric sector.

In NSEDP, it is stated that the country shall contribute to development of global industries by utilizing rich hydro potential as well as become “Battery of ASEAN” through electricity export. To realize these policies, the GOL is promoting highly concessional funding from overseas, establishment and strengthening of electricity related laws and regulations, highly efficient and transparent IPP-based power development with the purpose of investment promotion. GOL has signed a Memorandum of Understanding (MOU) with Thailand to export 7,000 MW electricity and with Vietnam to export 5,000 MW. The electricity export mainly through IPPs has been progressing relatively smoothly and is contributing to the country’s economic development through accumulation of foreign reserves. However, in recent years, the growth rate of the domestic demand of electricity has been far beyond the forecast, and imports of electricity from neighboring countries have been exceeding exports since 2007. (See Figure 1.1-3.)

Looking at electric power circumstance in Laos, such circumstance that the country has no alternative but to rely on import electricity from neighboring Thailand due to its transmission line network which is divided into three regions, northern, central and southern regions and insufficient electricity supply to domestic demand has permanently been continuing. The conditions of current power purchase agreement between EDL and Electricity Generating Authority of Thailand (EGAT) are, therefore, favorable to EGAT and tariff of import electricity is set at higher rate than tariff of export electricity. Consequently, it affects adversely to profit and loss results of EDL.

The Lao government is investigating to dissolve this unbalanced contract in the future from the viewpoint of energy security and improvement of balance of international payments of the country. Since it is important in order to do that to enhance electric power supply system within the country so that it shall not rely on import electricity from Thailand, the country is trying to interconnect the divided domestic transmission line network in Laos as well as to promote development of domestic power sources which are currently lacking.

Under such background, investigation on construction of IPP for domestic market developed in order to dissolve electricity shortage in the country and contribute to economic development of the country will be implemented in this survey. The investigation will also be implemented for the purpose to give benefits of developments to the poor in the region, especially for the purpose to improve access to electricity.

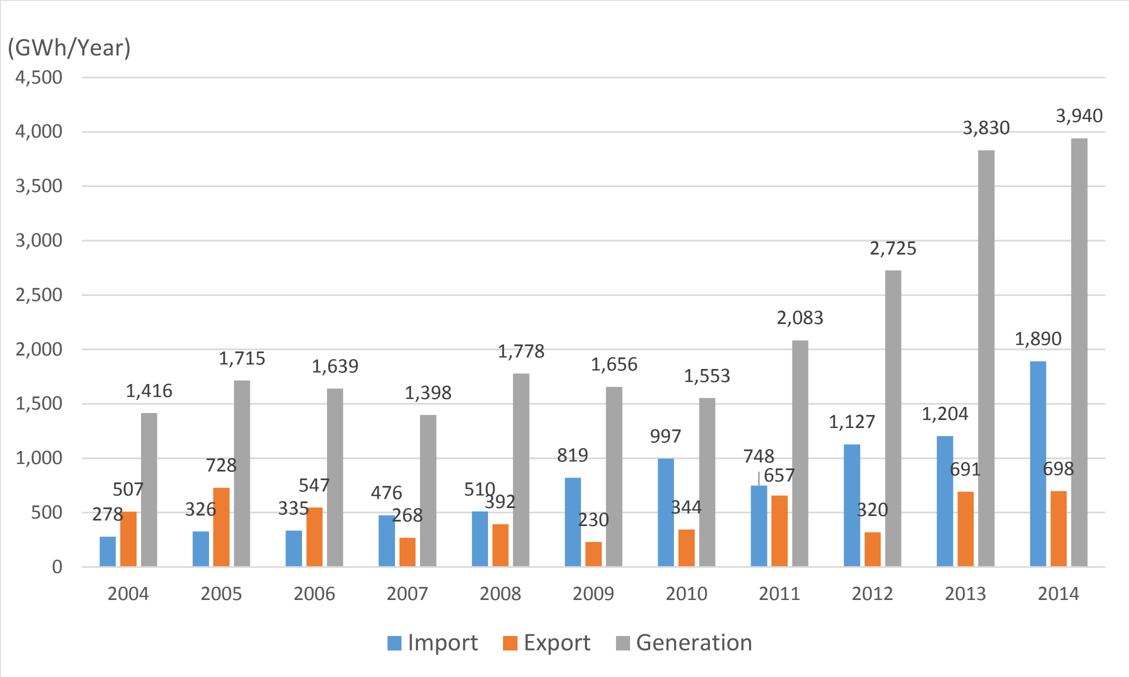

Figure 1.1-3 Production, Import, and Export in the Country

(Source: Power Development Plan (PDP 2015-2025), Fig. 1.8-1, EDL, 2014)

1.2 Objectives of the Preparatory Survey

The objectives of the Preparatory Survey is to satisfy requirements for developing the Xe Katam hydropower project (hereinafter referred to as "the Project") which include the identification of objective and effectiveness of the Project, scope of the Project, Project cost estimation, establishment of the implementation schedule, study of the construction method and procurement of materials, Project scheme, Project implementation structure, implementation of the environmental and social considerations, and investment evaluation.

CHAPTER 2

PROJECT OUTLINE

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2.1 Project Location

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The power station will be constructed at the site located on Bolaven Plateau in Champasak Province, 80 km east of Pakse, the second largest city of Laos. Power generated utilizing Xe Katam River, one of branches of Xe Namnoy River will be connected to Pakxong Substation via transmission line. Good access from the existing road is available.

Figure 2.1-1 Location of the Project

(Source: Prepared by JICA Study Team)

Figure 2.1-2 Location of the Project (Expanded)

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2.2 Project Outline

For this Project, MOU concerning development was executed with the government of Laos in 2004. Since 2007 when exclusive development right (Project Development Agreement: PDA) was awarded by the government of Laos, development has been continued.

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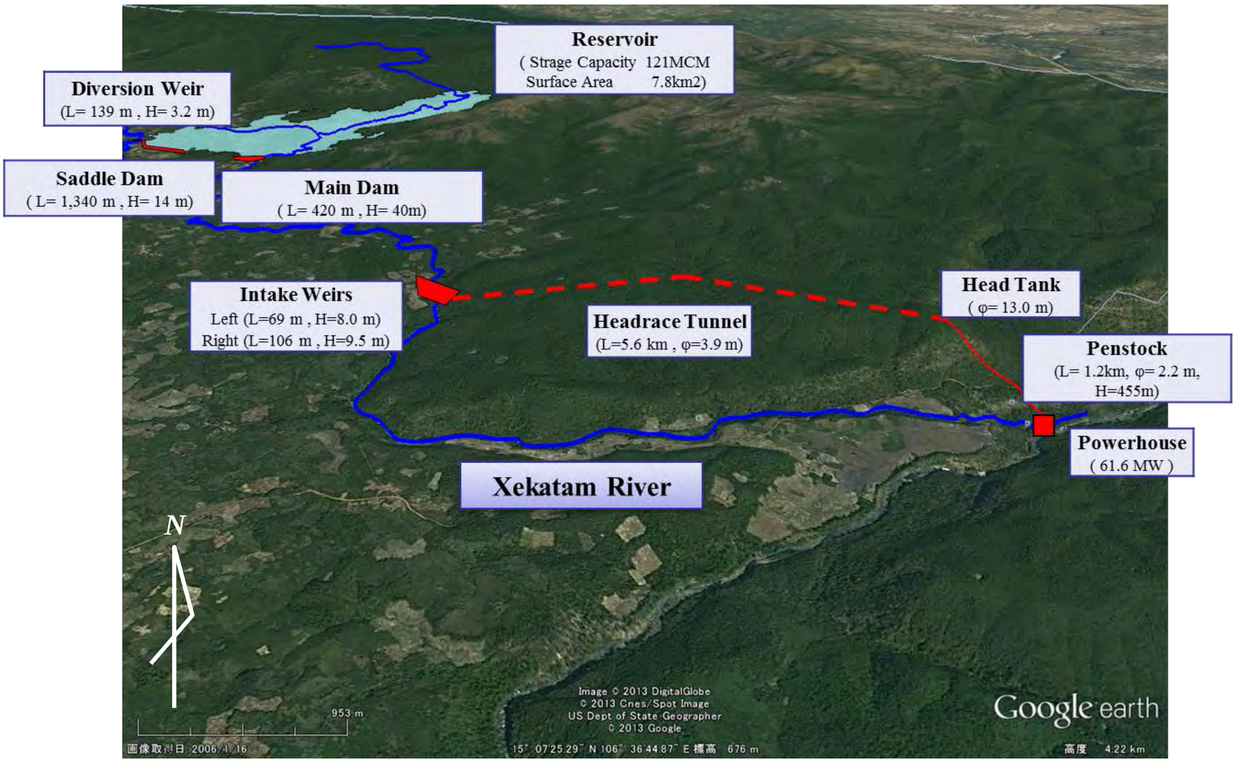

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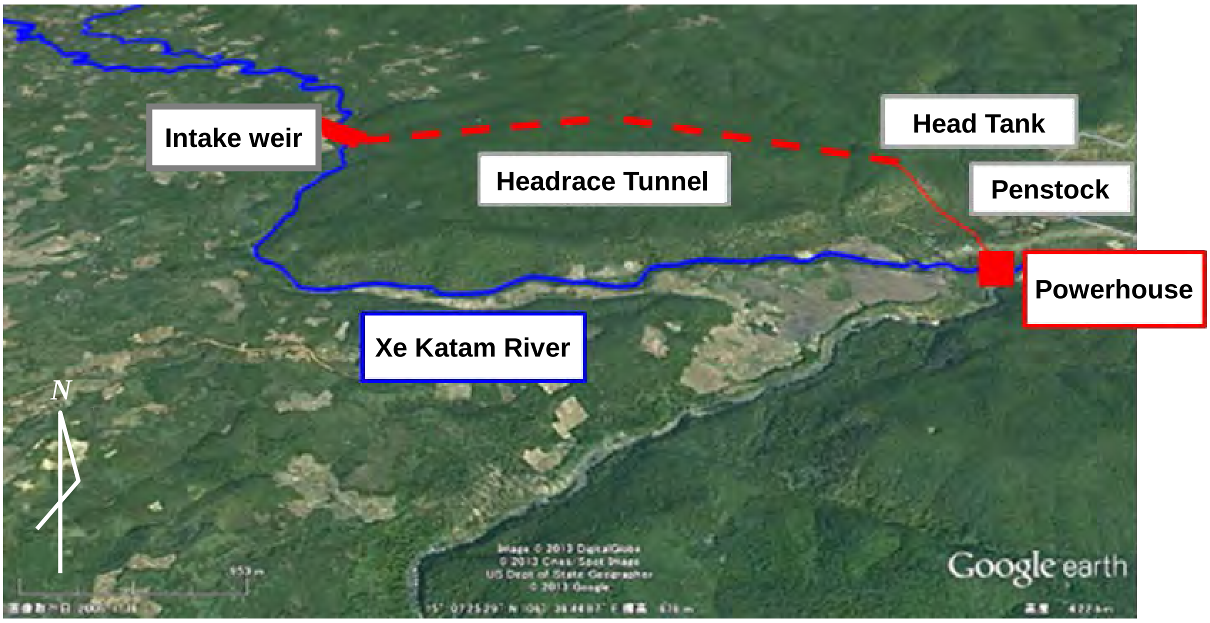

Figure 2.2-2 Outline Map of the Project

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For details of the project specifications, refer to Chapter 4.

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2.3 Results of Study on the Project

Geological survey and hydrologic analysis relating to the facilities which are only required for dam waterway type (main dam, saddle dam, diversion weir, etc.) and common facilities (intake weir, headrace, power station, etc.) were conducted in Chapter 3 “Survey” and comparative investigation was conducted in Chapter 4 “Design”.

As a result of this survey, it was decided that power generation type should be run-of-river type and accordingly neither main dam nor saddle dam would be constructed. For details, refer to Section 4.1.4 “Optimization of the Project Scale including Design of Civil and Electro-Mechanical Facilities”.

CHAPTER 3

SURVEY

CHAPTER 3 SURVEY

3.1 Survey on Legal and the Power Sector concerning the Project

3.1.1 Survey on Laws and Regulations in Laos

Table 3.1-1 shows laws and regulations related to implementation of IPPs.

Table 3.1-1 Laws related to Implementation of IPPs

Related laws	Date of Issuance
Electricity Law	2011/12 amendment
Enterprise Law	2005/12
Investment Promotion Law	2009/7
Land Law	2003/10
Tax Law	2011/12 amendment
Customs Law	2011/12 amendment
Laws related to the environmental and social consideration are shown in Chapter 6.	-

(1) Electricity Law

The Electricity Law is the fundamental law about the electric power industry in Laos. The electricity law is established about the investment, the establishment, a procedure of the right application, the permission of the project about the electric power industry for generations, transmission and distribution.

A right application procedure of the electricity business to be related to an IPP business operation in particular includes following items.

(a) execution of the memorandum of understanding (MOU),
(b) execution of the project development agreement (PDA) and
(c) execution of the concession agreement (CA).

And also, MOU and PDA can be extended by the consent of the Government of Laos (GOL).

(a) The extension application of them shall be submitted to the GOL by one month before the contract termination.

(b) The extension term of the PDA shall be less than six months per one extension. The times of extension are limited to less than two times for the generation projects selling electricity to domestic market and less than three times for the generation projects selling electricity to outside of Laos.

(c) The contract term of CA is less than 30 years.

Definition of MOU, PDA and CA is as described below, though there is no clear definition in the eyes of law.

(a) MOU

At the initial phase of development, SPC submits to Lao government an application for the location where development of a hydro power station is considered to be possible based on the results of synoptic survey, Lao government grants permission to this and MOU is concluded.

(b) PDA

The SPC that concluded MOU conducts feasibility study (F/S) from the viewpoints of environmental/social aspect, technical aspect and financial aspect. The SPC reports to Lao government the results of the F/S and if Lao government finds that realization of the SPC's project is highly likely, then PDA is concluded.

(c) CA

During the PDA period, the SPC conducts consultation and negotiation regarding detailed design based on the results of the F/S and contract for construction works based thereon, finance origination, partnership formation, negotiation of PPA, permission and authorization of Lao government (tax, land use right, etc.), etc. The SPC also conducts detailed survey with respect to environmental/social aspect to formulate a measure to mitigate influence and monitoring plan. These items are agreed upon among concerned parties including Lao government and upon fixing conditions for permission and authorization concerning the development, CA is concluded.

(2) Enterprise Law

The Law on Enterprises determines the principles, procedures and measures for the incorporation, operation and management of enterprises in the Lao People's Democratic Republic. Specially, SPCs for power generations are categorized as a limited company. Procedures of establishment and operation (dividend, reserve, audit and etc.) of SPCs are defined in the Enterprise Law.

[The establishment of the limited company]

The establishment of the limited company shall be carried out on the following procedures and condition.

(a) More than two co-founders are required. A company establishment contract shall be submitted to a member of company license department of where the head office of the limited company is located.

(b) The limited company shall look for the purchase subscriber of all stocks after submitting the company establishment contract. However, it is forbidden to disclose the purchasers. The subscribers of stock purchase are called "a stock subscriber".

(c) An establishment meeting shall be carried out.

(d) The founder appoints all duties as a president-director elected in an establishment meeting.

(e) The president-director requires the payment of the stock from the founder or stock subscribers.

(f) The president-director registers the license of the company within 30 days from the day after the payment of the stock meets a condition.

(3) Investment Promotion Law

The Law on Investment Promotion aims to enhance the roles and benefits of investments contributed to the national socio-economic growth in a continuous and sustainable manner; and significantly to the national protection and development.

Investments consist of three types and electric industry is categorized in concession business.

In addition, terms of exemption from corporation tax depend on promoted 3 sectors and promoted 3 zones.

Electric industry is categorized as activities with top level of promotion in promoted sectors and Zone 1 or 2 in promoted zones.

As it is, however, provided for that "regarding concession project of mining, power or afforestation, pertinent laws shall be observed", details will be adjusted in the negotiation of concession right in due course.

It should be noted that there is no specific restriction of foreign investment.

[Types of Investment]

The investors can invest in these following types of investment;
- General business;
- Concession business;
- Activities for development of Special Economic Zones and Specific Economic Zones.

[Promoted Sectors]

Promoted sectors are agriculture, industry, handicraft and services. Detailed list of promoted activities will be determined by the Government in 3 different levels based on the prioritized activities of the Government, activities related to poverty reduction, improvement of living conditions of the people, construction of infrastructure, human resource development, employment, etc.

The promotion is divided into 3 levels as follow:

Level 1: Activities with top level of promotion;
Level 2: Activities with medium level of promotion;
Level 3: Activities with low level of promotion;

(Note: There is no clear criteria regarding difference in level of promotion.)

[Promoted Zones]

The establishments of the promoted zones are based on the socio-economic infrastructures and geographical conditions of the country which are divided in to three promoted zones as follows:

Zone 1: Zones where there are insufficient socio-economic infrastructures favorable to facilitate investments. These zones are mainly mountainous remote areas.
These zones will be classified as a top level of investment promotion;

Zone 2: Zones where there are some socio-economic infrastructures that are partially able to facilitate investments in some extent. The difficulty of geographical situation of these zones is not as hard as Zone 1. These zones will be classified as a medium level of investment promotion;

Zone 3: Zones where there are good infrastructures available to support investments. These zones will be classified as a low level of investment promotion;

The detailed list of the promoted zones will be determined in the specific regulation.

[Incentives related to profit taxes]

1. Zone 1
   - Activities with Level 1 of investment promotion shall receive profit tax exemption for 10 years.
   - Activities with Level 2 of investment promotion shall receive profit tax exemption for 6 years.
   - Activities with Level 3 of investment promotion shall receive profit tax exemption for 4 years.

2. Zone 2
   - Activities with Level 1 of investment promotion shall receive profit tax exemption for 6 years.
   - Activities with Level 2 of investment promotion shall receive profit tax exemption for 4 years.
   - Activities with Level 3 of investment promotion shall receive profit tax exemption for 2 years.

3. Zone 3
   - Activities with Level 1 of investment promotion shall receive profit tax exemption for 4 years.
   - Activities with Level 2 of investment promotion shall receive profit tax exemption for 2 years.
   - Activities with Level 3 of investment promotion shall receive profit tax exemption for 1 year.

Profit tax exemption starts from the date of the enterprise beginning its business operations. For the activities to produce new products, research and new technology, the profit tax exemption commences from the date the enterprise starts making profit. After finishing the period of profit tax exemption as mentioned above the enterprise shall pay profit tax in accordance to the Tax Law.

Mining and hydropower concession and forestry (deforestation business) shall comply with concerned laws.

[Incentives related to customs duty and other taxes]

In addition to the incentives related to profit tax, investors shall be also entitled to the following customs duty and other tax incentives:

1. Exemption from profit tax in the next accounting year for business that spends the net profit to expand its business;

2. Exemption from import duty on raw materials, equipments, spares parts and vehicles that are directly used for production.
   As for import tax exemption of these items, it shall comply with specific regulations.

(4) Land Law

Although it is decided that lands are owned by the Nation in the Article 17 of the constitution, it is admitted to individual, family and corporation to use, lease and set concession of lands.

The objectives of the Land Law are to determine the regime on the management, protection and use of land in order to ensure efficiency. In order to manage land efficiently, land is classified into 4 regions and 8 categories, and governmental authorities who are responsible for each classified land are decided.

[Classification of Land Regions and Land Categories]

Land in the whole country is divided into the following regions and categories:

1. Regions:
   - Urban Regions;
   - Rural Regions;
   - Specific Economic Regions;
   - Special Economic Regions

2. Categories:
   - Agricultural land;
   - Forest land;
   - Water area land;
   - Industrial land;
   - Communication land;
   - Cultural land;
   - Land for national defense and security;
   - Construction land.

It is necessary to get approval of National Assembly for changing categories of lands. It is required in this project to change category of lands from agricultural, forest and water area land into industrial land.

In order to set the right to use lands, it is necessary to check the right of land-user. But it is necessary to register the land-right based on the customary right of use land because lands are almost not registered except urban area. The customary right of use land is decide by the enforce regulations of Land Law.

(5) Tax Law

Tax Law is to determine types, coverage and rate of tax. Exemption and reduction of tax are regulated in investment promotion law.

[Tax exemption/reduction]

Tax exemption and reduction are applied to the following cases:

1. It is based on the multi-lateral treaties (multiplex or tax evasion) which Laos joins.
2. It is based on investment promotion law.
3. The project that is important at a national level with Diet approval.
4. The unexpected situation that the Diet approves as a natural disaster occurs. For example, in the case of a storm, a disease, a flood, a drought, an earthquake, fire and others, extensive damage.

(6) The Customs Law

The Customs Law determined coverage of the tax about the import and export and a tax rate. The exemption from taxation of import goods, the reduction of taxes are determined in investment promotion law.

[Exemption from taxation and reduction of tax for promoting investment]

Regarding all import goods, the priority and condition obey only investment promotion law.

(7) Business authorization procedure

The authorization procedure of the IPP business obeys by Electricity Law, Enterprise Law and Investment Promotion Law shown in Table 3.1-2.

Table 3.1-2 Laws related to IPP Business Development

Related laws		Government	Date of Issuance
MOU	(Memorandum of Understanding)	MPI	2004.09
PDA	(Project Development Agreement)	MPI	2007.12
CA	(Concession Agreement)	MEM	-
PPA	(Power Purchase Agreement)	EDL	-
SHA	(Share Holder Agreement)	MPI	-
ESIA	(Environmental and Social Impact Assessment)	MONRE	-
LPA	(Land Procurement Agreement)	MONRE	-

Figure 3.1-1, Figure 3.1-2 and Figure 3.1-3 show the procedures of permission of CA, PPA and IPP concession.

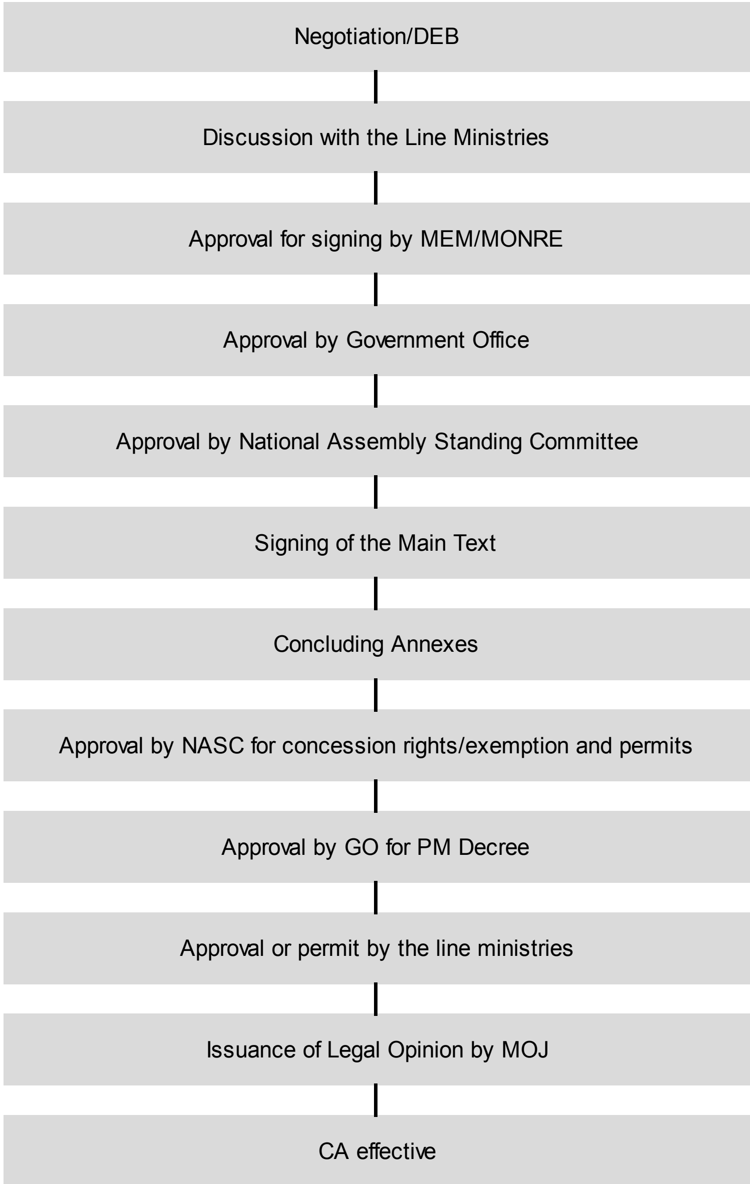
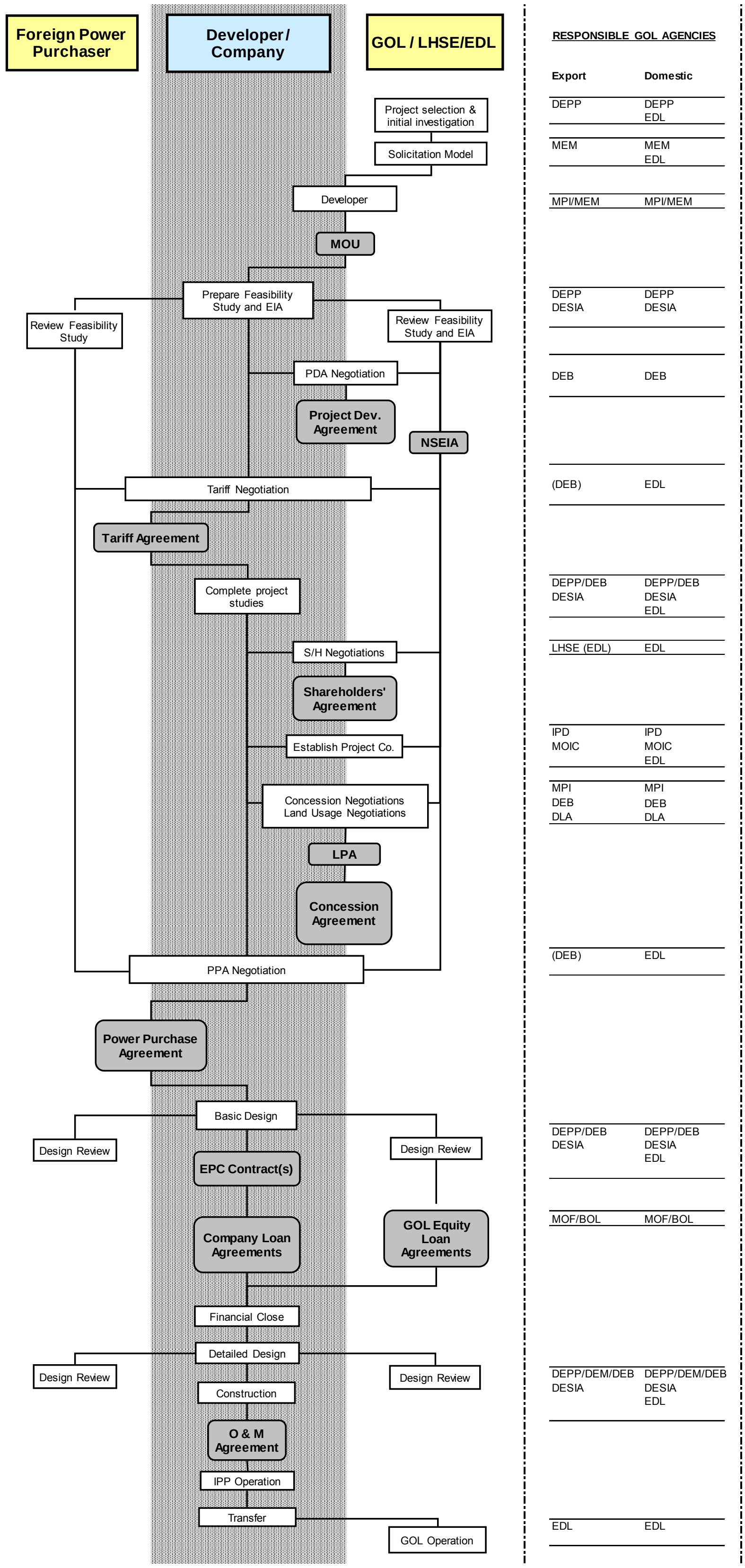


Figure 3.1-1 Procedure of Permission of CA

(Source: Prepared by JICA Study Team)

Figure 3.1-2 Procedure of Permission of PPA

(Source: Prepared by JICA Study Team)



MPI	:	Ministry of Planning and Investment
MEM	:	Ministry of Energy and Mines
IPD	:	Investment Promotion Department, MPI
DEPP	:	Department of Energy Policy and Planning, MEM
DEB	:	Department of Energy Business, MEM
DEM	:	Department of Energy Management, MEM
MONRE	:	Ministry of Natural Resources and Environment
DESIA	:	Department of Environmental and Social Impact Assessment, MONRE
DLA	:	Department of Land Administration, MONRE
MOIC	:	Ministry of Industry and Commerce
MOF	:	Ministry of Finance
BOL	:	Bank of Lao PDR
MOJ	:	Ministry of Justice
LHSE	:	Lao Holding State Enterprise - for Export IPP
EDL	:	Electricite du Laos - for Domestic (or Export) IPP
ECI	:	Electric Construction & Installation - for SPP

Figure 3.1-3 Procedure of Permission of IPP Concession

(Source: based on Materials of MEM and modified by JICA Study Team)

3.1.2 Current Status and Facing Issues of Power Sector in Laos

(1) Social and economic situation in Laos

Laos carried out various economic stimulus package such as policies to invite the investment from the foreign countries toward the rebuilding of the country since a revolution of 1975. Although Laos got heavy recession caused by a currency crisis of 1997, recently Laos continues to be robust with growing rising around 8% of annual rate. Because such factors as rise of wages, labor scarcity, a large flood in 2011, etc. in Thailand are overlapped, expectation of Laos as one of candidates of “Thailand + 1” is mounting and new movement of construction of new factories has emerged keeping pace with the policy of special economic zone.

The population of Laos is approximately 6.5 million as of 2012 and increasing 100,000 people in every year. The population density is 24 people/km^2. Since approximately 75% of population is farmers and population density is low against wide area of the territory, peoples run agriculture which depends on sky conditions. In rainy season rice cropping is prevailing while cultivation of vegetables is prevailing in dry season. Annual production of rice is approximately 2.6 million tons.

Major race in Laos is Lao, and approximately various 40 races exist in whole Laos. Generally, Lao is used as a common language, and a lot of English and French are used as a foreign language. The Laotian main religion is Buddhism, and there are Christianity, Hinduism and etc. The staple food of the life of the nation generally likes dishes of the hot taste characterizing the Southeast Asia system dish as a dish with vegetables, a fish, a chicken, pork, beef, meat of the animals of water buffalo meat and others with glutinous rice.

Table 3.1-3 Facts of Laos

Country	Lao People’s Democratic Republic
Land area	236,800 km^2
Population	Approximately 6.5 million
Adjacent countries	China, Cambodia, Vietnam, Thailand, Myanmar
GDP	US$ 8.3 billion (as of 2011)
Tax income (%GDP)	13.68%
Number of doctors/1,000 people	0.27 (as of 2010)
Birth rate	3.2 (as of 2011)
Principal industries	agriculture, electric power industry, sightseeing, mining

(Source: MPI)

Table 3.1-4 Land Area and Population in Laos (2012)

No	Province	Land area (Km2)	Population		Population density
			Total	female	
1	Vientiane capital	3,920	797,130	398,654	203
2	Phongsaly	16,270	179,822	89,390	11
3	Luangnamtha	9,325	171,967	86,548	18
4	Oudomxay	15,370	314,269	156,943	20
5	Bokeo	6,196	173,962	87,229	28
6	Luangprabang	16,875	463,485	231,232	27
7	Huaphanh	16,500	333,762	165,336	20
8	Xayabury	16,389	389,139	192,653	24
9	Xiengkhuang	16,358	282,769	139,978	17
10	Vientiane	22,554	506,881	249,362	22
11	Borikhamxay	14,863	281,207	139,013	19
12	khammuane	16,315	390,701	197,995	24
13	savannakhet	21,774	937,907	473,686	43
14	saravane	10,691	384,438	195,003	36
15	Sekong	7,665	103,326	52,046	13
16	Champasack	15,415	670,122	337,110	43
17	Attapeu	10,320	133,545	67,802	13
Laos		**236,800**	**6,514,432**	**3,259,980**	**28**

(Source: MPI)

Table 3.1-5 Principal Industries invested by Foreign Capital in Laos

Unit: 1000 US$

	2011	2012
Agriculture-forestry		
Number of Projects	123	17
Foreign investment	515 942.85	114 890.28
Total	608 513.22	125 770.29
Industry and handicraft		
Number of Projects	77	3
Foreign investment	262 734.47	184.00
Total	360 710.44	1 086.16
Mining, Fuel		
Number of Projects	44	59
Foreign investment	1 657 568.44	332 640.67
Total	1 757 356.38	418 360.15
Hydropower		
Number of Projects	**3**	**16**
Foreign investment	**18 700.00**	**950 563.59**
Total	**25 100.00**	**1 232 042.32**
Garment		
Number of Projects	4	–
Foreign investment	6 700.00	
Total	25 100.00	

(Source: MPI)

Table 3.1-6 Principal Products in Laos

Products	Unit	2010	2011	2012
Food, tobacco				
Processing of meat	Tons	14,796.2	16,426.3	21,545.5
Salt	Th. tons	35.5	45.4	47.6
Drinking water	Th.hl	9,788.0	10,669.0	11,547.0
Liquor	Th.hl	7.5	7.5	7.7
Beer	Th.hl	2,008.5	2,899.6	4,406.9
Soft drinks	Th.hl	278.7	284.7	324.2
Coffee	Tons	644.9	768.4	891.4
Cassava Flour	Tons	12,926.9	16,263.2	19,475.6
Polished Rice	Tons	700,296.1	767,772.3	887,384.3
Sugar	Tons	3,011.4	4,961.4	6,878.6
Mining, mineral products				
Gold	Kg	5,105.8	3,402.7	7,001.3
Copper-1	Tons	64,322.0	78,015.0	87,259.0
Copper-2	Tons	298,730.0	280,711.0	288,153.6
Copper-3	Tons	3,793.0	3,384.0	4,970.0
Lead	Tons	2,710.0	2,721.0	328.0
Tin	Tons	925	524	1,484
Coal lignite	Th. tons	501.6	511.7	510.1
Gypsum	Th. tons	553.3	686.1	619.3
Coal	Th. tons	211.7	166.6	331.4
Zine	Tons	5,000.0	4,320.0	2,324.0
Limestone	Tons	1,194,894.0	815,200	910,000.0

(Source: MPI)

(2) Economic conditions of the southern area in Laos

The southern area in Laos consists of 5 provinces such as Savannakhet Province, Saravane Province, Sekong Province, Champasak Province, and Attapeu Province. A Lao group lives on level ground, and a minority race lives in points mainly. The inhabitants support life with Laotian general agriculture and vegetables removed from nature. The area of total five provinces is approximately 65,865 square kilometers, and its population is approximately 2.22 million. There is much population in Savannakhet Province and Champasak Province, and there are mining industries, special economic zones and the world heritages which are important to tourism.

The special economic zone of the Savannakhet Province becomes in particular the important base of the future manufacturing industry in a Laotian policy. Because various kinds of factories are built in this special economic zone, and it is essential for them to obtain electricity for the production.

In addition, a bauxite mine is planned in Champasak Province and the site needs power of 3,600 MW. Therefore the Lao government plans development of power resources to cope with the demand and the construction of the grid in a PDP 2010-2020 plan.

There is Bolaven heights in the Champasak Province and the land is rich enough to produce many kinds of vegetables. A Thai company cultivates farm products on the land and exports it to Bangkok, Thailand. And also, coffee plants are very popular and its production reaches 30,000 tons - 40,000 tons per a year. The production is exported to Europe and Japan in order to obtain foreign currency.

Table 3.1-7 5 Provinces in Southern Area (2012 estimate)

No	Province	Land area (Km2)	Population		Population density
			Total	Female	
1	Savannakhet	21,774	937,907	473,686	43
2	Saravane	10,691	384,438	195,003	36
3	Sekong	7,665	103,326	52,046	13
4	Champasack	15,415	670,122	337,110	43
5	Attapeu	10,320	133,545	67,802	13
Total		**65,865**	**2,229,338**	**1,125,647**	**34**

(3) Current Situation of Power Sector

(a) Ministries and agencies of Laos concerning IPP projects

1) MEM: Ministry of Energy and Mines

Power sector of Laos is in control of MEM. The structure of MEM is shown in the Figure 3.1-4.

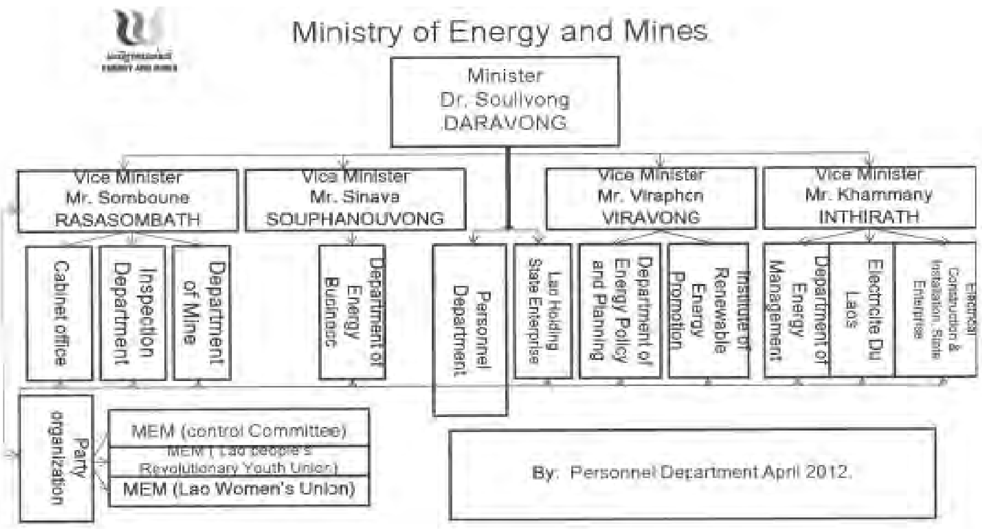


Figure 3.1-4 Structure of MEM

(Source: MEM)

2) EDL: Electricité du Laos

EDL is under control of MEM and is a country owned company. Electricity business is vertically integrated in Laos which means EDL implements generation, transmission and distribution businesses. EDL maintains power supply and power import and export of Laos. Though GOL is reviewing the possibility of investing the Project, EDL is to be the investor of the Project. In addition, all power generated by the Project is planned to be sold to EDL.

3) **MPI: Ministry of Planning and Investment**

MPI is responsible for facilitating foreign investment, implement investment process and maintain investment for concession business such as constructing of hydro power plants.

4) **MONRE: Ministry of Natural Resources and Environment**

MONRE is responsible for implementing environmental business. Descriptions will be stated in Section 6.3.4 (2).

(b) Electric Demand Forecast for Whole Laos

1) **Balance of Supply and Demand in Whole Laos**

According to "PDP 2015–2025", transmission line interconnecting with northern region, central region and southern region which have so far had respective independent grid will be completed in 2016. It is, therefore, considered that the electricity generated by this Project cannot contributes only to southern region but also to the other regions. Such being the circumstance, we will explain in this clause expected situation of balance of supply and demand in future in whole territory of Laos.

Figure 3.1-5 shows expected balance of supply and demand in whole territory of Laos which is expected in PDP 2015 – 2025. This figure shows balance in rainy season and dry season and positive value means that supply capacity is beyond expected demand while negative value means that supply capacity is below expected demand and supply capacity is potentially insufficient.

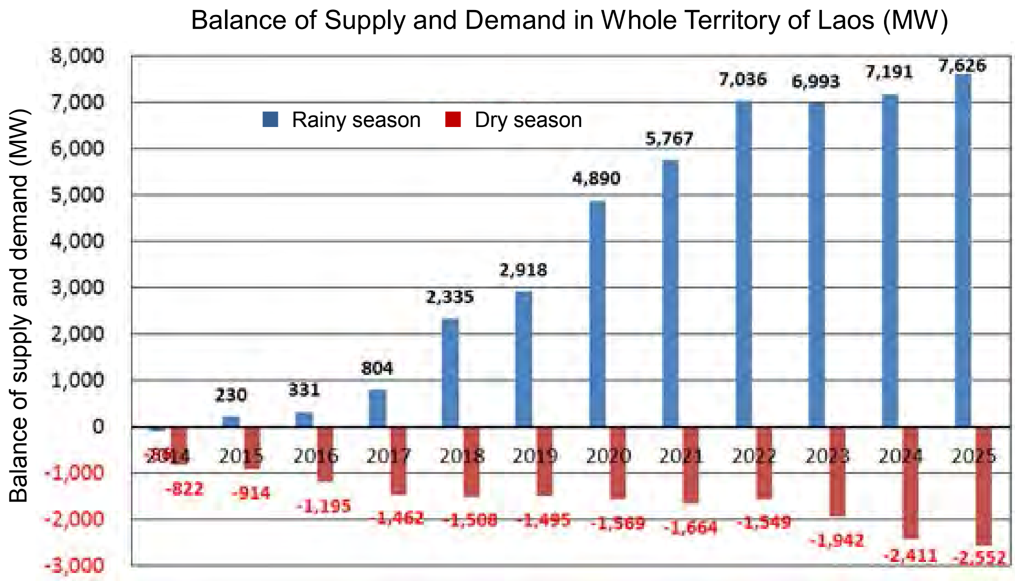


Figure 3.1-5 Expected Supply-Demand Balance in the Whole Country (Power Generation Capacity)

From this figure it can be observed that while there will be some margin in power generating capacity in rainy season in 2015 and thereafter, in dry season such situation that supply capacity is always below expected demand will continue and its shortfall will reach to 2,552 MW in 2025. Although Xe Katam Hydropower Plant Project decided to adopt "Run-of-River" type because of economical reason, although in studied, at first, "Dam Waterway" type which can generate more electricity than "Run-of-River" type in dry season. As a result, this project generates less but can be operated at the maximum output even for a short hours and can generate 43 GWh even in dry season because it can reserve a certain amount of water in an Intake Weir. Therefore it can be said that Xe Katam Hydropower Plant can contribute, to a certain extent, to dissolving Demand-Supply-Imbalance of Laos in dray season.

Moreover, because oversupplied electricity will be expected to be sold mainly to neighbor Thailand, this project can contribute to resolve export/import-price-differences in power purchase condition between Thailand and Laos.

Figure 3.1-6 shows situation of supply-demand balance with respect to annual electric energy as of 2015.

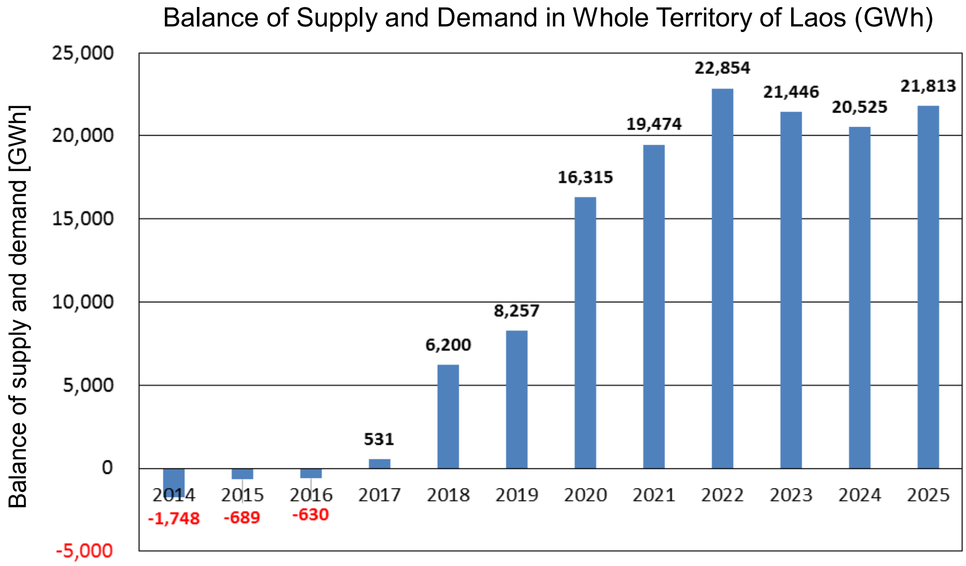


Figure 3.1-6 Forecast of Supply-Demand Balance in the Whole Country (Annual Electric Energy)

From this graph, it is considered that supply-demand balance with respect to annual electric energy will become improved in 2017 and thereafter. At a glance, supply of electric power to domestic market appears to be excessive. Increasing amount of export electricity to Thailand will, however, be able to contribute to dissolving export/import-price-difference in power purchase condition between Thailand and Laos. Xe Katam Hydropower Plant Project will be able to increase power generation capacity for domestic market and is in line with the policy of Lao government that amount of import electricity from Thailand should be reduced and amount of electricity export should be increased. It is thus considered to take an important role as domestic power source in Laos.

(c) Power Development Plan of Whole Laos

1) Power Development Plan of Whole Laos

Table 3.1-8 shows power generation source development projects up to 2025 listed in "PDP 2015 – 2025". As shown in the table, Xe Katam Hydropower Plant Project is one of the projects which have already been planned in the PDP.

Table 3.1-8 Progress Situation of Generation Development until 2025

Classifi-cation	System	Power station	Prefecture	Type of power generation	Installed capacity [MW]	Amount of power generation [GWh/year]	Developer	Status	COD
EDL	Northern region	Nam Khan 2	Luangprabang	Hydro/ reservoir	130.0	558.0	EDL ← Exim Bank China (China)	Under construction	2015
		Nam Khan 3	Luangprabang	Hydro/ reservoir	60.0	249.5	EDL ← Exim Bank China (China)	Under construction	2016
		Nam Song	Luangprabang	-	4.7	26.2	Joint Venture MVS, Siam International	MOU	2019
	Central region 1	Nam Sana	Vientiane	Hydro/ Run-of-River	14.0	49.6	EDL 100%	Under construction	2014
		Nam Ngum 1 expansion phase 2	Vientiane	Hydro/ reservoir	80.0	59.0	EDL ← China	Under construction	2016
		Nam Chiane	Vientiane	Hydro/ reservoir	104.0	448.2	EDL 100%	Under construction	2017
		Nam Ngum 1 expansion phase 1	Vientiane	Hydro/ reservoir	40.0	60.0	EDL ← JBIC (Japan)	Under construction	2017
		Nam Ngum 3	Vientiane	Hydro/ reservoir	480.0	2146.0	EDL	Under construction	2020
	Central region 2	Nam Theun Kengseuaten	Borikhamxay	Hydro/ reservoir	54.0	200.0	EDL ← Thailand	Under construction	2010
		Nam Hinboun	Khammouan	Hydro/ reservoir	30.0	197.0	EDL 100%	Under construction	2017
	Southern region	Houay Lamphan Ngai	Xekong	Hydro/ reservoir	88.0	500.0	EDL 100%	Under construction	2015
		Xeset 3	Champasak	Hydro/ Run-of-River	23.0	82.0	EDL 100%	Under construction	2016
		Selabam expansion	Champasak	Hydro/ Run-of-River	7.7	37.1	EDL ← JBIC (Japan)	PPA	2017
		Xekaman 2A, 2B	Xekong	Hydro/ reservoir	190.0	701.0	EDL	FS	2021
		Nam Kong 1	Attapeu	Hydro/ reservoir	150.0	600.0		FS	2022
IPP	Northern region	Nam Khan 4	Luangprabang	Hydro/ Run-of-River	47.0	-	-	MOU	-
		Hongsa	Xayaboury	Thermal/Coal (Brown coal)	1878.0	12582.0	Banpu (Thailand) 40%, Ratchaburi (Thailand) 40%, LHSE (Laos) 20%	Under construction	2015
		Nam Long 2	Luangnamtha	-	12.5	92.0	-	Under construction	2016
		Nam Beng	Oudomxay	Hydro/ reservoir	36.0	145.0	China National Electrical Equipment Corporation (China) 80%, EDL 20%	Under construction	2016
		Nam Ou 2	Luangprabang	Hydro/ Run-of-River	120.0	546.0	Sinohydro (China) 85%, EDL 15%	Under construction	2017
		Nam Ou 5	Phongsaly	Hydro/ reservoir	240.0	1049.0	Sinohydro (China) 85%, EDL 15%	Under construction	2017
		Nam Ou 6	Phongsaly	Hydro/ reservoir	180.0	739.0	Sinohydro (China) 85%, EDL 15%	Under construction	2017
		Nam Nga 2	Oudomxay	-	14.5	62.6	-	PDA	2017
		Nam Phoun	Xayaboury	Hydro/ reservoir	60.0	276.0	-	PDA	2017
		Nam Ngao	Bokeo	Hydro/ Run-of-River	20.0	85.2	EDUPEA Encom	MOU	2018
		Nam Tha 1	Luangnamtha	Hydro/ reservoir	168.0	759.4	China Southern Power Grid Co., Ltd. (China) 75%, EDL 25%	Under construction	2018
		Nam Ou 1	Luangprabang	Hydro/ reservoir	180.0	710.0	Sinohydro (China)	CA	2018
		Nam Ou 3	Luangprabang	Hydro/ reservoir	210.0	826.0	Sinohydro (China)	CA	2018
		Nam Ou 4	Phongsaly	Hydro/ reservoir	132.0	519.0	Sinohydro (China)	CA	2018
		Nam Ou 7	Phongsaly	Hydro/ reservoir	210.0	838.0	Sinohydro (China)	CA	2018
		Pak Beng (Mekong)	Oudomxay	Hydro/ Run-of-River	912.0	4846.0	China Datang Overseas 81%, Laos 19%	-	2018
		Nam Ham	Xayaboury	Hydro	4.0	16.0	PEA Envom (Thailand) 67%, EDL 30%, Cobie (Thailand) 3%	CA	2019

Classifi-cation	System	Power station	Prefecture	Type of power generation	Installed capacity [MW]	Amount of power generation [GWh/year]	Developer	Status	COD
IPP	Northern region	Nam Houng (Upstream)	Xayaboury	-	5.0	23.2	-	CA	2019
		Nam Houng (Downstream)	Xayaboury	-	12.5	68.0	-	CA	2019
		Nam Pha	Luangnamtha	Hydro/ reservoir	180.0	730.0	Asian Pacific Business Link HND Bhd. (Malaysia) 80%, EDL 20%	PDA	2019
		Xayaboury (Mekong)	Xayaboury	Hydro/ Run-of-River	1285.0	9390.0	Karnchang 30%, Natee Synergy 25%, EDL 20%, Electricity Generating Public 12.5%, Bangkok Expressway Public 7.5%, PT Construction 5%	Under construction	2019
		Nam Seung Cascade	Luangprabang	Hydro/ Run-of-River	195.0	-	China Sichuan Gurong Group Co.	PDA	2020
		Nam Tha	Bokeo	-	14.8	50.0	-	Under planning	2020
		Nam Ngum - Nam Kene	Xayaboury	Hydro/ reservoir	70.0	370.0	Sand and Thai	MOU	2021
		Nam Pui	Xayaboury	Hydro/ Run-of-River	60.0	294.0	Mudajaya Corporation Bhd. (Malaysia)	MOU	2021
		Nam Nga	Luangprabang	Hydro/ reservoir	60.0	260.0	-	MOU	2022
		Nam Leng	Phongsaly	Hydro/ reservoir	60.0	240.0	Venture Capital and Equipment Inc. (Vietnam)	FS	2022
		Nam Phak	Oudomxay	Hydro/ Run-of-River	34.6	-	-	MOU	2022
		Luangprabang (Mekong)	Luangprabang	Hydro/ Run-of-River	1200.0	6500.0	Petro Vietnam Power Corporation (Vietnam)	MOU	2022
		Nam Boung 2	Phongsaly	-	15.0	79.0	-	CA	-
		Pklay (Mekong)	Xayaboury	Hydro/ Run-of-River	1320.0	5948.0	CEIEC, Shinohydro	-	-
		Nam Seng	Luangprabang	Hydro/ reservoir	10.0	60.2	-	CA	-
	Central region 1	Nam Ngum 4	Xieng Khuang	Hydro/ reservoir	220.0	822.2	VLV, EDL	FS	2012
		Nam Ngiep 3A	Xieng Khuang	Hydro/ reservoir	44.0	152.3	-	Under construction	2014
		Nam Sim	Huaphanh	-	8.0	32.0	Energy Development AS (Norway) 75%, ECI (Laos)	Under construction	2015
		Nam Samouay	Vientiane	-	5.0	28.0	Sanamxay Road Building Construction Co., Ltd.	Under construction	2015
		Nam Ngiep 2	Xieng Khuang	Hydro/ reservoir	180.0	732.0	CWE (China) 90%, EDL 10%	Under construction	2015
		Nam San 3A (Upstream)	Xieng Khuang	Hydro/ reservoir	69.0	278.4	-	Under construction	2015
		Nam San 3B (Downstream)	Xieng Khuang	Hydro/ reservoir	45.0	173.5	-	Under construction	2015
		Nam Pha Gnai	Vientiane	-	15.0	126.0	DSK (Laos)	Under construction	2016
		Nam Lik 1	Vientiane	Hydro/ reservoir	64.0	256.0	Hydro Engineering (Thailand) 40%, PTTi 40%, POSCO 10%, EDL 20%	Under construction	2016
		Nam Theun	Vientiane	-	-	-	Lao Company (Laos)	MOU	2017
		Nam Phay	Vientiane	Hydro/ reservoir	86.0	419.5	Norinco international Corporation 80%, EDL 20%	Under construction	2017
		Nam Kene	Vientiane	Hydro/ Run-of-River	5.0	19.7	SV group, PPNK Company	CA	2018
		Nam Mo 2	Xieng Khuang	Hydro/ Run-of-River	120.0	503.4	Hanoi Investment 65%, Viet-Lao Economical Cooperative General Co. 35%	CA	2018
		Nam Hao	Huaphanh	Hydro/ Run-of-River	15.0	75.0	-	MOU	2018
		Nam Bak 2	Vientiane	Hydro/ Run-of-River	40.0	205.0	SIAN-NG 2	PDA	2019
		Nam Et 4,5,6	Huaphanh	-	-	-	CWE (China)	Under planning	2019
		Nam Neun 1	Huaphanh	Hydro/ reservoir	124.0	575.0	IndoChina Consulting	MOU	2019

Classifi-cation	System	Power station	Prefecture	Type of power generation	Installed capacity [MW]	Amount of power generation [GWh/year]	Developer	Status	COD
IPP	Central region 1	Nam Neun 2	Huaphanh	Hydro/ reservoir	56.0	230.0	IndoChina Consulting	MOU	2019
		Nam Bak 1	Vientiane	Hydro/ reservoir	160.0	744.0	Southeast Asia Energy Co., Ltd.	CA	2020
		Nam Phouan	Vientiane	Hydro/ reservoir	51.8	202.5	Velcan Energy (France)	PDA	2020
		Nam Et 1,2,3	Huaphanh	Hydro/ reservoir	264.0	1057.7	Houang Anh Gai Lai Mineral Joint Stock Company	FS	2020
		Nam Ngiep 2A	Xieng Khuang	Hydro/ Run-of-River	12.4	70.5	-	MOU	2020
		Nam Ngiep 2B	Xieng Khuang	Hydro/ Run-of-River	8.6	31.7	-	MOU	2020
		Nam Ngiep 2C	Xieng Khuang	Hydro/ Run-of-River	13.8	73.0	-	MOU	2020
		Nam Ngum (Downstream)	Vientiane	-	-	-	Lao Company (Laos)	Under investigation	2021
		Nam The	Xieng Khuang	Hydro/ Run-of-River	24.0	50.0	Nong Hai Group	CA	2022
		Nam Xam 1	Huaphanh	Hydro/ reservoir	94.0	323.1	Sai Ngon Investment Group 80%, EDL 20%	FS	2022
		Nam Xam 3	Huaphanh	Hydro/ reservoir	196.0	635.8	Sai Ngon Investment Group 80%, EDL 20%	Under construction	2022
		Nam Pot	Xieng Khuang	Hydro/ reservoir	15.0	70.5	ACE Consultant	PDA	2022
		Nam Peun 1	Huaphanh	-	-	-	-	MOU	2022
		Nam Pern 2	Huaphanh	-	12.0	68.0	-	MOU	2022
		Nam Ma 1A	Huaphanh	Hydro/ Run-of-River	39.0	156.4	Linh Linh JFC	MOU	2023
		Nam Ma 2A	Huaphanh	Hydro/ Run-of-River	18.0	73.5	Linh Linh JFC	MOU	2023
		Nam Feung	Vientiane	Hydro/ reservoir	45.0	113.0	Syntec Construction Public Co.	MOU	2023
		Nam Ma 1	Huaphanh	Hydro/ Run-of-River	44.0	181.0	Linh Linh JFC	MOU	2023
		Nam Ma 2	Huaphanh	Hydro/ Run-of-River	30.0	117.8	Linh Linh JFC	MOU	2023
		Nam Ma 3	Huaphanh	Hydro/ Run-of-River	18.0	76.3	Linh Linh JFC	MOU	2023
		Nam Feung 2	Vientiane	-	25.0	90.0	-	Under planning	2023
		Nam Feung 3	Vientiane	-	20.0	80.0	-	Under planning	2023
		Xanakham (Mekong)	Vientiane	Hydro/ Run-of-River	660.0	3969.0	China Datang Overseas 81%, Laos 19%	PDA	2024
		Sam Tai	Huaphanh	Thermal/Coal (Brown coal)	-	-	-	-	2028
		Houa Muangi	Huaphanh	Thermal/Coal (Brown coal)	-	-	-	-	2029
		Nam Mo 1	Xieng Khuang	Hydro/ Run-of-River	55.0	222.0	-	PDA	-
	Central region 2	Xeneu	Khammouan	-	53.0	209.0	-	MOU	2010
		Nam Mang 1	Borikhamxay	Hydro/ reservoir	64.0	224.8	EDL 10%, Dongfang 75%, A&C 10.75%, etc.	Under construction	2016
		Nam Ngiep 1 (off take)	Borikhamxay	Hydro/ Run-of-River	289.0	1620.0	Kansai Electric Power Co., Inc. (Japan) 45%, EGAT International (Thailand) 30%, LHSE (Laos) 25%	Under construction	2019
		Xelanong 2	Ssvannakhet	Hydro/ reservoir	40.0	142.7	China Gezhouba Group Company Ltd.	MOU	2020
		Nam Theun 1	Borikhamxay	Hydro/ reservoir	600.0	2371.0	-	MOU	2020
		Xelanong 1	Ssvannakhet	-	70.0	256.7		MOU	2021
		Nam Mouan	Borikhamxay	Hydro/ reservoir	100.0	439.0	Chubu Electric (Japan)	MOU	2021

Classifi-cation	System	Power station	Prefecture	Type of power generation	Installed capacity [MW]	Amount of power generation [GWh/year]	Developer	Status	COD
		Xebanghieng 2 (Tadsakoy)	Savannakhet	Hydro/ reservoir	15.0	68.0	-	Under construction	2022
		Xebanghieng 1	Savannakhet	-	60.0	182.2	CWE (China)	MOU	2023
		Xebanghieng 2	Savannakhet	-	90.0	288.0	CWE (China)	MOU	2023
		Nam Theun 4	Borikhamxay	Hydro/ reservoir	80.0	-	-	MOU	-
	Central region 2	Xelanong 3 Ban Tangeun	Ssvannakhet	Hydro/ Run-of-River	80.0	-	-	MOU	-
		Ban Vangdeun Nam Mouan	Borikhamxay	Hydro/ reservoir	60.0	-	-	-	-
		Xetanouan	Savannakhet	-	35.0	142.7	China Gezhouba Group Company Ltd.	MOU	-
		Nam Sor	Borikhamxay	-	4.2	19.0	-	CA	-
		Xekok 1,2	Savannakhet	-	14.8	61.5	-	CA	-
		Houay Kapheu 1	Saravan	-	5.0	38.0	-	Under construction	2014
		Xenamnoy 1	Attapeu	Hydro/ reservoir	14.8	101.0	Xenamnoy 1 Company	Under construction	2014
		Xenamnoy 6	Champasak	-	5.0	40.0	-	Under construction	2014
		Sugar Thermal	Attapeu	Thermal power	20.0	105.0	Houang Anh Gai Lai Mineral JS Co. 80%, EDL 20%	Under construction	2015
		Xekaman 1 (off take)	Attapeu	Hydro/ reservoir	290.0	1069.0	VLP (Vietnam) 100%	Under construction	2016
		Xeset - Kengsun	Saravan	-	13.0	42.9	-	CA	2016
		Houay Kapheu 2	Saravan	-	5.0	22.0	-	CA	2016
IPP		Nam Kong 3	Attapeu	Hydro/ reservoir	45.0	170.0	Houang Anh Gai Lai Mineral JS Co. 80%, EDL 12.77%	Under construction	2017
		Nam Kong 2	Attapeu	Hydro/ reservoir	66.0	263.0	Houang Anh Gai Lai Mineral JS Co. 80%, EDL 12.77%	Under construction	2017
		Xekaman-Sanxai	Attapeu	Hydro/ reservoir	32.0	121.0	VLP (Vietnam) 100%	Under construction	2017
		Tadlang Nam Sen	Champasak	Hydro/ Run-of-River	5.0	18.0	-	MOU	2017
		Don Sahong	Champasak	Hydro/ Run-of-River	260.0	2044.0	Mega First (Malaysia) 80%, Laos 20%	Under construction	2018
	Southern region	Nam Phak	Champasak	Hydro/ reservoir	150.0	511.0	Nava Bharat (Singapore) 65%, EDL 15%, Kobe Green Power Co., Ltd. (Japan) 20%	CA	2018
		Houay Champi	Champasak	Hydro/ Run-of-River	5.0	27.3	-	MOU	2018
		Xepian-Xenamnoy	Champasak	Hydro/ reservoir	410.0	1880.0	SK Engineering 26%, Korea Western Power 25%, Ratchaburi 25%, LHSE 24%	Under construction	2019
		Houay Por	Saravan	-	15.0	63.0	Houay Por Power Co., Ltd.	Under construction	2019
		Xekatam	Champasak	Hydro/ reservoir	81.0	299.0	Kansai Electric Power Co., Inc. (Japan)	PDA	2019
		Tha Kho (Mekong)	Champasak	-	-	-	France	FS	2020
		Xepian-Houaysoy	Attapeu	Hydro/ Run-of-River	115.0	253.0	DMD	FS	2020
		Xekong 3A (Upstream)	Attapeu	Hydro/ Run-of-River	105.0	410.5	Song Da Corporation Co.	PDA	2020
		Xekong 3B (Downstream)	Attapeu	Hydro/ Run-of-River	100.0	393.5	Song Da Corporation Co.	PDA	2020
		Xepon 3	Saravan	Hydro/ reservoir	54.4	222.5	EDL, Korea Water Resource Corporation	MOU	2020
		M Kalum	Xekong	Thermal/Coal (Brown coal)	300.0	2100.0	-	Under construction	2022
		Xekaman 4	Attapeu	-	80.0	318.0	Viet-Lao Power Company	PDA	2020

Classifi-cation	System	Power station	Prefecture	Type of power generation	Installed capacity [MW]	Amount of power generation [GWh/year]	Developer	Status	COD
IPP	Southern region	Xekong (Downstream A)	Attapeu	-	76.0	387.0	V&H Corporation (Laos)	FS	2020
		Xexou	Attapeu	Hydro/ reservoir	30.0	50.0	Houang Anh Gai Lai Mineral Joint Stock Company	FS	2022
		Nam Ang Tabeng	Attapeu	Hydro/ Run-of-River	40.9	183.3	Velcan Energy (France)	PDA	2022
		Xekong 4	Xekong	Hydro/ reservoir	300.0	1901.0	Region oil (Russia)	PDA	2022
		Pak Ngoy (Mekong)	Champasak	Hydro/ Run-of-River	686.0	2751.0	Charoen Energy & Water Asian Co., Ltd.	PDA	2023
		Ban Koum (Mekong)	Champasak	Hydro/ Run-of-River	1872.0	8433.0	Italian Thai, Asia Corp Holding Ltd.	MOU	2030
		Nam Emeun	Xekong	Hydro/ reservoir	105.0	-	-	MOU	-
		Xekong (Downstream B)	Attapeu	Hydro/ Run-of-River	50.0	200.0	V&H Corporation (Laos)	PDA	-
		Xekong 5	Xekong	Hydro/ reservoir	330.0	1613.0	Inter-RAO-Engineering (Russia), region Oil (Russia)	PDA	-
	Others	Wind power generation	Xekong, Khammouan, Svannakhet	Wind	500.0	-	Impacted Asia Ltd.	MOU	-

(Source: EDL System Planning Office)

2) Transmission and Substation Facilities Development Plan in the Whole Country

Figure 3.1-7 shows an electric power system diagram of Laos in 2025 which appears in PDP 2015 – 2025.

The current system is divided into Northern Central Area – northern part of Southern Area line and Northern Central Area –southern part of Southern Area line, which will be interconnected in 2016 as previously mentioned. The line interconnecting Southern Area with Central Area is 115 kV transmission line which is constructed under Yen Loan (between Pakbo and Saravan). In addition, Central area and Southern area is to be interconnected with 230 kV transmission lines.

After installation of these interconnections, a supply and demand control is going to be possible within whole Laos. Furthermore, interconnections not only within the country but also with nearby countries such as Vietnam and Cambodia is planned.

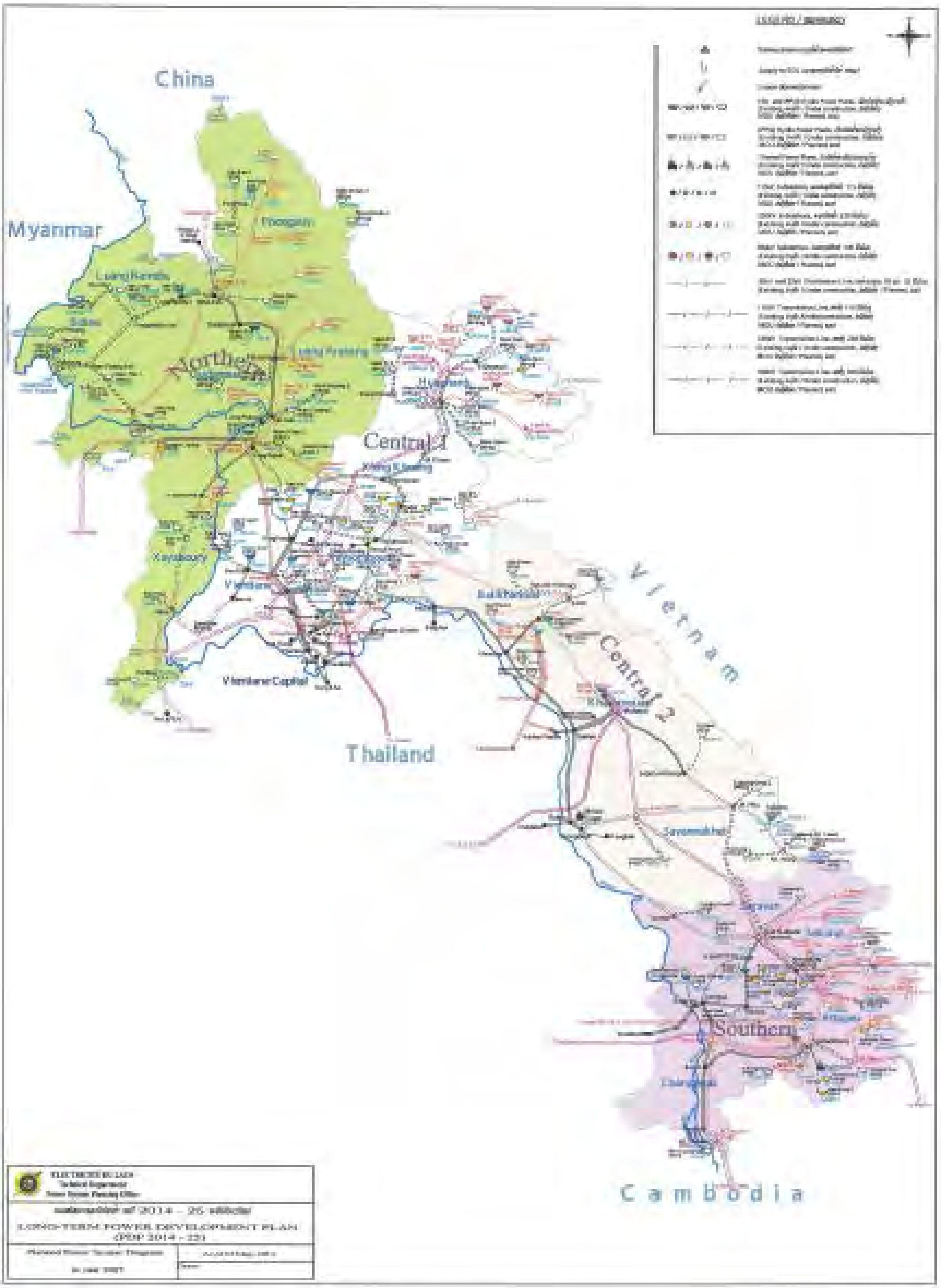


Figure 3.1-7 Electric Power System Diagram of Laos in 2025 (including Future Projects)

(4) Facing issues of power sector

(a) Current status of import/export to/from adjacent countries

While Laos export electricity to EGAT in Thailand in order to obtain foreign currency, Laos import electricity from adjacent countries to meet rapid growth of electricity demand. Importing electricity from adjacent countries is increasing from the beginning of 1990 to 2010. In the past, Laos export 10 times as much as imported electricity. At last importing electricity has been larger than exporting electricity since 2007.

In 2011, much domestic power was generated due to influence of high water, which contributed to lessening balance of import electricity and export electricity. In 2012, however, record of high excess of import over export (Import 1127 GWh – Export 320 GWh = 807 GWh) was marked and the trend of excessive import over export continued in 2013 when it was 514 GWh (Import 1205 GWh – Export 691 GWh = 514 GWh).

Table 3.1-9 and Figure 3.1-8 show change of electricity export and import.

Table 3.1-9 Trend of Power Balance between Imports and Exports

Year	Generation	Import	Export	Domestic Sale
1991	834.6	34.9	562.6	220.7
1992	751.8	41.3	459.8	252.7
1993	919.6	47.7	595.8	264.3
1994	1,198.3	57.5	829.3	303.4
1995	1,085.0	76.8	675.6	337.5
1996	1,247.8	87.6	792.4	379.5
1997	1,218.7	101.7	710.2	433.9
1998	947.8	142.3	405.2	513.3
1999	1,168.9	172.2	598.1	565.6
2000	1,578.6	159.9	862.9	639.9
2001	1,553.7	182.5	796.4	710.3
2002	1,570.2	200.8	771.4	766.7
2003	1,386.8	229.3	434.7	883.7
2004	1,416.5	277.6	507.1	902.8
2005	1,751.1	325.6	727.8	1,011.1
2006	1,639.3	334.6	547.1	1,112.4
2007	1,398.4	475.9	268.0	1,298.4
2008	1,777.6	510.0	391.8	1,577.9
2009	1,655.9	818.6	229.5	1,901.3
2010	1,552.7	999.0	341.3	2,228.2
2011	2,083.1	747.9	678.3	2,399.4
2012	1,895.9	1,127.3	320.4	2,874.2
2013	2,077.8	1,205.1	690.8	3,381.0

(Source: EDL Annual Report 2013)

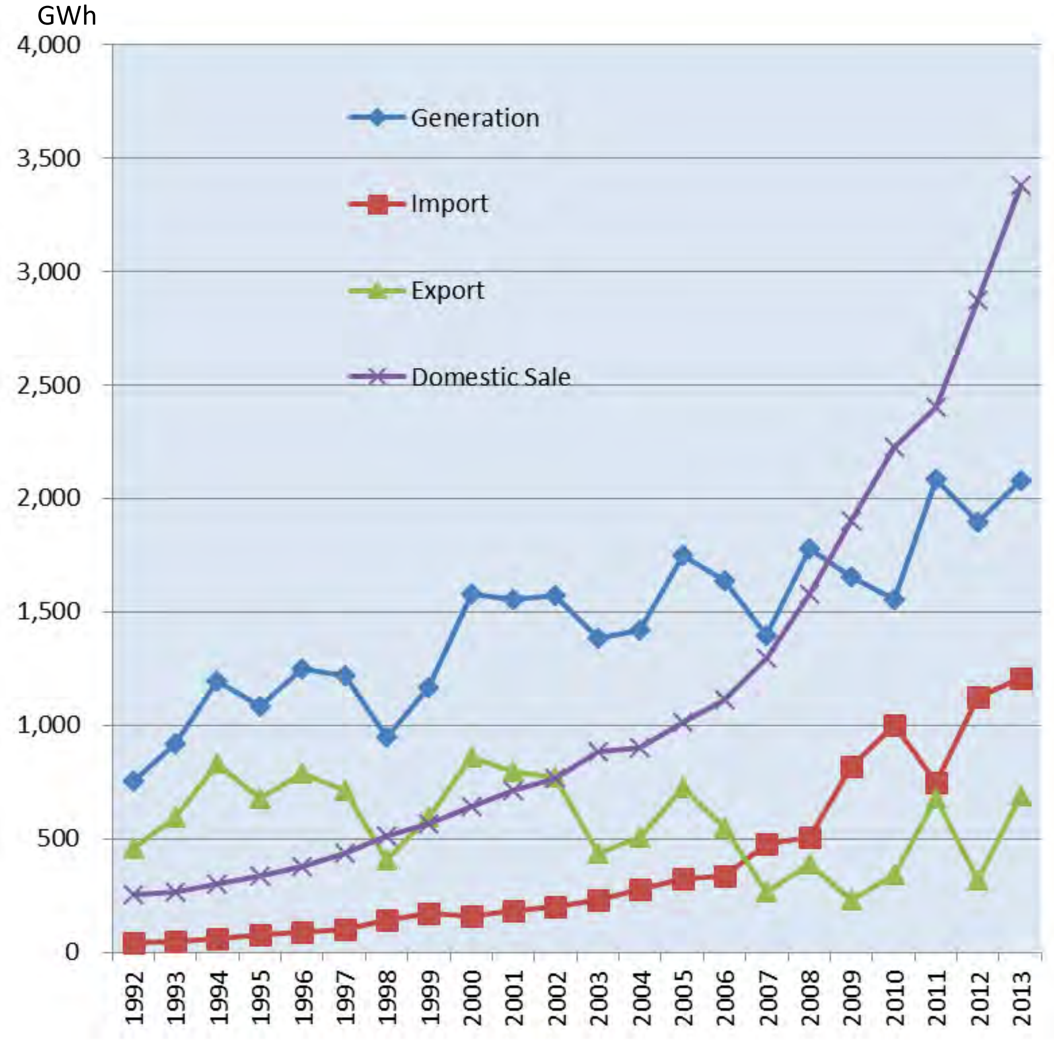


Figure 3.1-8 Trend of Power Balance between Imports and Exports

(Source: EDL Annual Report 2013)

Table 3.1-10 shows amount of imported electricity by source country.

Looking at source country of electricity import, import from Thailand (EGAT + PEA) has been growing and occupied 80% of total import in 2013. Especially a deal with EGAT alone occupied more than 70% of the total.

Table 3.1-10 Trend of Power Imports (by countries)

(Unit: GWh)

Years	Thailand			China	Vietnam	Total
	EGAT	PEA	Total			
1998	136.4	3.4	139.8	0.0	2.3	142.1
1999	162.4	4.8	167.2	0.0	5.0	172.2
2000	147.3	6.0	153.4	0.0	6.6	159.9
2001	165.4	8.9	174.3	0.0	8.2	182.5
2002	178.7	11.6	190.3	0.0	10.5	200.8
2003	203.2	13.9	217.1	0.0	12.2	229.3
2004	248.2	17.0	265.2	0.0	12.4	277.6
2005	289.3	21.8	311.1	0.0	14.9	326.0
2006	290.5	26.9	317.4	0.0	17.2	334.6
2007	409.4	32.4	441.8	14.6	19.6	475.9
2008	431.0	38.6	469.6	17.8	22.6	510.0
2009	719.0	52.6	771.7	21.6	25.4	818.6
2010	819.8	70.4	890.2	77.0	31.8	999.0
2011	526.9	74.5	601.5	112.5	34.0	747.9
2012	908.4	69.8	978.1	112.7	36.5	1,127.3
2013	882.1	77.0	959.1	218.7	27.2	1,205.1

(Source: EDL Electricity Statistics 2012 and 2013)

Table 3.1-11 indicates change in tariff for export and import of electricity between EDL and EGAT.

On the other hand, import price from EGAT is higher than export from EDL. This brings negative impact to EDL's financial status.

In addition, a charge (Excess Charge) to pay when import electricity exceeds export electricity was set. Therefore there is a strong needs of the power generations which can supply electricity to inside of Laos in a peak time. 2013 tariff was same as 2012 tariff.

Table 3.1-11 Trend of Tariff between EDL and EGAT

Unit：Baht/kWh

category			2010	2012, 2013
Export		Peak	1.60	1.60
		Off Peak	1.20	1.20
Import		Peak	1.79 (1.60)	1.74 (1.60)
		Off Peak	1.39 (1.20)	1.34 (1.20)
	Excess Charge	Peak	1.30 (no time of use)	1.93
		Off Peak		0.70
	Excess Charge Tariff	Peak	3.09 (2.90)	3.69 (3.53)
		Off Peak	2.69 (2.50)	2.04 (1.90)

Peak : Mon-Fri 9:00-22:00, Off Peak : exclusive of Peak time
( ): Emergency tariff

Source: EDL Annual Report 2010, 2012, 2013

Table 3.1-12 shows results of export and import of electricity between EDL and EGAT in 2013.

The amount of electricity imported from EGAT by EDL was 882 GWh and the amount exported to EGAT was 680 GWh, which resulted in excess of import over export by 202 GWh. Breakdown of excess of import was 124 GWh for peak time and 78 GWh for off-peak time.

Calculating by applying tariffs described in Table 3.1-11 to these results, payment to EGAT by EDL amounts to 1,609 MBaht and payment to EDL by EGAT is 900 MBaht, which makes the balance 709 MBaht to be paid to EGAT by EDL.

Table 3.1-12 Results of Electricity Export and Import between EDL and EGAT (2013)

Month	2013								
	Total (GWh)			Peak (GWh)			Off Peak (GWh)		
	Import	Export	Balance	Import	Export	Balance	Import	Export	Balance
1	68	20	47	27	8	19	41	13	28
2	81	40	41	34	10	24	47	31	16
3	122	29	93	49	10	39	73	19	54
4	124	21	103	51	9	42	73	13	60
5	153	9	144	64	3	61	89	6	83
6	100	20	81	38	5	34	62	15	47
7	50	93	-43	18	24	-6	32	69	-37
8	40	164	-124	13	48	-35	27	116	-88
9	17	168	-151	5	51	-46	12	117	-105
10	20	87	-68	7	30	-22	12	58	-46
11	51	20	31	18	8	10	33	12	21
12	57	9	49	10	6	5	47	3	44
Total	882	680	202	334	210	124	548	470	78

(Source: EDL)

Tariff (B/kwh)	1.74	1.60	1.93	1.34	1.20	0.70

	Cost（MBaht）
Import （Payment from EDL to EGAT）	1,609.11
Export （Payment from EGAT to EDL）	900.08
Balance	709.03

Peak : Mon-Fri 9:00-22:00、 Off Peak : Without Peak Priod
Import : EDL buys electricity from EGAT
Export : EDL sells electricity to EGAT
Balance : Import - Export

(b) Action taken by Lao government toward rectification of export/import-price in power purchase condition with EGAT

Lao government is investigating to cancel this export/import-price-difference in power purchase condition in the future from the viewpoint of energy security and improvement of the country's balance of international payments. As a background of existing export/import-price-difference in power purchase condition between Laos and Thailand, there exists the situation that generation costs are forced to added to operate power stations whose costs are more expensive in order to secure electricity supply because demand/supply balance is also severe in Thailand in dry season when electricity is mainly in short in Laos.

In order to dissolve export/import-price difference, it is important to enhance its own power supply system which does not rely on import electricity from Thailand. The country shall, therefore, interconnect transmission line network which is now divided to develop the transmission line network which allows for integrated operation in the country as well as develop proactively power sources which are now insufficient.

(c) Improvement of the situation of electricity import from EGAT due to development of Xe Katam Hydropower Station

Table 3.1-13 shows monthly selling electricity (planned) of Xe Katam Hydropower Station.

Annual selling electricity is 296GWh consisting of power sold in peak time of 100GWh and that of off-peak time of 197GWh (the total may not correspond to result of addition because of round-off). The annual selling electricity of 296GWh is obtained from total annual power generation 299GWh deducted by power loss, which corresponds to amount of power (planned) to be sold to EDL.

Table 3.1-13 Planned Power Generation of Xe Katam Hydropower Station

Month	XeKatam		
	Total (GWh)	Peak (GWh)	Off Peak (GWh)
1	5	5	0
2	3	3	0
3	3	3	0
4	6	5	1
5	16	7	8
6	29	9	21
7	52	13	39
8	57	14	43
9	56	14	42
10	43	11	32
11	17	7	10
12	9	8	1
Total	296	100	197

Peak : Mon-Fri 9:00-22:00
Off Peak : Without Peak Priod

Table 3.1-14 shows estimation of electricity import and export between EDL and EGAT if Xe Katam Hydropower station should have been connected with the system of EDL in 2012 (estimation assuming that all power generated by Xe Katam Hydropower Station will export to EGAT).

Amount of power imported from EGAT by EDL is 908 GWh while that exported to EGAT is 608 GWh which is increase by 296 GWh. As a result, excess of import becomes 301 GWh which is decrease to a half from 597 GWh. The excess of import consists of 185 GWh import during peak time and 116 GWh import during off-peak time.

Calculating by applying tariffs described in Table 3.1-11 to these results, payment to EGAT by EDL is 1,362 MBaht and payment to EDL by EGAT is 1,295 MBaht, which makes the balance of 67 MBaht paid to EGAT by EDL.

Due to addition of electricity from Xe Katam Hydropower Station, payment to EGAT by EDL is decreased from 709 MBaht (see Table 3.2-12) to 67 MBaht (see Table 3.2-14) which is decrease by 642 MBaht. This means that electric power of 296 GWh will reduce payment by 642 MBaht which has the value equivalent to 2.17 Baht/kW (642 MBaht/296 GWh, 7.2¢/kWh). Thus significance of Xe Katam Hydropower station is remarkable.

Table 3.1-14 Estimation of Electricity Export and Import between EDL and EGAT after Connection of Xe Katam Hydropower Station

Month	2013 Results + Xe Katam								
	Total (GWh)			Peak (GWh)			Off Peak (GWh)		
	Import	Export	Balance	Import	Export	Balance	Import	Export	Balance
1	68	25	42	27	13	14	41	13	28
2	81	43	38	34	13	21	47	31	16
3	122	32	90	49	12	36	73	19	54
4	124	27	97	51	14	37	73	13	60
5	153	24	129	64	10	54	89	14	75
6	100	49	51	38	13	25	62	36	26
7	50	145	-96	18	37	-19	32	108	-76
8	40	222	-181	13	63	-50	27	159	-131
9	17	223	-207	5	65	-60	12	159	-147
10	20	130	-111	7	41	-33	12	89	-77
11	51	38	13	18	16	2	33	22	11
12	57	18	39	10	13	-3	47	5	42
Total	882	976	-94	334	310	24	548	667	-118

Tariff (B/kwh)	1.74	1.60	1.93	1.34	1.20	0.70

	Cost (MBaht)
Import (Payment from EDL to EGAT)	1,362.00
Export (Payment from EGAT to EDL)	1,295.49
Balance	66.52

Peak : Mon-Fri 9:00-22:00、 Off Peak : Without Peak Priod
Import : EDL buys electricity from EGAT
Export : EDL sells electricity to EGAT
Balance : Import - Export

(5) Policy of rural electrification

In this clause, policy to enable stable power supply to general population will be explained.

Lao government is promoting rural electrification with a long-term goal that rural electrification rate should reach to 90% by 2020. The household electrification rate which was 73.0% in 2010 became 87.3% as of 2013. Thus the plan is steadily progressing.

Rural electrification is being promoted under support of the World Bank and Asian Development Bank (ADB) which are working with Lao side partners (EDL/MEM). Table 3.1-15 shows a list of rural electrification projects by the World Bank and ADB.

Table 3.1-15 List of Rural Electrification Project by World Bank and ADB

	Period	Implementation institute	Amount of project (million US$)
<ADB>			
Vientiane Rural Electrification PJT I	-1987	ADB	7.20
Vientiane Rural Electrification PJT II	-1990	ADB	10.30
Nam Ngum-Luang Prabang Power Transmission	1989-1998	ADB	20.30
Power Transmission and Distribution	1997-2002	ADB	58.31
Northern Area Rural Power Distribution	2004-2009	ADB	51.51
Subtotal – ADB			147.62
<World Bank>			
Southern Province Electrification (SPE)	1988-1994	WB	30.44
Provincial Grid Integration PJT	1993-2000	WB	47.52
Southern Province Rural Electrification	1998-2004	WB	41.41
Rural Electrification PJT I	2006-2012	WB	36.27
Rural Electrification PJT II	2010-	WB	37.62
Subtotal – World Bank			193.26
Total – ADB and World Bank			**340.88**

Source: FY2014 Survey Report of Electric Power Circumstance in Laos and Cambodia, December 2014, Japan Electric Power Information Center, Inc. (JEPIC)
(Prepared by JEPIC based on materials of International Bank for Reconstruction and Development and the World Bank))

AS mentioned above, the World Bank plays an important role in rural electrification in Laos. In this connection, a report issued by affiliated agency of the World Bank gave extremely high evaluation as follows: “The progress of electrification in Laos is outstanding among successful examples in the world.”

As a characteristic scheme in the policy of rural electrification in Laos, there is a program called Power to Poor (P2P) that discount of initial cost of power supply entrance wire shall be granted to poor household. The following is an outline of P2P:

Outline of Power to Poor Program (P2P)

As a result of follow-up survey at Phossaad Village in southern region which was electrified on whole village basis under Southern Province Rural Electrification Project which was the initial electrification program, it was found that among total 270 households in the village, 63 households had not been electrified as of the end of 2008.

As a measure for the households that cannot afford to be electrified because of economic reason even though electric power is available in a village, non-interest loan with the upper limit of 700,000 LAK was made available (on the condition that 200,000 LAK in average shall be paid for connection cost from this money) and thereafter the scheme that requires monthly repayment of 20,000 LAK was adopted. This is the program called Power to Poor (P2P). It should be noted that total of this monthly repayment and expected monthly payment for electricity (= 10,000 LAK) was set as the level equivalent to what had been paid as heating and lighting expenses when it had not been electrified. In order to promote this program smoothly, EDL established a dedicated fund (P2P Revolving Fund).

As a result of this program, household electrification rate of Phossaad Village became 100% in two months.

This P2P program was expanded seriatim targeting the villages which have passed 2 years since electrification on entire-village basis and contributed to increase of electrification rate.

In addition to the above, although EDL used to make consumers bear 30% of cost of new construction of 22kV distribution line in 2000 and before that, EDL thereafter took a measure to bear the whole cost. (Provided, however, that when individual consumer installs electricity, cost of a meter and associated materials shall be, in principle, borne by the consumer.)

As a result of various measures as described above, Laos is achieving significant electrification rate from a global perspective. Since respective aide agency and implementation agency is effectively functioning, it is important to continue this policy.

(6) Interest and movement of other donors in hydro power generation sector and this Project

Supports from the other international organization towards Electricity Power Sector in Laos is as followings.

(a) Support from IFC (International Finance Corporation)

Table 3.1-16 shows projects assisted by IFC

Table 3.1-16 Projects Assisted by IFC

(Unit: million US$)

Name of project	Time of implementation	Amount
Nam Ngum 3 (Hydropower generation) project investment (proposal)	Non-approved at the end of 2011	No more than 100
EDL rural electrification investment (proposal)	2010-	No more than 15
Hydropower generation environmental & social performance standard (advisor)	2012-2017	4.8

(b) Support from Asian Development Bank (ADB)

Table 3.1-17 shows projects assisted by ADB

Table 3.1-17 Projects Assisted by ADB

(Unit: million US$)

Name of project	Kind	Time of implementation (Year of approval, etc.)	Amount
Greater Mekong Sub-region Northern Power Transmission Project	TA	2006	-
Greater Mekong Sub-region Northern Power Transmission Project	Grant	2010	-
Nam Ngiep 1 Hydropower Project	Loan and other	2014	50
Greater Mekong Sub-region Nam Theun 2 Hydroelectric Project (Social and environmental monitoring)	TA	2008	1
Greater Mekong Sub-region Nam Theun 2 Hydroelectric Project	TA	2003, 2004	-
Greater Mekong Sub-region Nam Theun 2 Hydroelectric Project	Loan	2005	-
Small and Mini Hydroelectric Development Project	TA	2010	2
Ban Sok-Pleiku Power Transmission Project in the Great Mekong Sub-region	-	2012	-
Nabong-Udon Thani power transmission project	TA	2007	1
Northern Area Rural Power Distribution Project	TA, Loan	1998, 2003-2011	-
Nam Ngum 3 Hydropower Project in the Great Mekong Sub-region	TA, Loan due diligence	2007-2013	116
Nam Leuk Hydropower Project	Loan and other	1995-2004	-
Power Sector Strategy Study	TA	1999-2003	0.8
Theun-Hinboun Hydropower Project	Loan and other	-2000, 2002	-
Nam Ngum-Luang Prabang Transmission Project	Loan	2002	20
Nam Ngum 500 kV Transmission Line Project	TA	1997	-
Corporate and Financial Development of EDL	TA	1996-1997	0.3
Xeset Hydropower Project	-	1987-1992	-

Among above, projects which might be indirectly beneficial for the Xe Katam Project is as followings.

Corporate and Financial Development of EDL

It was supported about developing corporate planning of EDL and electricity tariff. This support might be indirectly beneficial for “IPP development like Xe Katam Hydropower Projects” or for “stable off-take of generated electricity” because this support about “development of corporate planning to realize EDL’s electricity power development as independent organization with profits” and “study of electricity tariff for each voltage level and demand pattern” might be contributed to improve financial statement of EDL.

- The terms of reference will include the following:
  - (i) develop, in close consultation with EDL’s Board and Management, specific operational objectives for 1996-2000, In terms of EDL’s profitability, operational performance (i.e., collection and arrears ratios), financial structure, and the economic benefits derived from EDL’s operations;
  - (ii) based on a review of current private sector Investment activity, Government incentives for private-sector investment In the power subsector, prospective pipeline projects within EDL, and the current state of development of the power subsector; develop estimates of the demand for financing EDL will face
  - (iii) review EDL’s current operations, in close consultation with the Government as the sole shareholder, with the objective of identifying the major areas of weak performance; based on the review, develop specific recommendations for change in EDL’s operational policies, operational procedures, and staff training programs that will directly address the major operational weaknesses;
  - (iv) taking account of the Government’s dual objectives of increasing the electrification ratio within the country and increasing foreign exchange earnings through the export of power, Identify the relative cost to EDL and benefits to the country from each of these aspects of EDL’s operations; based on this analysis, critically assess EDL’s current operating policies for private sector power operations and rural electrification, and recommend improvements that will enhance the efficiency of such operations; identify the costs associated with rural electrification operations that could be the basis for an explicit subsidy from the Government to allow EDL to undertake a degree of small-scale rural electrification without detriment to its financial condition and general operational capabilities; and
  - (v) based on the output of the tasks described in (i) to (iv), develop yearly financial projections that EDL could realistically achieve during 1996-2000 and that will offer the best prospects for achieving the objectives developed from (i) above; the output from this task will be presented as a business development plan that may propose appropriate diversification of EDL’s activities.
- As a result of implementation of this management plan, operation strategy and corporate plan were accepted by management of EDL and constituted foundation of future strategy review and appropriate planning and institutionalization.
- The terms of reference will include the following:
  - (i) review the current pricing structure of the electricity sector; this will include a review of the long-run marginal cost of supply, both economic and financial, at different delivery points, as well as a review of the desirability and practicability of having a uniform tariff throughout the country;
  - (ii) carry out a survey of residential consumers to determine their ability and willingness to pay;

(iii) develop a tariff policy based upon appropriate financial and cost recovery objectives of the power sector and consumer's ability and willingness to pay;

(iv) review the adequacy of the existing tariff in terms of both level and structure based on the tariff policy developed in (iii) above and by drawing on, where appropriate, experience with tariff levels and the structure of other power utilities of the region;

(v) review the billing and collection capabilities of EDL, determine the extent to which these capabilities may affect the implementation of a revised tariff structure, and recommend suitable improvements; and

(vi) formulate and recommend an appropriate tariff structure that is consistent with the tariff policy developed in (iii) above, and the billing and collection capabilities of EDL, that will enable the power subsector to meet its operational budgets and to finance a reasonable proportion of its capital development program (new capacity additions under build-operate-transfer or joint-venture type of investments and their likely costs should be considered in formulating the bulk tariff).

- Based on the results of this investigation on electricity tariff, the tariff was increased by 90%.

(c) Support from World Bank (WB)

Table 3.1-18 shows projects assisted by the World Bank

Table 3.1-18 Projects Assisted by World Bank

(Unit: million US$)

Name of project	Time of implementation (Year of approval, etc.)	Amount
Lao Rural Electrification Phase I Project	2006	3.75
Lao Rural Electrification Phase II Project	2010	20
Lao Rural Electrification Phase III Project	2011	1.82
Technical Assistance (TA) for Capacity Development in Hydropower and Mining Sector	2010-2015	8.0
GMS Power Trade (Laos) Project	2007-2015	15.0
Nam Theun 2 Power Project (including Social and Environment Project)	2005	20.0
Southern Provinces Rural Electrification Project	1998	34.7
Provincial Grid Integration Project	1992	36.0
Nam Ngum Hydroelectric Project	1981	15.0

Among above, projects which might be indirectly beneficial for the Xe Katam Project is as followings.

TA for Capacity Development in Hydropower and Mining Sector

It was supported to develop policies, regulations and guidelines in Hydropower and Mining Sector. As a port of this technical assistance, especially, standard Concession Agreement (CA) for Laos was made and might be applied to Hydropower Projects like Xe Katam.

GMS Power Trade (Laos) Project/L-7: TA for updating Tariff Study

Among all the efforts, update of investigation on EDL tariff is being implemented as one of TA. By assisting EDL in investigation on tariff, financial condition, etc. of EDL will be improved and may possibly bring about benefits indirectly to development of IPP such as Xe Katam Project and stable electricity purchase by EDL.

As the result and planning of the IPP projects in Laos, projects outlines (installed capacity, markets, etc.), Investors (name, nationality, etc.) and schedule, etc. are shown in Table 3.1-19 to Table 3.1-21.

Table 3.1-19 IPP Project in Lao PDR (Under Operation)

No.	Name of Project	Location/ Province	Installed capacity (MW)	Status		Investors (Sponsors)	Planned Market (Country)	Remarks (Project cost, etc.)
				MOU/ PDA/CA	Commercial Operation Date			
1	Theun-Hinboun	Bolikhamxay	220	Under operation	1998	• EDL (Laos) 60% • Nordic (Norway) 20% • GMS (Thailand) 20%	Laos/ Thailand	About 0.26 Billion USD
2	Houay Ho	Champasak/ Attapeu	152	Under operation	1999	• EDL (Laos)20% • Suez Energy (Belgium) 60% • HHTC (Thailand) 20%	Thailand	About 0.24 Billion USD
3	Nam Lik 1-2 Hydropower	Vientiane	100	Under operation	2010	• EDL (Laos) 10% • CWE (China) 90%	Laos	About 0.15 Billion USD
4	Nam Theun 2 Hydropower	Khammouane and Bolikhamxay	1075	Under operation	2010	• LHSE (Laos) 25% • EDF (France) 40% • EGCO (Thailand) 35%	Laos/ Thailand	About 1.45 Billion USD
5	Nam Ngum 5 Hydropower	Luangprabang and Xiengkhouang	120	Under operation	2012	• EDL (Laos) 15% • Sinohydro (China) 85%	Laos	About 0.2 Billion USD
6	Nam Ngum 2 Hydropower	Vientiane	615	Under operation	2013	• EDL (Laos) 25% • CH. Kanchang (Thailand) 28.5% • PT Construction & Irrigation Co., (Laos) 4% • Ratchaburi (Thailand) 25% • Bangkok Expressway PCL (Thailand) 12.5% • TEAM Consulting Engineering 1% • Shalapak Group (USA) 4%	Thailand	About 0.75 Billion USD
7	Nam Nhone	Bokeo and Luangnamtha	2.4	Under operation	2013	Nam Nhone Power Company 100%	Laos	-
8	Tad Salen Hydropower	Savannakhet	3.2	Under operation	2013	SIC Manufacturer (Thailand) 100%	Laos	About 5 Million USD
9	Theun-Hinboun Hydropower Expansion	Bolikhamxay	220 +60	Under operation	2013	• EDL (Laos) 60% • Nordic Group (Norway) 20% • MDX (Thailand) 20%	Laos/ Thailand	-
10	Xekaman 3 Hydropower	Sekong	250	Under operation	2013	• EDL (Laos) 15% • VLP (Vietnam) 85%	Laos/ Vietnam	-

(Source: made from MEM-Department of Energy Promotion & Department's documents, hearing with EDL and other published)

Table 3.1-20 IPP Projects in Lao PDR (Under Construction)

No.	Name of Project	Location/ Province	Installed capacity (MW)	Status: MOU/ PDA/CA	Status: Commercial Operation Date	Investors (Sponsors)	Planned Market (Country)	Remarks (Project cost, etc.)
1	Hongsa Lignite	Xayaboury	1878	PDA (HOA) Signed 18/12/2006 Tariff MOU 13/05/09	2015	• LHSE (Laos) 20% • Ratchaburi (Thailand) 40% • BANPU 40%	Laos/ Thailand	
2	Xekaman 1 Hydropower	Attapeu	64	CA Signed 10/02/2011	2015	• GOL (Laos) 15-30% • VLP (Vietnam) 70-85%	Vietnam/ Laos	
3	Xayabouri (Mekong)	Xayaboury/ Luangprabang	1260	CA Signed 29/10/2010	2019	• GOL (Laos) 20% • Ch.Kanchang & PT (Thailand) 80%	Laos/ Thailand	
4	Nam Ngum 3 Hydropower	Vientiane and Xieng Khouang	460	PDA Signed 15/11/97	2017	• LHSE (Laos) 23% • Marubeni (Japan) 25% • Ratchaburi (Thailand) 25% • GMS (Thailand) 27%	Thailand	
5	Nam Ou 3	Phongsaly/ Luangprabang	120	PDA Signed 15/10/2007	2016	• GOL (Laos) 10-25% • Sinohydro (China) 90%-75%	Thailand or China and Laos	
	Nam Ou 5		240		2017			
	Nam Ou 6		180		2017			
6	Nam Sim	Houaphan	8	PDA Signed 02/10/2007	2015	• ECI (Laos) 25% • Energy Development as (Norway) 75%	Laos	
7	Nam Sane	(Xiengkhouang)	8	(PDA Signed 19/06/2008)	2014	(•GOL (Laos) 25%) (•Rohas Euco Industries Berhad (Malaysia) 75%)	(Laos)	
8	Xenamnoy 1	Champasak/ Attapeu	15	PDA Signed 25/01/2010	2014	• GOL (Laos) 10% • Phongxubthavy Road and Bridge Construction Co., Ltd 90%	-	
9	Nam Khan 2	Luangprabang	126.2	MOU Signed 13/10/2006	2015	Sinohydro (China)	Laos	
10	Nam Khan 3	Luangprabang	47	MOU Signed 13/10/2006	2016	Sinohydro (China)	Laos	
11	Nam Long 2, 3	(Luangnamtha)	8	(MOU Signed 10/1/2007)	2016	(Luangpaseuth Construction Co., Ltd)	-	

(Source: made from MEM-Department of Energy Promotion & Department's documents, hearing with EDL and other published documents)

Table 3.1-21 Representative IPP Projects in Lao PDR (Planning/PDA stage)

No.	Name of Project	Location/ Province	Installed capacity (MW)	Status		Investors (Sponsors)	Planned Market (Country)	Remarks (Project cost, etc.)
				MOU/ PDA/CA	Commercial Operation Date			
1	Don Sahong (Mekong)	Champasak	240	PDA Signed 13/02/2008	2016	• GOL (Laos) 20% • Mega First (Malaysia) 80%	Laos/ Thailand	
2	Nam Beng	Oudomxay	34	PDA Signed 10/03/2010	2015	China National Electrical Equipment Corp.	Laos	
3	Nam Kong 1	Attapeu	150	PDA Signed 23/06/2008	2017	• Region Oil (Russia) 80% • LHSE (Laos) 20%	Thailand	CA/PDA Negotiation
4	Nam Lik 1	Vientiane	60	PDA Signed 08/04/2008	2014	• GOL (Laos) 20% • Hydro Engineering Co. (Thailand) 80%	Laos	CA/PPA Negotiation
5	Nam Mang 1	Bolikhamxay	57	PDA Signed 20/05/2010	2012	· Far-East Industrial Co., Ltd (China)	Laos	CA/PDA Negotiation
6	Nam Mo	Xiengkhouang	150	PDA Signed 30/03/2008	2014	• GOL (Laos) 15% • Viet-Lao Economical Cooperative General Company 85%	Vietnam	CA/PPA Negotiation
7	Nam Ngiep 1 Hydropower	Bolikhamxay	262.9	PPA, CA Signed 08/2013	2019	• LHSE (Laos) 25% • The Kansai Electric Power (Japan) 45% • EGAT Inter (Thailand) 30%	Laos/ Thailand	
8	Nam Ngiep 2	Xiengkhouang	180	PDA Signed 25/08/2010	2015	• CWE (China)	-	
9	Nam Phak	Champasak	45	PDA Signed 06/11/2009	delayed from 2013	• EDL (Laos) 20% • Kobe Green Power Co., Ltd (Japan) 80%	Laos	
10	Nam Theun 1 Hydropower	Bolikhamxay	523	PDA Signed 28/11/04	2018	• LHSE (Laos) 20% • Gamuda (Malaysia) 40% • EGCO (Thailand) 40%	Laos/ Thailand	CA/PPA Under Negotiation (tariff concluded)
11	Sekong 4 Hydropower	Sekong	300	PDA Signed 23/06/2008	2017	• Region Oil (Russia) 80% • LHSE (Laos) 20%	Thailand	CA/PPA Negotiation
12	Se Kong 5 Hydropower	Sekong	330	PDA Signed • 19/6/2009	2016	· Region Oil (Russia) · Strategic partners to be invited	Thailand/ Laos	CA/PPA Negotiation
13	Xepian-Xenamnoy	Attapeu and Champasak	390	PDA Signed 14/11/2008	2016	• LHSE (Laos) 24% • SK Engineering & Construction (Korea) 26% • Korea Western Power Co., Ltd (Korea) 25% • Ratchaburi Electric Generating Holding Public Co., Ltd. (Thailand) 25%	Thailand/ Laos	
14	Phou Ngoy (Mekong)	Champasak	651	PDA Signed 07/12/2010	-	• Charoen Energy and Water Asia Co., Ltd (Thailand)	Thailand/ Laos	

(Source: made from MEM-Department of Energy Promotion & Department's documents, hearing with EDL and other published documents)

3.2 Topography and Geology

3.2.1 Regional Topography

The Project site is located at the northeastern Bolaven Plateau. The Bolaven Plateau is a large mesa and was formed by the rifting of the basement rocks composed of Mesozoic sedimentary sequences and these erosions. The basaltic lava erupted and overlaid the lifted basement in the broad area of the plateau in the early Quarternary. The highest elevation is approx. 1,300m at Pakxong. Topography is gentle on the western plateau between Pakse and Pakxong. In the eastern plateau, there are cliffs and steep slopes higher than 500m along the Sekong River.

The Xe Namnoy River, which the powerhouse site faces flows from south to northwest and joins the Sekong River. The Xe Namnoy River dissected valley deeply and made the chained cliffs (300 – 500m high) on the both banks.

The Xe Katam River, which is a branch of the Xe Namnoy River flows with a gentle gradient from northwest to southeast. There is a waterfall which height is more than 100m upstream of the confluence of the Xe Katam River and the Xenamnoy River. This waterfall, named "Xe Katam Fall" is a scenic spot for local tourism.

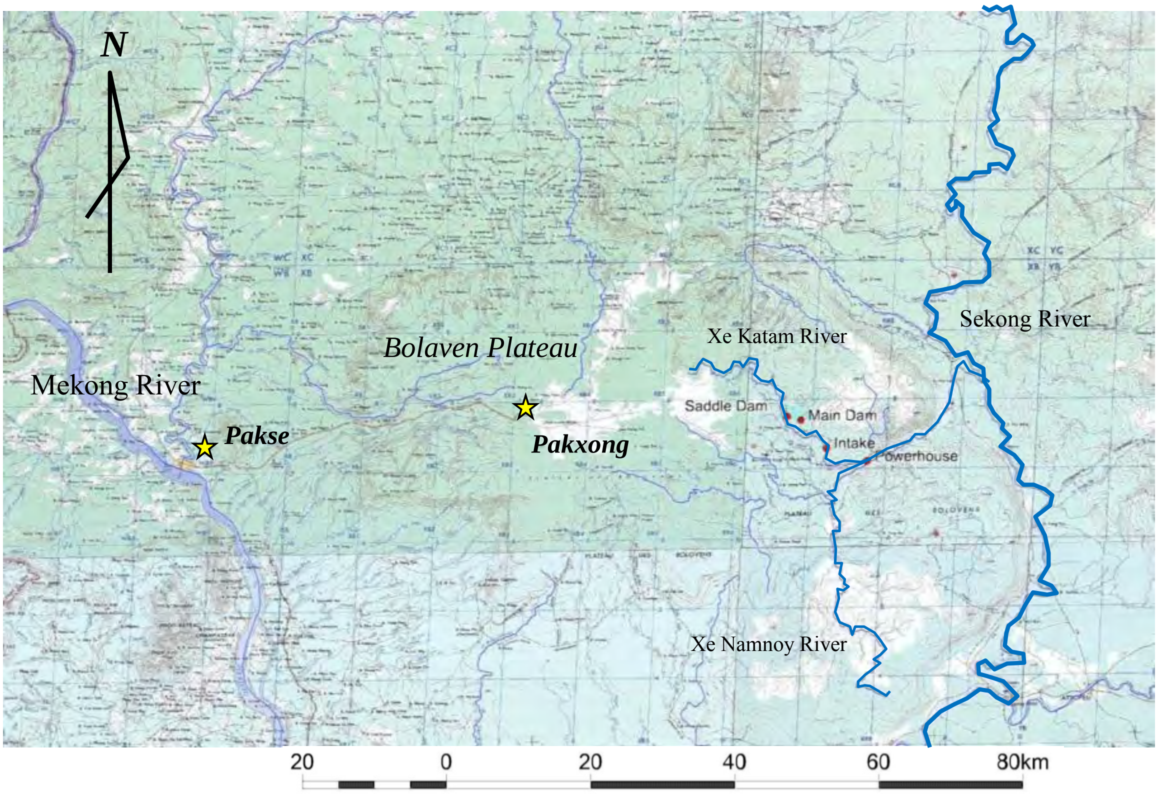
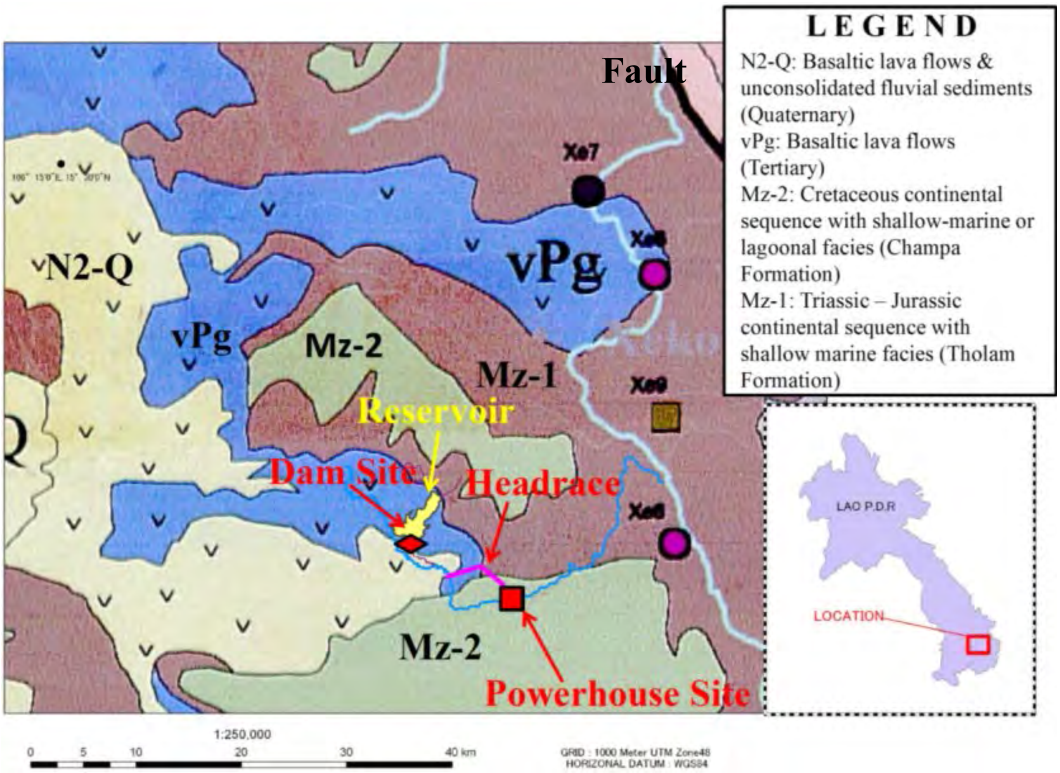


Figure 3.2-1 Large Area Topography including the Project Site

3.2.2 Regional Geology

The Bolaven Plateau consists of the Triastic - Jurassic Tholam Formation and the Cretaceous Champa Formation as the basement. Both formations has sedimentary layers of shallow marine or lagoonal faces, which composes conglomerate, sandstone and mudstone mainly. These sequences are almost horizontal or very gentle angle, and have undergone minimal orogenesis. Sufficient diagenesis had occurred in the formations and make the layers except mud stone hard. These basement rocks were overlaid by basalt lava (N2-Q and vPg, in Figure 3.2-2) and the relevant eruption products in the early Quarternary over the Bolaven Plateau. In the hills neighboring the east edges of the plateau, basalt lavas filled in the valleys. The slopes of the hills are uniformly covered with colluvium or residual soil originating from basement rocks. The gentle slopes from Pakxong to Pakse consist of thick laterite soil originating from basalt lava.

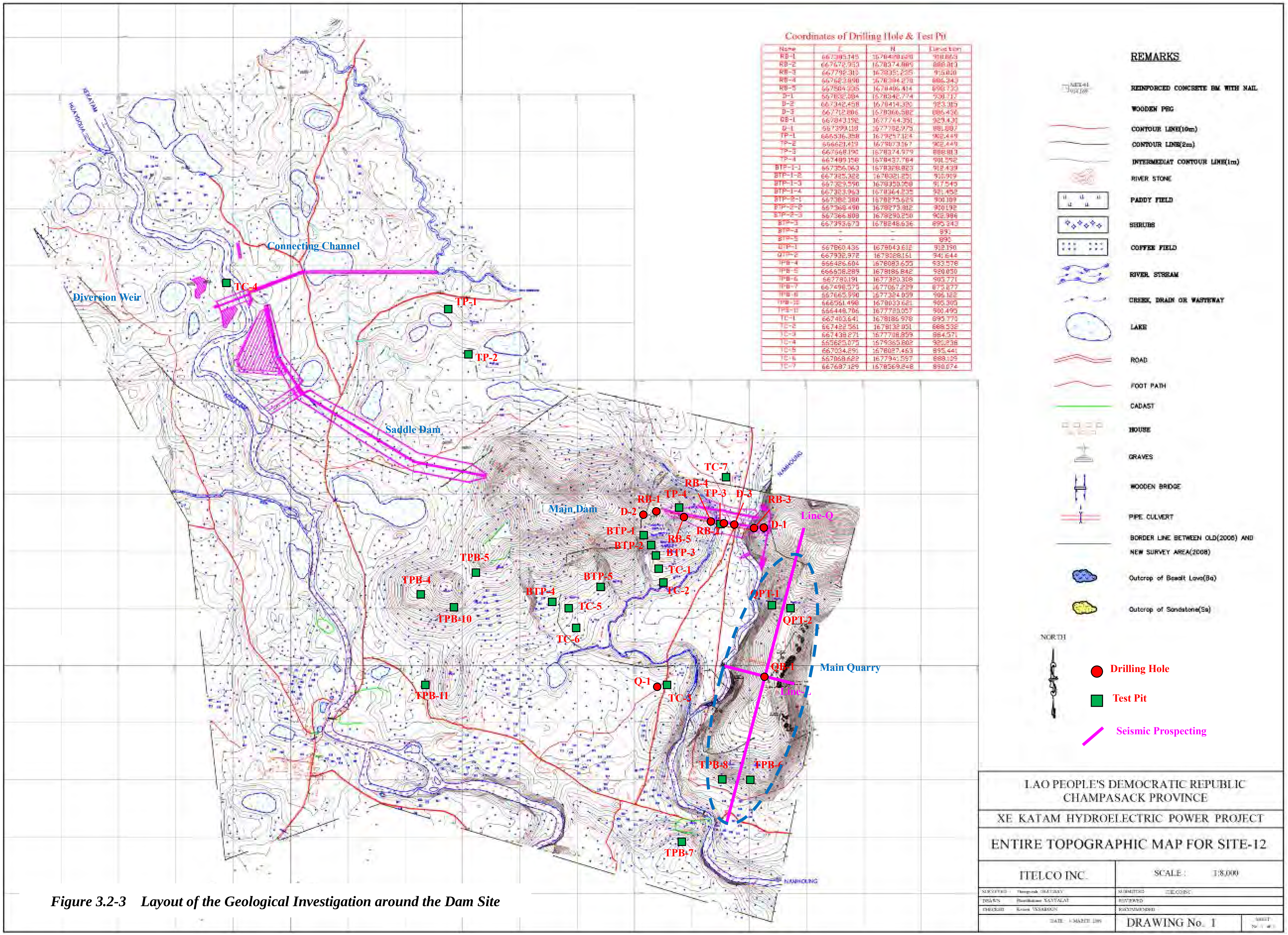


(Source: LAO P.D.R. Geological and Mineral Occurrence Map, Scale 1:1,000,000, British Geological Survey, 1990)

Figure 3.2-2 Large Area Geological Map including the Project Site

3.2.3 Summary of Existing Geological Investigation

Total four (4) geological investigations were carried out at the Project site in 2005, 2006, 2009 and 2013. In the first investigation (2005), three (3) drillings, and four (4) test pit excavations on the dam site, one (1) drilling on the headrace, two (2) drillings on the penstock and laboratory tests (soil) were conducted. In the second investigation (2006), two (2) drillings on the main dam site, five (5) test pit excavations on the right bank, two (2) test pit excavations on the quarry, one (1) drilling on the penstock, seismic prospecting (five (5) lines, 2.3km in the total length) along penstock to headrace, and laboratory tests (soil/rock) were conducted. In the third investigation (2009), eleven (11) test pit excavations around the dam site, one (1) drilling and seismic prospecting (two (2) lines, 1.0km in the total length) on the quarry, one (1) drilling on the head tank, one (1) drilling on the powerhouse, and laboratory tests (soil/rock) were conducted. In the fourth investigation (2013), three (4) drillings and seven (7) test pit excavations around the dam site, one (1) drilling on the penstock, two (2) drillings on the powerhouse and laboratory tests (soil/rock) were conducted. Figure 3.2-3 through Figure 3.2-6 show layouts of these and Table 3.2-1 through Table 3.2-5 show quantities of each investigation.



Coordinates of Drilling Hole & Test Pit

Name	E	N	Elevation
RB-1	667385.145	1678420.420	900.863
RB-2	667672.953	1678374.885	888.813
RB-3	667792.315	1678351.235	915.020
RB-4	667623.898	1678394.270	886.343
RB-5	667504.335	1678406.414	898.733
D-1	667832.384	1678342.774	930.717
D-2	667342.458	1678414.320	923.315
D-3	667712.806	1678366.582	886.436
QB-1	667843.192	1677744.391	929.431
Q-1	667399.118	1677782.975	881.887
TP-1	666536.358	1679257.124	902.449
TP-2	666621.419	1679073.167	902.449
TP-3	667568.190	1678374.979	888.813
TP-4	667489.158	1678437.784	901.592
BTP-1-1	667356.063	1678328.823	912.439
BTP-1-2	667325.322	1678321.251	910.919
BTP-1-3	667329.590	1678350.358	917.545
BTP-1-4	667323.963	1678364.235	921.452
BTP-2-1	667382.380	1678275.625	900.109
BTP-2-2	667368.490	1678273.812	900.192
BTP-2-3	667366.808	1678290.250	902.986
BTP-3	667393.673	1678248.636	895.343
BTP-4	-	-	891
BTP-5	-	-	890
QTP-1	667860.435	1678043.612	912.190
QTP-2	667932.972	1678028.151	941.644
TPB-4	666426.604	1678083.655	933.578
TPB-5	666638.289	1678186.842	920.050
TPB-6	667780.191	1677320.308	905.771
TPB-7	667496.575	1677067.229	875.277
TPB-8	667665.590	1677324.059	906.122
TPB-10	666561.498	1678033.621	905.305
TPB-11	666448.706	1677720.057	900.495
TC-1	667403.641	1678186.978	895.770
TC-2	667422.561	1678132.051	888.532
TC-3	667438.271	1677708.859	884.571
TC-4	665625.075	1679365.802	920.236
TC-5	667034.891	1678027.463	895.441
TC-6	667068.622	1677941.597	888.125
TC-7	667687.129	1678569.248	890.074

Figure 3.2-3 Layout of the Geological Investigation around the Dam Site

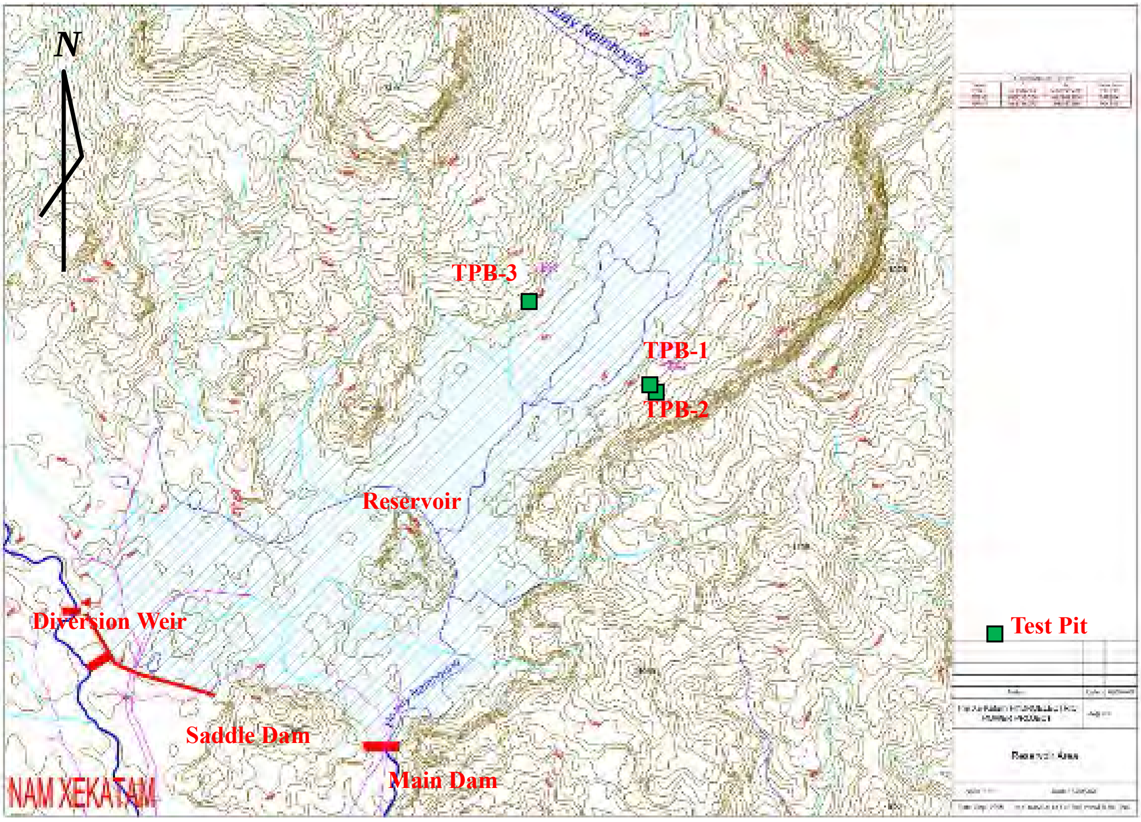


Figure 3.2-4 Layout of the Geological Investigation in the Reservoir Area

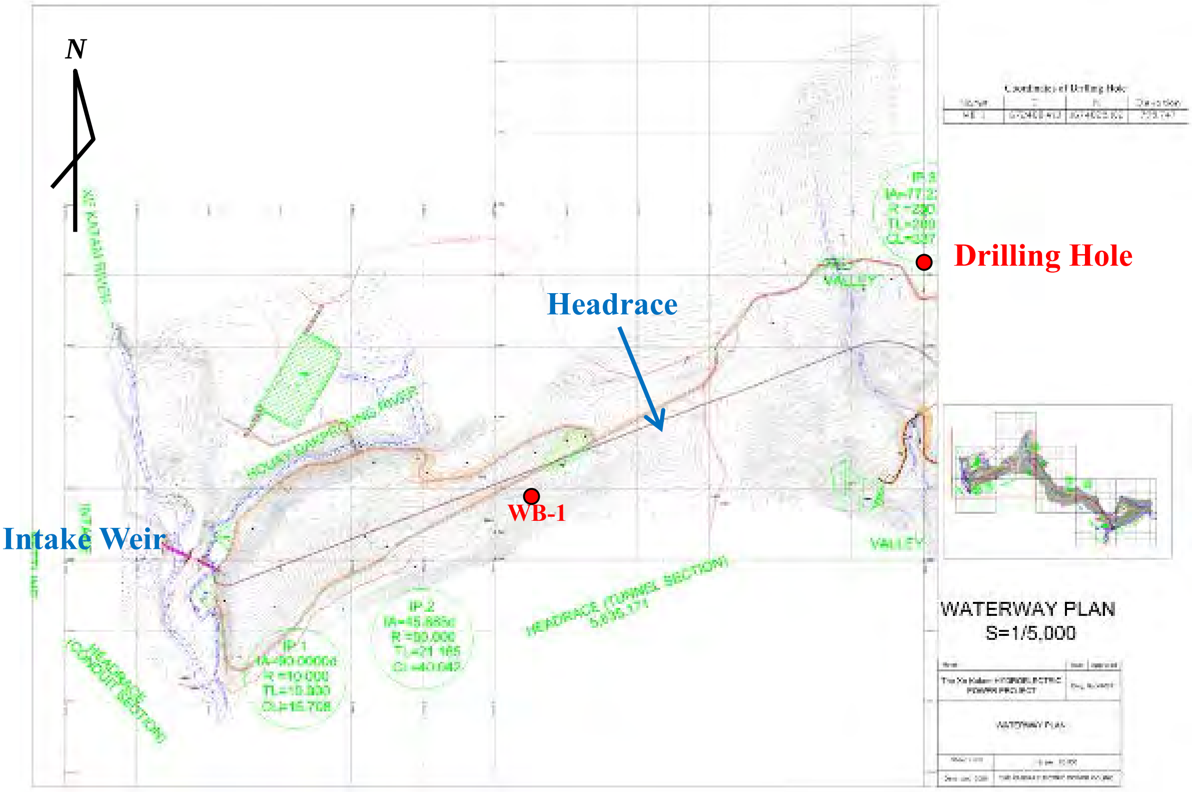
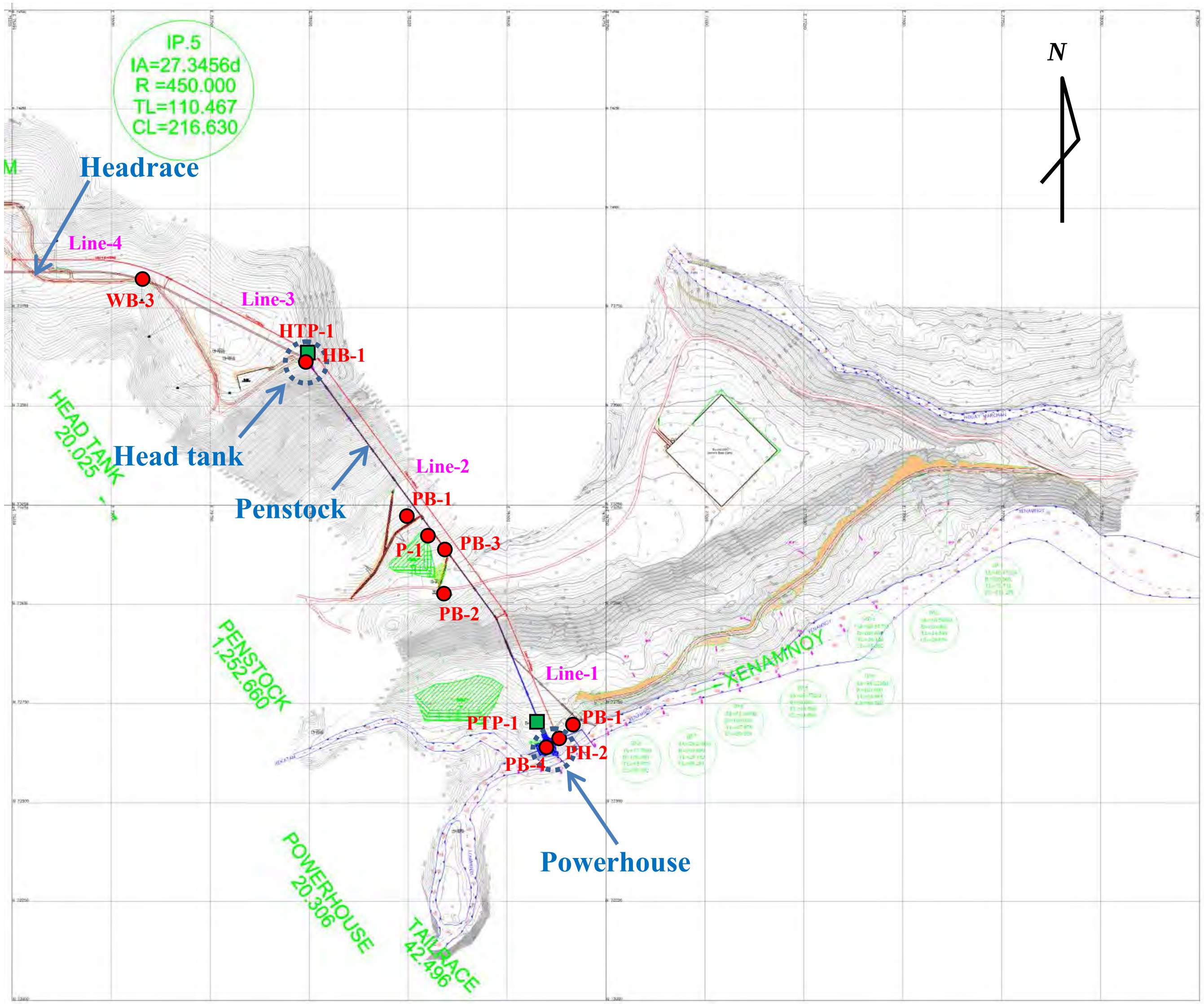


Figure 3.2-5 Layout of the Geological Investigation on the Headrace Tunnel



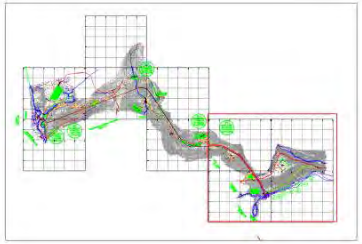
Coordinates of Drilling Hole

Name	E	N	Elevati
WB-3	675590.410	1673814.342	782.34
HB-1	675992.830	1673612.461	772.26
PB-1	676244.434	1673213.711	505.97
PB-2	676343.490	1673024.926	473.83
PB-3	676339.616	1673146.537	-
P-1	676297.300	1673176.904	493.21
PB-4	676606.532	1672642.159	315.62
PH-1	676658.861	1672701.383	316.56
PH-2	676621.448	1672654.392	313.82

Drilling Hole

Test Pit

Seismic Prospecting



WATERWAY PLAN
S=1/5,000

Notes	Date	Approved
The Xe Katam HYDROELECTRIC POWER PROJECT	Dwg. No.XK001	
WATERWAY PLAN		
Sheet 3 of 3	Scale : 1/5,000	

Figure 3.2-6 Layout of the Geological Investigation on the Penstock to Powerhouse

Table 3.2-1 Summary of Seismic Prospecting in the Project

Line	Length	Location	Year	Remarks
Line-1	300m	Xe Namnoy to powerhouse	2006	PB-4 on the Line-1
Line-2	890m	Penstock to head tank	2006	PB-1, PB-2, PB-3 on the Line-2
Line-3	485m	Head tank to headrace	2006	HB-1 on the Line-3
Line-4	320m	Headrace	2006	WB-3 on the Line-4
Line-5	200m	Crossing Line-2 on penstock	2006	WB-3 on the Line-5
Line-Q	700m	Longitudinal line on quarry	2009	QB-1 on the intersection point between two lines
Line-L	300m	Traverse line on quarry	2009	

Table 3.2-2 Summary of Drilling Works

I.D	Location	Coordinate X	Coordinate Y	Z	Depth (m)	Year	Purpose	Remarks
RB-1	Main dam	667385.145	1678428.62	918.865	40	2005	Investigating rock conditions and these permeability on the right bank	SPT, Lugeon test
RB-2	Main dam	667672.953	1678374.889	888.813	40	2005	Investigating rock conditions and these permeability on the riverbed	SPT, Lugeon test, Rock test in laboratory
RB-3	Main dam	667792.31	1678351.235	915	40	2005	Investigating rock conditions and these permeability on the left bank	SPT, Lugeon test, Rock test in laboratory
RB-4	Main dam	667623.89	1678384.27	886.343	40	2006	Investigating thickness of basalt lava and re-check Lugeon values in 2005 on the riverbed	Lugeon test
RB-5	Main dam	667504.335	1678406.414	898.733	40	2006	Investigating thickness of residual soil and re-check Lugeon values in 2005 on the right bank	Lugeon test
D-1	Main dam	667832.084	1678342.774	930.717	50	2013	Investigating rock conditions and these permeability at the rim portion on the left bank	Lugeon test
D-2	Main dam	667342.458	1678414.32	923.315	50	2013	Investigating rock conditions and these permeability at the rim portion on the right bank	Lugeon test
D-3	Main dam	667712.806	1678366.582	886.436	50	2013	Investigating rock conditions and these permeability on the riverbed	Lugeon test
QB-1	Quarry	667843.192	1677744.351	929.43	40	2009	Investigating thickness of residual soil and rock conditions on quarry	Rock test in laboratory
Q-1	Downstream area of dam site	667399.118	1677702.975	881.887	20	2013	Investigating thickness of residual soil and rock conditions on basaltic plain	Rock test in laboratory
WB-1	Headrace	672488.413	1674825.105	795.749	40	2005	Investigating thickness of residual soil and rock conditions at thin overburden portion on the tunnel	
WB-3	Headrace	675590.41	1673814.342	782.347	40.7	2009	Investigating thickness of residual soil and rock conditions at thin overburden portion on the tunnel	
HB-1	Head tank	675992.83	1673612.461	772.263	40.5	2009	Investigating rock conditions on head tank	
PB-1	Penstock	676244.434	1673213.711	505.971	40	2005	Investigating thickness of colluvium on gentle slope	SPT
PB-2	Penstock	676343.49	1673024.926	473.839	30	2005	Investigating thickness of residual soil and rock conditions on basaltic plain	SPT
PB-3	Penstock	676339.616	1673146.537	-	40	2006	Investigating thickness of colluvium on gentle slope	
P-1	Penstock	676297.3	1673176.904	493.21	50	2013	Investigating thickness of colluvium and depth of basement on gentle slope	SPT
PB-4	Powerhouse	676606.532	1672642.159	315.624	29.3	2009	Investigating rock conditions on powerhouse	
PH-1	Powerhouse	676658.861	1672701.383	316.565	20	2013	Investigating rock conditions on the alternative powerhouse	
PH-2	Powerhouse	676621.448	1672654.392	313.82	10	2013	Investigating rock conditions on the alternative powerhouse	
Total Length of Drilling					**750.5m**			

*The colored portions in the table indicate the latest investigations (2013)

Table 3.2-3 Summary of Test Pit Excavation

I.D	Location	Coordinate		Z	Depth (m)	Year	Purpose	Remarks
		X	Y					
TP-1	Reservoir	666536.358	1679257.124	902.449	3.0	2005	Investigating core materials for the min dam and thickness of residual soil of basalt	
TP-2	Reservoir	666621.419	1679073.167	902.449	3.0	2005		
TP-3	Main dam	667668.19	1678374.979	888.813	2.5	2005	Investigating core materials for the main dam and thickness of residual soil of basalt	Stopped at 2.5m deep due to hard cobbles
TP-4	Main dam	667489.158	1678437.784	901.592	3.0	2005	Investigating core materials for the main dam and thickness of residual soil on the right abutment	
BTP-1	Downstream area 200m from the main dam	667356.063	1678328.823	912.439	3.5	2006	Investigating core materials for the main dam and thickness of residual soil on the right bank	
BTP-2	Downstream area 200m from the main dam	667382.38	1678275.629	900.109	3.5	2006	Investigating core materials for the main dam and thickness of residual soil on the right bank	
BTP-3	Downstream area 200m from the main dam	667393.673	1678248.636	895.343	4.6	2006	Investigating core materials for the main dam and thickness of residual soil on the right bank	
BTP-4	Downstream area 700m from the main dam	-	-	891	5.0	2006	Investigating core materials for the main dam and thickness of residual soil on the right bank	
BTP-5	Downstream area 500m from the main dam	-	-	890	5.0	2006	Investigating core materials for the main dam and thickness of residual soil on the right bank	
QTP-1	Quarry	667860.436	1678043.612	912.19	3.0	2006	Investigating thickness of residual soil on the quarry	
QTP-2	Quarry	667932.972	1678028.161	941.644	3.0	2006	Investigating thickness of residual soil on the quarry	
HTP-1	Head tank	675973.226	1673629.868	779.800	5.0	2006	Investigating thickness of residual soil on the head tank	
PTP-1	Penstock	676536.653	1672769.482	336.000	5.0	2006	Investigating thickness of residual soil on a gentle slope	
TPB-1	Reservoir	669570.917	1680997.472	930.992	4.0	2009	Investigating core materials for the main dam and thickness of colluvium on a slope in reservoir	
TPB-2	Reservoir	669599.556	1680962.854	942.204	3.5	2009	Investigating core materials for the main dam and thickness of colluvium on a slope in reservoir	
TPB-3	Reservoir	668780.053	1681527.200	904.515	3.2	2009	Investigating core materials for the main dam and thickness of colluvium on a slope in reservoir	Stopped at 3.2m deep due to hard cobbles
TPB-4	Downstream area 1km from the main dam	666426.604	1678083.655	933.578	3.0	2009	Investigating core materials for the main dam and thickness of residual soil on the right bank	
TPB-5	Downstream area 700m from the main dam	666658.289	1678186.842	920.05	1.5	2009	Investigating core materials for the main dam and thickness of residual soil on the right bank	Stopped at 1.5m deep due to hard sandstone
TPB-6	The southern Quarry	667780.191	1677320.308	905.771	5.0	2009	Investigating core materials for the main dam and thickness of residual soil on the quarry	
TPB-7	Downstream area 1.2km from the main dam	667498.575	1677067.229	875.277	5.0	2009	Investigating core materials for the main dam and thickness of residual soil on the basaltic plain	
TPB-8	The southern Quarry	667665.99	1677324.059	906.122	4.0	2009	Investigating core materials for the main dam and thickness of residual soil on the quarry	
TPB-9	Downstream area 1.0km from the main dam	666561.498	1678033.621	905.305	3.7	2009	Investigating core materials for the main dam and thickness of residual soil on the right bank	
TPB-10	Downstream area 1.2km from the main dam	666448.706	1677720.057	900.495	5.0	2009	Investigating core materials for the main dam and thickness of residual soil on the right bank	

I.D	Location	Coordinate		Z	Depth (m)	Year	Purpose	Remarks
		X	Y					
TPB-11	700m east-southeast from Nong Mek village	667403.641	1678186.978	895.77	3.2	2009	Investigating core materials for the main dam and thickness of residual soil	
TC-1	Downstream area 200m from the main dam	667422.561	1678132.051	888.532	3.4	2013	Investigating core materials for the main dam and thickness of residual soil on the right bank	
TC-2	Downstream area 200m from the main dam	667438.271	1677708.859	884.571	1.7	2013	Investigating core materials for the main dam and thickness of residual soil on the right bank	Stopped at 1.7m deep due to submerging the pit
TC-3	Downstream area 700m from the main dam	665625.075	1679365.802	920.238	5.0	2013	Investigating core materials for the main dam and thickness of residual soil on the basaltic plain	
TC-4	Rim portion of saddle dam on the right bank	667034.291	1678027.463	895.441	2.2	2013	Investigating impervious materials for the main dam and thickness of residual soil of basalt	Stopped at 2.2m deep due to hard basaltic boulders
TC-5	Downstream area 700m from the main dam	667068.622	1677941.597	888.109	4.5	2013	Investigating core materials for the main dam and thickness of residual soil on the right bank	
TC-6	Downstream area 700m from the main dam	667687.129	1678569.248	890.074	3.4	2013	Investigating core materials for the main dam and thickness of residual soil on the right bank	
TC-7	Upstream area 200m from the main dam	669570.917	1680997.472	930.992	1.7	2013	Investigating core materials for the main dam and thickness of residual soil on the basaltic plain	Stopped at 1.7m deep due to hard basaltic boulders
Total Test Pit Number :								**31**

*The colored portions in the table indicate the latest investigations (2013)

Table 3.2-4 Quantities of Rock Testing

Rock Type	Quantity					Remarks
	Porosity	Specific Gravity	Absorption	UCS	ASR	
Sandstone	6	6	6	10	2a	-Two pieces of fresh rock extracted from 36.0-37.0m section of RB-3 cores -Four pieces of somewhat weathered rock extracted from outcrops on the quarry -Two pieces of fresh rock extracted from 19.5-20.0m and 21.0-21.5 section of QB-1 cores
Mudstone	2	2	2	2	-	-Two pieces of fresh rock extracted from 28.4-28.8m and 36.5-37.0m section of QB-1 cores
Basalt	5	5	5	5	-	-Two pieces of fresh rock extracted from 19.5-19.9m and 25.5-25.9m section of RB-2 cores -Three pieces of fresh rock extracted from 13.0-14.0m section of Q-1 cores
Total	**13**	**13**	**13**	**17**	**2**	

Table 3.2-5 Quantities of Soil Testing

Item	Quantity	Location of Sampling
Grain Size Gradation	34	TP-1(1), TP-2(1), TP-3(1), TP-4(1), BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-1(1), TPB-2(1), TPB-3(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TPB-8(1), TPB-10(1), TPB-11(1), TC-1(1), TC-3(5), TC-4, TC-5(3), TC-6(2), RS1(1) (borrow pit for subsoil of road), Sand-bar on Sekong River (2)
Atterberg Limit	29	TP-1(1), TP-2(1), TP-3(1), TP-4(1), BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-1(1), TPB-2(1), TPB-3(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1)
Density	20	BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(4), TC-4(1), TC-5(2), TC-6(2), RS1(1)
Specific Gravity	34	TP-1(1), TP-2(1), TP-3(1), TP-4(1), BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-1(1), TPB-2(1), TPB-3(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TPB-8(1), TPB-10(1), TPB-11(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1) (borrow pit for subsoil of road), Sand-bar on Sekong River (2)
Natural Water Contents	34	TP-1(1), TP-2(1), TP-3(1), TP-4(1), BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-1(1), TPB-2(1), TPB-3(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TPB-8(1), TPB-10(1), TPB-11(1), TC-1, TC-3(5), TC-4, TC-5(3), TC-6(2), RS1(1) (borrow pit for subsoil of road), Sand-bar on Sekong River (2)
Compaction Test	22	BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1)
Consolidation Test	17	TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1)
Triaxial Compression Test (CU)	22	BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1)
Permeability Test	22	BTP-1(1), BTP-2(1), BTP-3(1), BTP-4(1), BTP-5(1), TPB-4(1), TPB-6(1), TPB-7(1), TPB-7D(1), TC-1(1), TC-3(5), TC-4(1), TC-5(3), TC-6(2), RS1(1)

* The figures in brackets are sample numbers

All drilling logs according to observations of drilling cores in the Project are shown in Figure 3.2-7 and Figure 3.2-8.

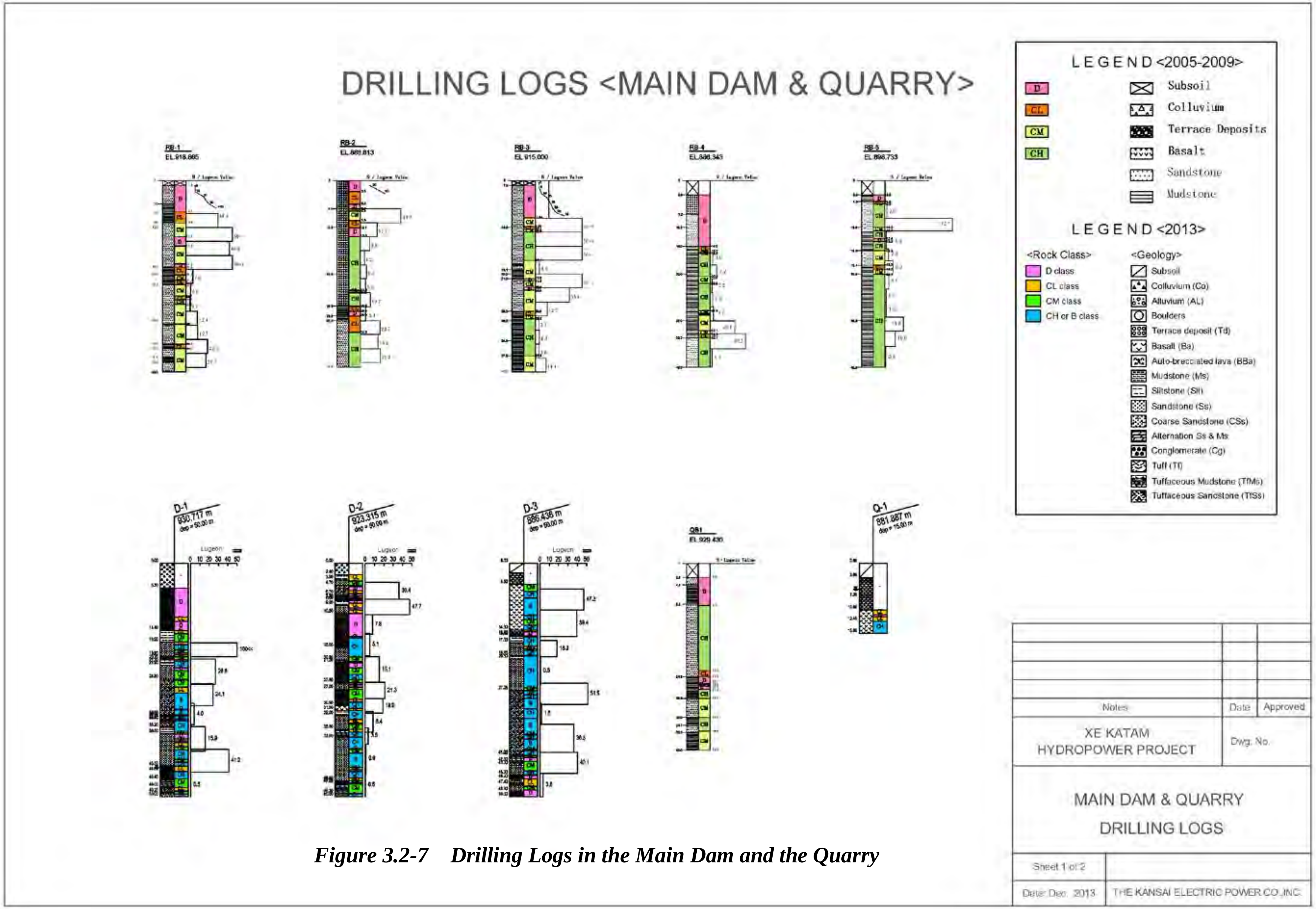


Figure 3.2-7 Drilling Logs in the Main Dam and the Quarry

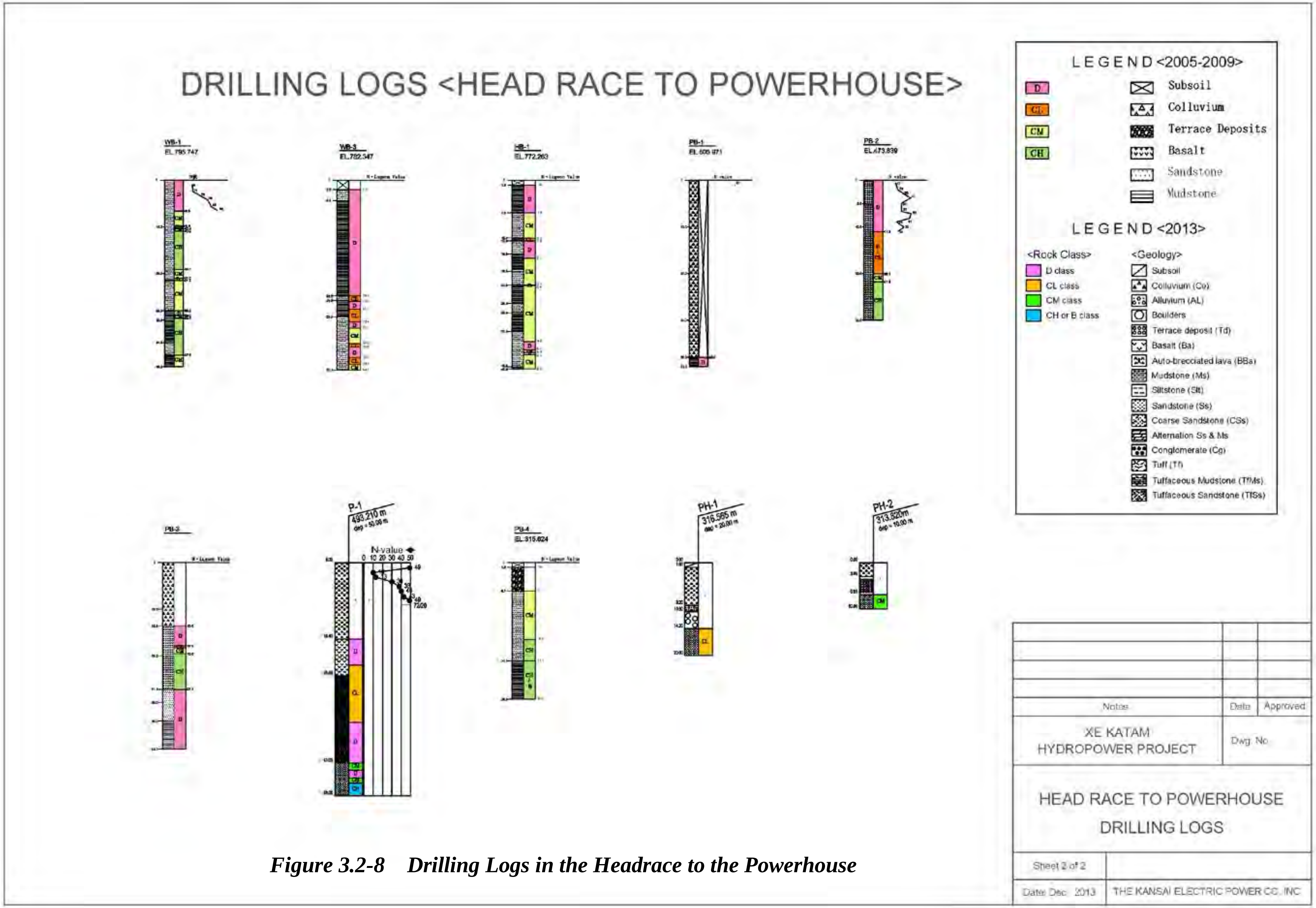


Figure 3.2-8 Drilling Logs in the Headrace to the Powerhouse

3.2.4 Topo, Geological Conditions and Geotechnical Evaluation

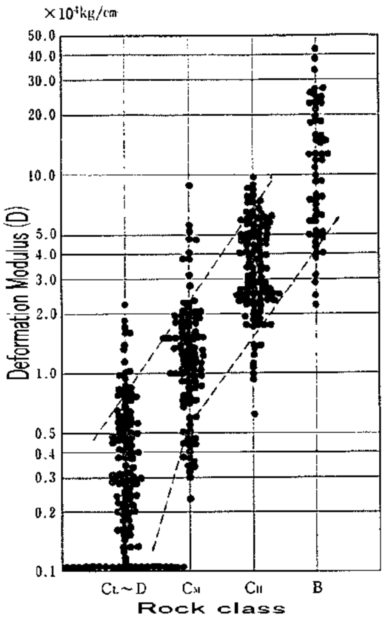
(1) Rock Classification System

In the Project, the unified rock classification system for civil engineering designs is defined according to the criteria of Central Research Institute of Electric Power Industry in Japan (CRIEPI). Although there's no in-situ rock testing in the site, the correspondences between the rock classification system and deformation modulus are shown in Table 3.2-6, for reference. These thresholds of deformation modulus are estimated values based on the results of various dam constructions in Japan (see Figure 3.2-9).

Table 3.2-6 Rock Classification System (CRIEPI Criteria)

Rock class	Description	Deformation Modulus (MPa)
B	The rock mass is very hard. There are basically no opening joints or cracks even if 1mm wide. The rock indicates very little sign of weathering or alternation on its surface. Sound by a hammer blow is clear.	1,500<
CH	The rock mass is relatively hard. The rock forming minerals and grains have undergone weathering except for quartz. The rock is contaminated by limonite. The cohesion of joints and cracks are slightly decreased due to being intercalated with thin soft materials and rock blocks are separated by a strong hammer blow along joints. Sound by hammer blow is little dim.	
CM	The rock mass is somewhat soft. The rock forming minerals and grains are somewhat softened by weathering except for quartz. The cohesion of joints and cracks are somewhat decreased due to being intercalated with relatively thick soft materials and rock blocks are separated by an ordinary hammer blow along the joints. Clay materials remain on the separation surfaces. Sound by hammer blow is somewhat dim.	500 – 1,500
CL	The rock mass is soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks are decreased due to being intercalated with thick soft materials and rock blocks are separated by a soft hammer blow along the joints. Sound by hammer blow is dim.	200 - 500
D	The rock mass is remarkably soft. The rock forming minerals and grains are softened by weathering on the whole. The cohesion of joints and cracks are absent due to heavy weathering or alteration, and rock mass are collapsed by a light hammer blow. Sound by hammer blow is remarkably dim.	< 200

(Source: CRIEPI, Rock Mass Classification, 1992)



(Source: Kikuchi et al, 1984, Geotechnically Integrated Evaluation on the Stability of Dam Foundation Rocks, Japan Society of Engineering Geology)

Figure 3.2-9 General Relationship between Rock Class and Deformation Modulus

(2) Main Dam

(a) Topographic Conditions

The main dam site is located on the Nam Houng River 2 km east-northeast of Nong Mek village. The right bank is an isolated low mountain and the left bank a thick mountain extending toward north-northeast. A basin is surrounded by over EL. 1,200m high mountains which form mesa landscape in the reservoir area, and the bottom of the basin is overlaid with basaltic lavas erupted during the early Quarternary period and forms a wide plain utilized as a paddy field. The slopes of the mountains are covered with colluvium supplied from the erosion front at a high elevation. The basaltic lavas are completely weathered on the plain whereas the outcrops of the hard rocks are spotted on the Nam Houng River.

(b) Stratigraphy

The dam foundation rocks consist of the Cretaceous Champa Fm. comprised mainly of red mudstone, sandstone and conglomerate, and the Quarternary basaltic eruptions. Around the dam site, hard rocks such as Basalt or Sandstone are exposed sparsely on the Nam Houng River, and banks or plain areas are covered with residual soil.

i) Sedimentary Rocks

The Champa Fm. consists of sandstone, reddish mudstone (silt and clay), conglomerate and these alternations. All beds uniformly tilt with gentler than 10º because orogenetic dynamics have been little on these sedimentary sequences (see Figure 3.2-10).

Figure 3.2-10 Outcrop of Champa Fm. on Cut-Slope along National

Sandstone, conglomerate or massive mudstone is basically medium hard to hard (UCS: 364-725 kgf/cm^2), but unconformity sections intercalated with weathering layer or laminated mudstone are generally soft. Especially sandstone indicates strong resistance against weathering and supplies boulders larger than 1.0m to the riverbed of the Nam Houng River. On the slopes of the quarry mountain, residual core-stones which have avoided weathering are spotted.

ii) Basalt

Basaltic lavas are composed of the plain areas at EL.880-890m around the dam site, and these were buried in valleys after uplifting of Champa Fm in the Quarternary. The Basaltic lavas are not exposed on slopes on banks. On the riverbed of the Nam Houng River, outcrops of basaltic lavas are scattered (see the left photo of Figure 3.2-11). The upper part and lower part of basaltic lavas consist of auto-brecciated lava which indicates clayey or sandy materials mixing gravels.

Reddish lateritic zone is formed 10m of thickness in depth in the upper part of basalt and it includes residual core-stones (φ10-50cm) as shown in the right photo of Figure 3.2-11. These boulders occasionally appear in the reservoir area.

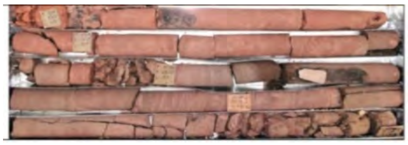
Hard bedrock of basalt on the Nam Houng

Core-stones and residual soil in a test pit

Figure 3.2-11 Outcrops of Basalt around the Main Dam Site

Based on drilling cores extracted on the main dam axis (RB-1 to 5 and D-1 to 3, total 8 holes), the stratigraphic compositions of the dam foundation rocks are evaluated as shown in Table 3.2-7.

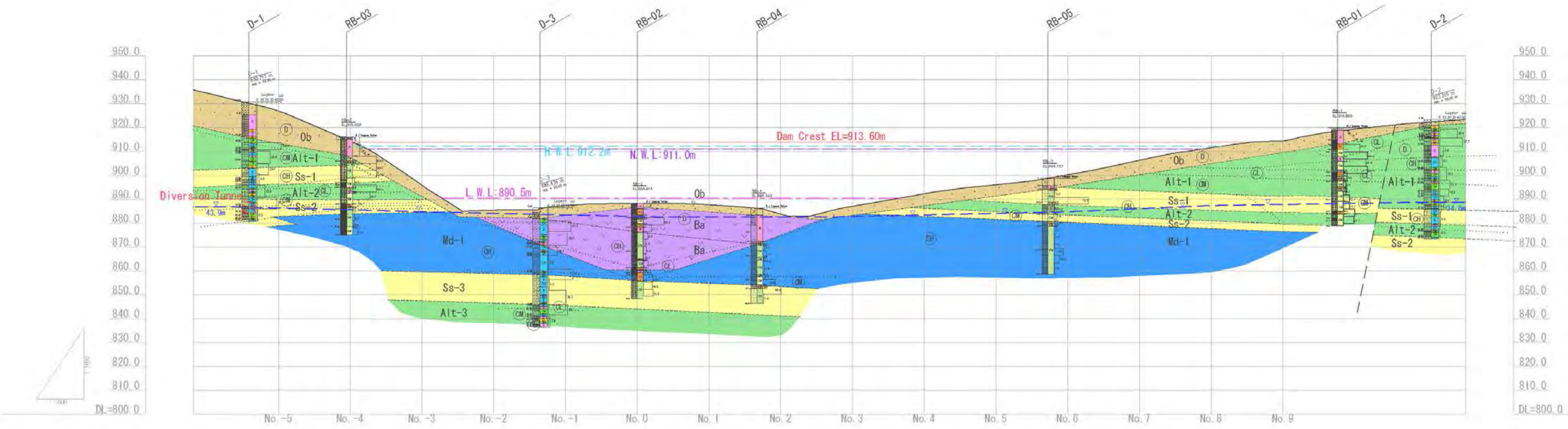
Table 3.2-7 Stratigraphy of Dam Foundation Rocks

Unit	Composition	Color	Thickness	Geotechnical Features*	Representative Core Photos
Ob	Overburden	-	3-15m	1. mainly fine soil 2. N value: 5 - 50 (Ave: 26) 3. In-situ permeability test has not done	 D-3:0-4m
Ba	Basalt	Dark grey	28m	1. - the auto-brecciated section including subsoil is max.15m - vertical cracks are opened and filled with clayey materials in lava sections - the boundary section to Champa Fm. is composed of auto-brecciated and the paleo residual soil approx. 2m thick 2. strength of fresh lava section (CH class): UCS=56.51 – 179.52 MPa 3. Lugeon value: over 40Lu	 D-3:10-14m (lava section)  D-3:14.3-15.6m (auto-brecciated section)
Alt-1	Alternated beds with rich mud sections	Red	Over 40m	1. clastic sections are occasionally intercalated at short intervals 2. mainly CL – CM class rocks 3. Lugeon value: - 20Lu< - 5 to 20Lu at deeper than EL.910m on the right bank	 D-2:15-20m
Ss-1	Sandstone	Grey	6-8m	1. - mainly hard sandstone - intercalating thin weathered layers along bedding planes 2. strength of sandstone section (CH class): UCS=45.13 – 71.12 MPa 3. Lugeon value: over 40Lu	 D-1:28-32m
Alt-2	Alternated beds with equivalent sand and mud	Dark brown - dark grey	4-6m	1. intervals of cracks are close and core-loss sections frequently appear 2. drilled cores are mixed with D to CM class rocks. strength of sandstone section (CM class): UCS= UCS35.71 MPa 3. Lugeon value: 5 to 20Lu	 D-1:35-39m
Ss-2	Sandstone	Grey - yellowish brown	4-6m	1. mainly sandstone, but several yellowish brown tuffaceous layers are intercalated 2. sandstone sections: CM – CH class rocks tuffaceous sections: CL class rocks 3. Lugeon value: - 5Lu> - over 40Lu at the boundary of top and bottom of this unit	 D-1:40-45m
Md-1	Mudstone	Red - Dark grey	30m	1. mainly massive mudstone 2. strength of CH class section: UCS=60.63 MPa 3. Lugeon value: - 5Lu> - over 10Lu at the boundary of top and bottom of this unit	 D-1:35-39m

Unit	Composition	Color	Thickness	Geotechnical Features*		Representative Core Photos
Ss-3	Coarse sandstone including conglomerate	Grey	15m	1.	- mainly hard sandstone - intercalated with thin weathered layers along bedding planes	 D-3:30-35m
				2.	strength of sandstone section (CH class): UCS= over 58.86 MPa	
				3.	Lugeon value: over 40Lu	
Alt-3	Alternated beds with equivalent sand and mud	Dark reddish brown - yellowish brown	over 6m	1.	brown colored and softened in the whole of this unit	 D-3:45-50m
				2.	mainly CL class rocks	
				3.	Lugeon value: - 5Lu> - over 10Lu at the boundary of top of this unit	

* 1. Geological features, 2. Mechanical features, 3. Permeability

The distribution of the stratigraphic units along the dam axis is shown in Figure 3.2-12. All units uniformly tilt with very a gentle gradient (1 - 5°) toward northeast (the strike azimuth of these bedding planes: NW-SE). The thickness of Alt-1, the top unit differs between the right bank and the left bank, that is to say, the thickness on the right bank tends to be thicker than one on the left bank. Furthermore, an elevation gap of Ss-1 approx. 5m is recognized although the hole distance between RB-1 and D-2 is only 40m. The fact may indicate that an inferred fault which displaces these beds runs between RB-1 and D-2.



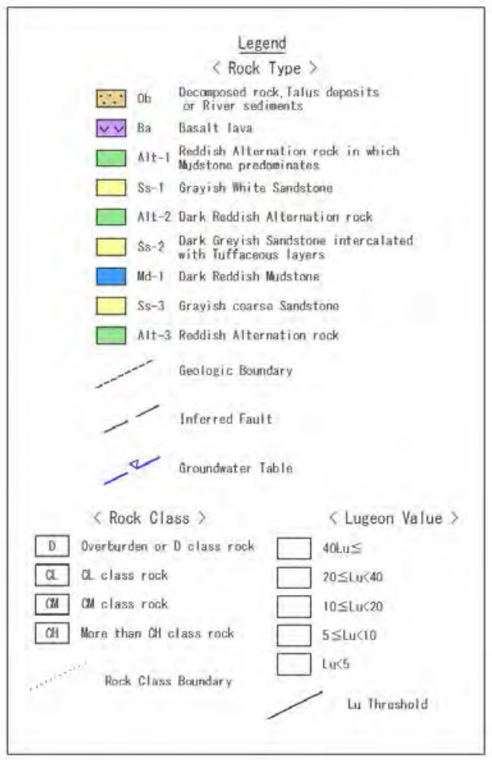


Figure 3.2-12 Geological Profile along the Main Dam Axis

(c) Evaluation of Foundation Rocks

i) Acceptability for Foundation

The rules regarding foundation rocks in the Project site are following:

D class	:	These rocks are basically not acceptable for foundation of concrete structure or core zone (impervious zone) of rock fill dam. However the rock zone (pervious zone) can be placed on D class rock except surface soil.
CL class	:	If the CL class rocks can be improved to the target permeability by grouting, the core zone can be placed on the rocks. However these basically have to be removed in case of the foundation of concrete structure.
CM class or the higher grades	:	These rocks are basically no problem for foundation.

ii) Rock Conditions along the Main Dam Axis

Figure 3.2-13 shows the assumed distributions of rock classes based on the observation of drilled cores on the dam axis. Several anxieties in the construction phase of the main dam are mentioned as follows:

- The lower boundary between basalt and Champa Fm. are deteriorated to D-CL class due to being auto-brecciated beneath the riverbed.
- Several tuffaceous layers corresponding to CL class underlies at EL. 880-890m on the left bank and it is anticipated that these weak layers parallel to the diversion tunnel route will appear on the tunnel face.
- On the right abutment of the dam, although CL class rocks appropriate to the core foundation appear at the shallow portions of drilled cores at RB-1 and D-2, deteriorated zone (D class) thicker than 10m is underlain beneath the shallow CL class rocks. There is a risk that D class rocks will possibly appear broadly on the core foundation of the right abutment.

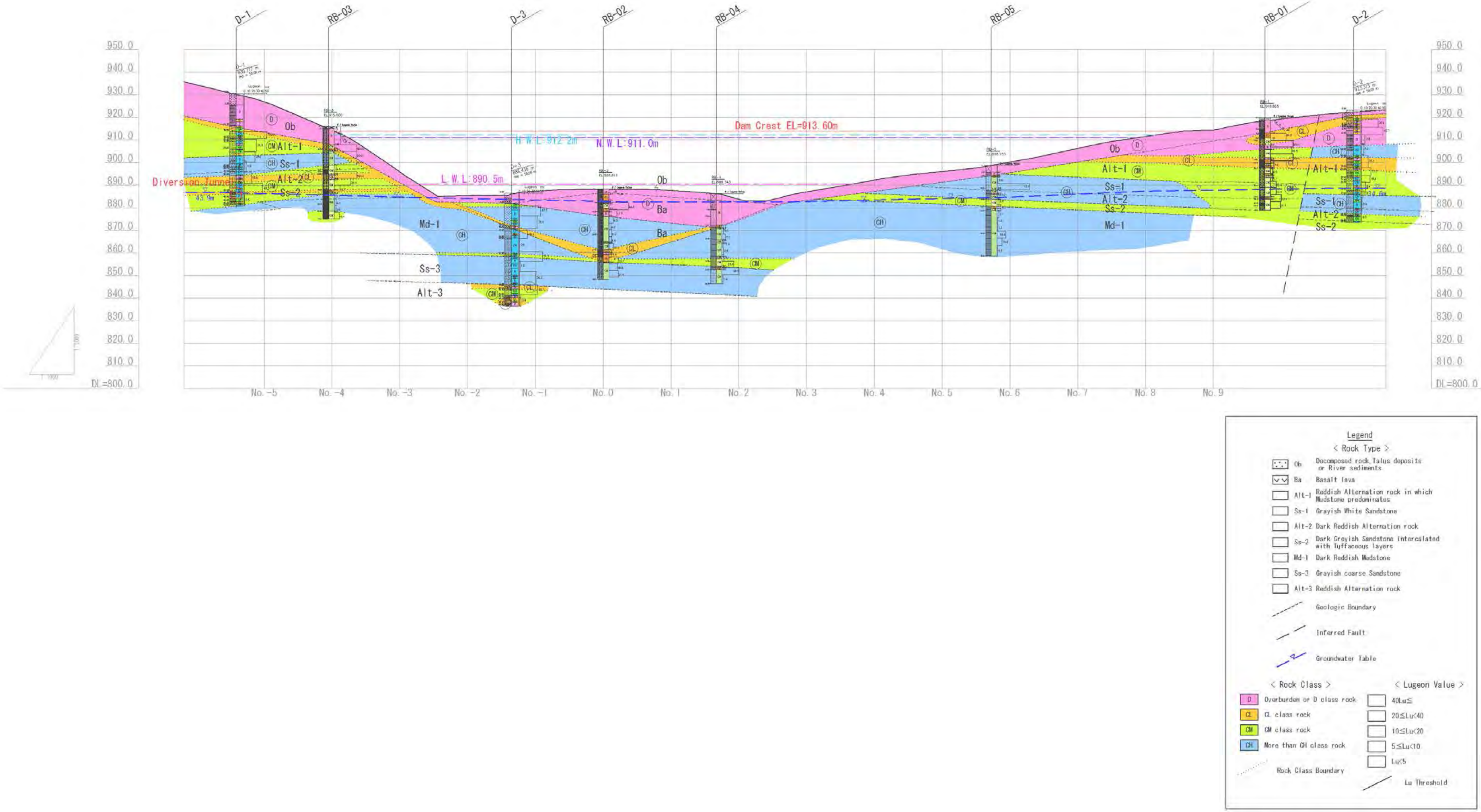


Figure 3.2-13 Geological Profile for Rock Class along the Main Dam Axis

(d) Permeability of Dam Foundation Rocks

i) Classification by Lugeon Values

Table 3.2-8 tabulates the classification of rock permeability on the cut-off line of the main dam according to the results of Lugeon test and witnessing the permeable sections on drilling cores. Anyway, the depth of curtain grout and the target Lugeon values to be improved in the Project are following:

- 5Lu from the surface to H*/2 in depth
- 10Lu from H/2 to H in depth

* H: Maximum dam height, the basis of surface is to be elevations of core foundation

Table 3.2-8 Classification of Rock Permeability in Xe Katam HPP

Threshold of Lugeon Value	Application of cut-off works	Remarks
40 ≤ Lu	-Very high permeable zone -To be improved to the target Lugeon value within the depth of H	Very rapid flow will possibly occur and induce piping in impounding. These zones shall be considered some measures e.g. auxiliary grouting besides the regular one. The improvability and grouting specification shall be confirmed by grouting trials in advance.
20 ≤ Lu < 40	-High permeable zone -To be improved to the target Lugeon value within the depth of H	
10 ≤ Lu < 20	-Semi-high permeable zone -To be improved to the target Lugeon value within the depth of H	
5 ≤ Lu < 10	-Mid- permeable zone -To be improved to the target Lugeon value within the depth of 2/H	
Lu < 5	-Impervious zone -Not covered by cut-off works	

ii) Hydro-geological Characteristics

Figure 3.2-14 shows an assumed Lugeon map along the main dam axis based on the classification.

According to groundwater level measured at D-1 and D-2 on the rim of the both banks (in rainy season), the groundwater table over the dam axis is almost horizontal at the river water level (approximately EL.885m). This flat groundwater implies the leakage paths connecting to ground surface at the deep portions on the both banks.

The high permeable zones corresponding to over 20Lu (zone I – V: see Figure 3.2-14), for which cut-off design should be paid attentions to, are extracted from the Lugeon map. The cut-off curtain shall shut any leakage paths in these permeable within the depth of the maximum dam height. The hydro-geological characteristics and risks regarding the high permeable zones are summarized in Table 3.2-9.

Table 3.2-9 Hydro-geological Characteristics each Special High Permeability Zone

Zone	Location		Stratigraphy	Hydro-geological Characteristics / Consideration
I	Shallow (within H/2)	Riverbed	Basalt	<Characteristics> - Basaltic lava erupted during the Quarternary period, and the vertical cooling joints in the rock mass have not been closed enough. - A part of open joints are filled with clayey materials. - The lower boundary between basalt and sedimentary basement is composed of brecciated materials and paleo-residual soil. <Risks> - Groundwater flows, as rapid flow along open joints - The clayey materials which fill in open joints or compose the paleo-soil in the boundary will interrupt grout percolating <Consideration> - Make a thick impervious zone by auxiliary grouting if single curtain cannot attain the target Lugeon value - The improvability shall be checked by grouting trials in advance
II		Both banks	Alt-1	<Characteristics> - The rocks consist of CL-CM class in the sedimentary sequence, but these rocks indicate over 40Lu due to being loosened by weathering and in-situ stress release <Risks> - Groundwater flows, as rapid flow along open joints - The clayey materials which fill in open joints will interrupt grout percolating <Consideration> - Make a thick impervious zone by auxiliary grouting if single curtain cannot attain the target Lugeon value - The improvability shall be checked by grouting trials in advance
III	Deep (within H)	Riverbed	Ss-3	<Characteristics> - The stratigraphic unit mainly consists of hard sandstone (CH-B class) intercalating thin weathered layers formed due to ancient sea-level changes, and open joints are developed due to in-situ stress release. - The sedimentary sequence including Ss-3 formation dips downward on the upstream side, that is to say, Ss-3 tends to be deeper in the reservoir area - On the both banks, an impervious mudstone (Md-1: 5Lu>) caps Ss-3 with approx. 30m thick <Risks> - Groundwater flows, as rapid flow along thin weathered layers and vertical open joints - Complicated permeable net in this unit will connect to ground surface through the basalt lavas under the riverbed if cut-off not done <Consideration> - Make an cut-off curtain across over the unit under the riverbed - A thick impervious mud layer (Md-1) will preclude excessive water loss form the reservoir
VI		Left bank	Ss-2	<Characteristics> - The unit mainly consists of hard sandstone, but soft tuffaceous layers are intercalated on the left bank. <Risks> - The boundary between sandstone and tuffaceous layer indicates very high permeability (40Lu<) and seems to extend horizontally to the bank side. <Consideration> - Make an cut-off curtain across over the unit within the depth of the maximum dam height - Ensure seepage path long enough to be gentle hydraulic gradient
V		Right bank	Alt-2	<Characteristics> - The stratigraphic unit consists of alternation layers (mainly CM class). The sandstone sections have open joints developed due to in-situ stress release, and the boundaries between sandstone and mudstone are weathered in parts <Risks> - Groundwater flows, as rapid flow along thin weathered layers and vertical open joints <Consideration> - Make an cut-off curtain across over the unit within the depth of the maximum dam height - Ensure seepage path long enough to be gentle hydraulic gradient

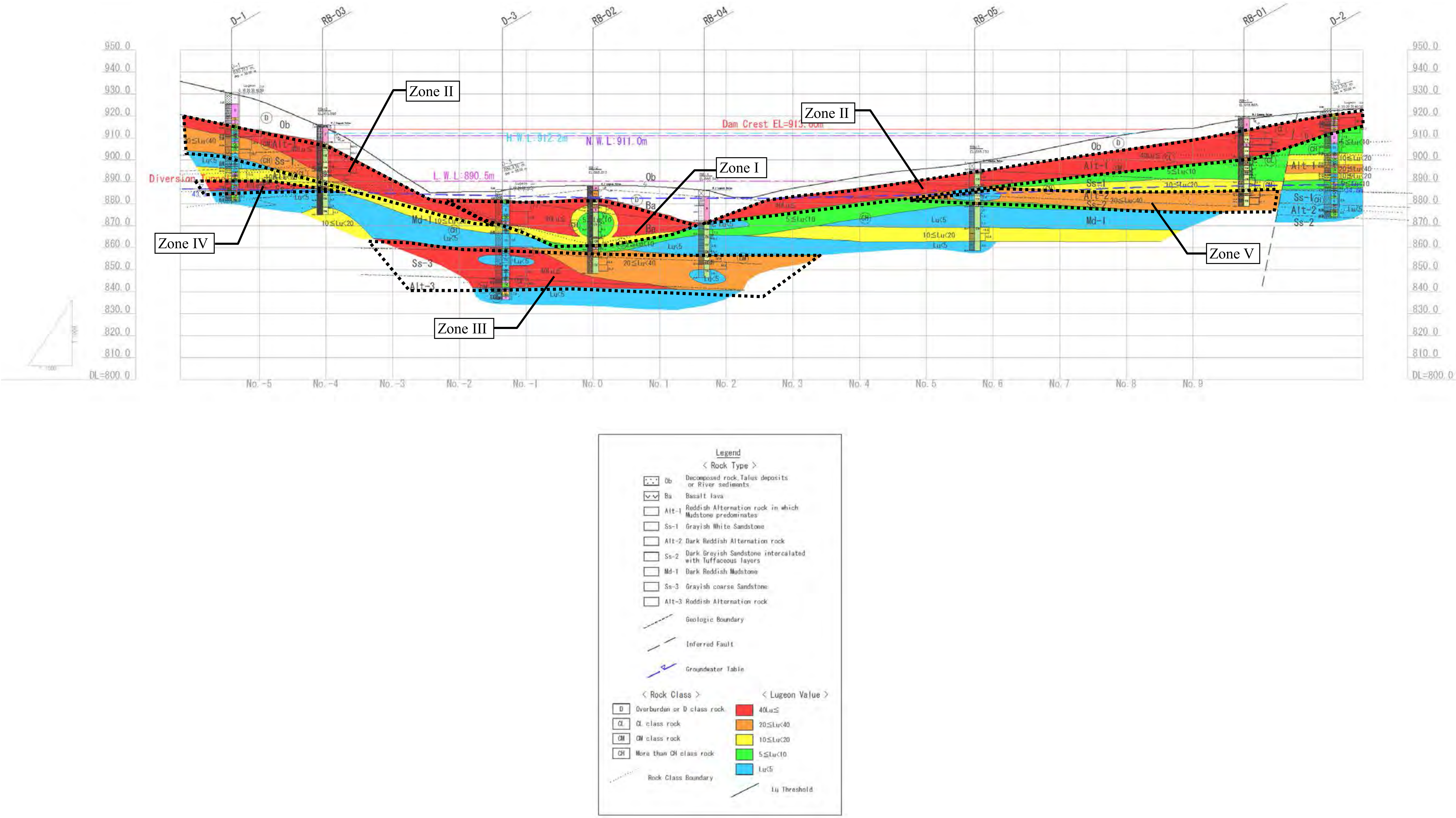


Figure 3.2-14 Lugeon Map along the Main Dam Axis

(3) Quarry

(a) Topo and Geological Conditions in Main Quarry

The main quarry is a mountain which extends north to south beside the main dam site. In 2009, Total two lines of seismic prospecting of which one was a longitudinal line parallel to the ridge (Line-Q: 700m) and another was a line crossing the ridge (Line-L: 300m), were conducted and one exploratory hole (QB-1) was conducted at the intersection point of the prospecting lines. After these site investigations, rock testing in laboratory was carried out using extracted rock samples from drilling cores.

The mountain has a relatively low ridge of which heights above the Nam Houng River are approx. 50m and is overlaid with thick overburden on the west slopes. On the east slopes of the mountain, sandstone outcrops are scattered in the range of EL.910 to 920m as shown in Figure 3.2-15. It seems that rock materials will be collected efficiently on the east slope thanks to thin overburden.

The geological profile from the quarry site through the dam site is shown in Figure 3.2-16.

According to drilling result at QB-1, the stratigraphic compositions of the quarry site are common with the dam foundation rocks on the left bank which were uncovered with extracted cores at D-1. The section 9-24m (EL.905-920m) in depth of QB-1 is the Ss-1 unit, the section 24-36.2m (EL.892.8-920m) in the depth is the Alt-2 and Ss-2 unit, and the section 36.5-40m (EL.889-892.8m) is the Md-1 unit. The Ss-1 consists of mainly CH class. On the other hand, the Alt-1 and Ss-2 includes core loss sections frequently and these are considered as CL to CM class in the whole of the unit. The Md-1 indicates reddish mudstone in which drilling cores are relatively hard and consist of mainly CM to CH class. All the units tilt gently to the upstream (north toward) with less than 5º dipping. The Ss-1 at QB-1 shows more than 15m thick but the thickness of Ss-1 get thinner from downstream to upstream and the thickness at D-1 is a half of at QB-1.

There are sandstone outcrops on the Nam Houng River 700-800m downstream from the main dam site. These exposed rocks correspond to Ss-3 in the geological profile along main dam axis.

(b) Topo and Geological Conditions in Alternative Quarry

The plane areas composed of basaltic lava expand widely at about elevation of the Nam Houng River in the reservoir area and the downstream area from the main dam site. Basaltic lavas generally underlie beneath lateritic soil according to the drilling results at RB-2, D-3 and Q-1. Adequate bedrocks for rock material appear below the riverbed elevation of the Nam Houng River though the thickness of overburden remarkably diverges at localities.

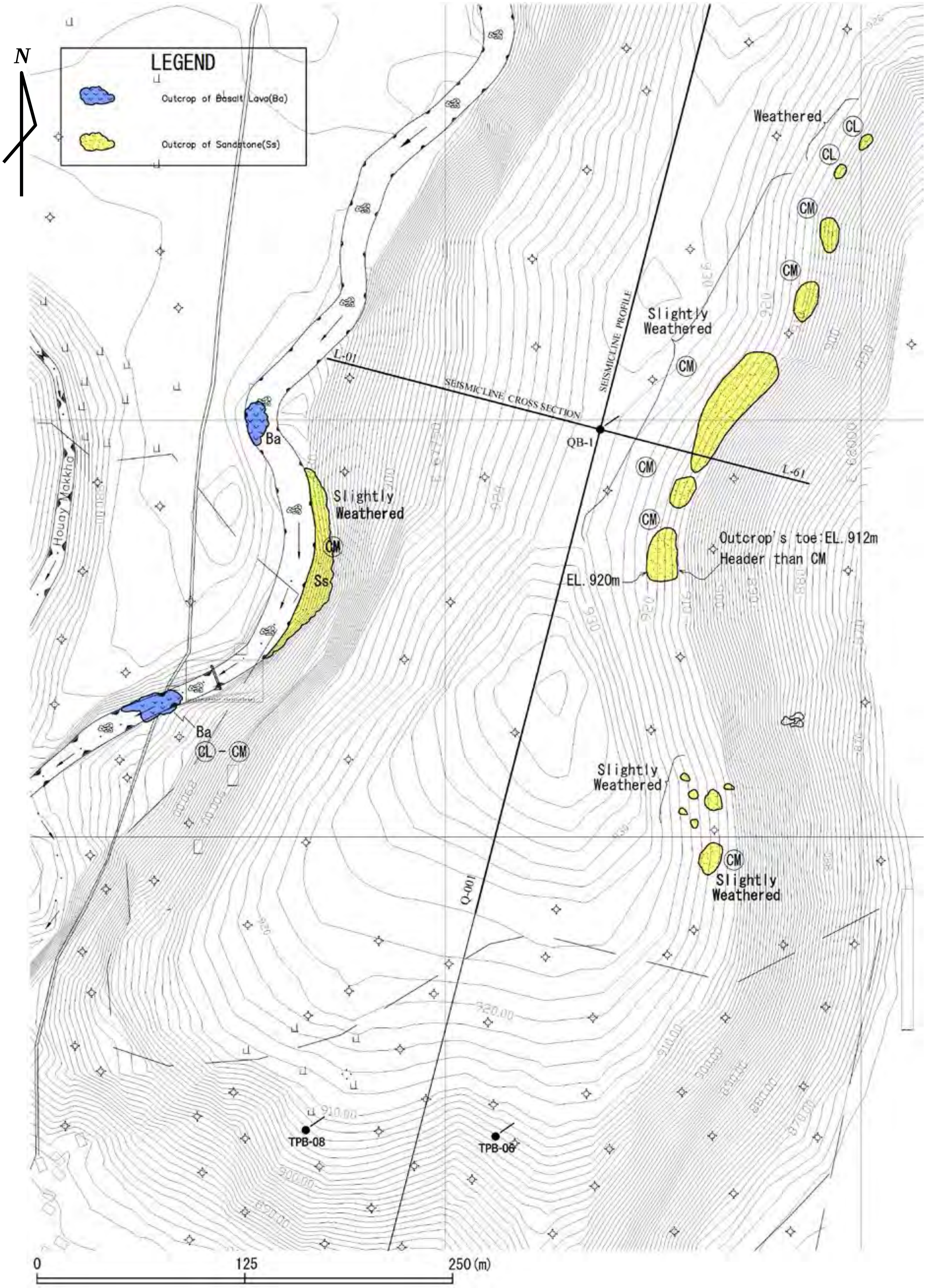


Figure 3.2-15 Distribution of Exposed Bedrocks around Main Quarry

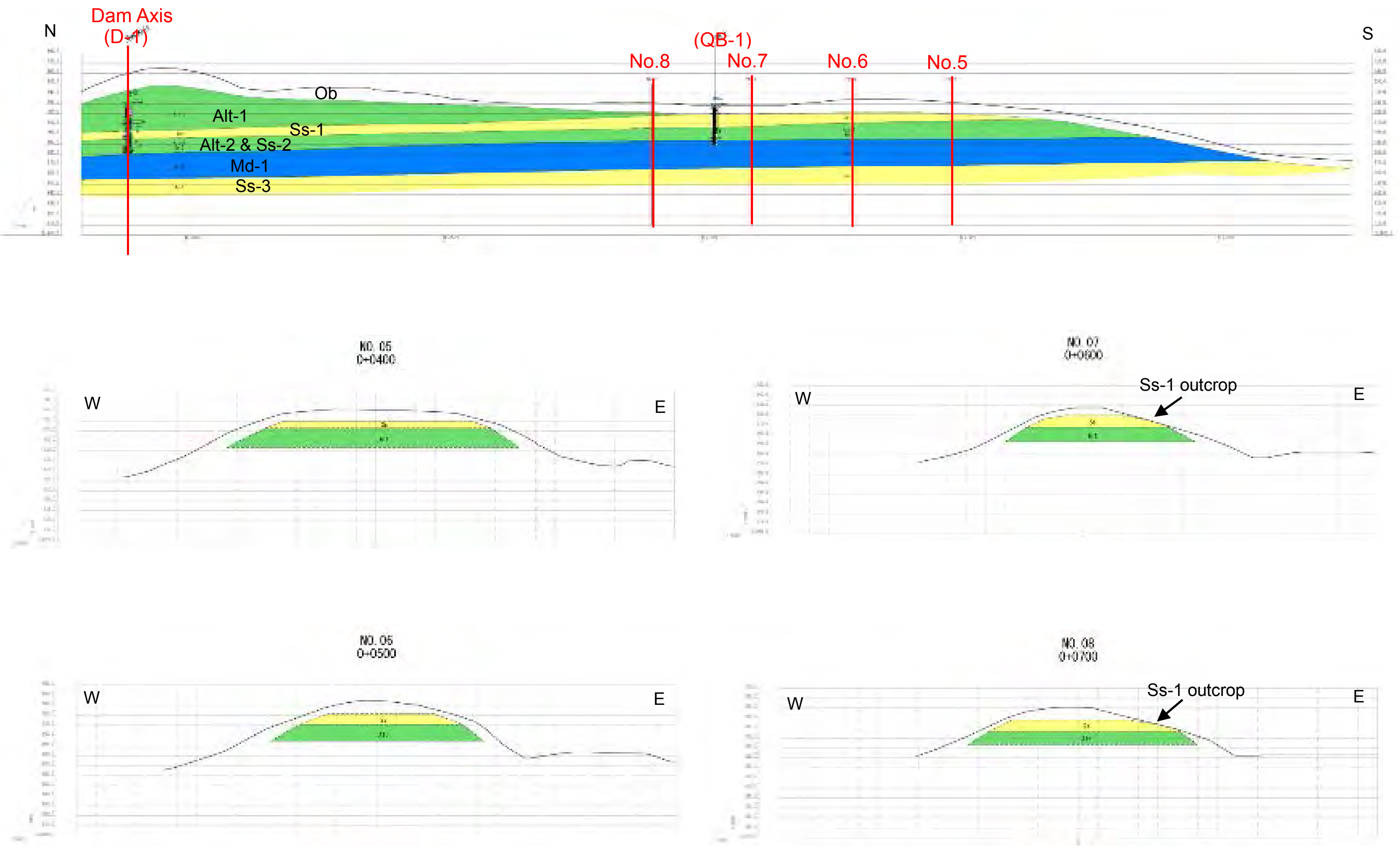


Figure 3.2-16 Geological Profiles in the Main Quarry

(c) Rock Properties of Main Quarry

i) Results of Rock Testing in Laboratory

Laboratory tests for rock materials and concrete aggregate in laboratory were carried out using extracted rock samples from drilling cores.

Physical / chemical quality targets of concrete aggregate in JIS standard are defined and tabulated in Table 3.2-10, for reference. Table 3.2-11 summarizes the results.

Table 3.2-10 Quality Targets for Concrete Aggregate Standardized by JIS

No.	Testing Items	Coarse Aggregate	Sand
1	Absolute dry specific gravity (g/cm^3)	over 2.5	over 2.5
2	Absorption (%)	under 3.0	under 3.0
3	Loss by Abrasion (%)	under 40	-
4	Amount of material passing No.200 sieve (%)	under 1.0	under 7.0
5	Alkaline-Silica Reaction (Chemical method)	Sc/Rc < 1.0	
6	Alkaline-Silica Reaction (Mortar-bar method)	Dilatability: less than 0.100% (after 6 months)	

(ource: JIS A 5005、JIS A 1145、JIS A 1146)

Ss-1: The specific gravity and absorption of fresh sandstone satisfies the JIS standards. However, the tests for abrasion resistance and amount of material passing No.200 sieve have not conducted yet. The rock samples extracted from outcrops indicate that their strengths (UCS) are lower than drilling core samples and their absorptions are higher than 3.0% due to being somewhat weathered.

Md-1: The specific gravity and absorption of fresh mudstone satisfies the JIS standards and its strengths show high as well as sandstone. However, there is a sign of slaking on existing drilling cores.

ii) Evaluation for Availability

The availability of rock fragments in each the stratigraphic unit composed of the main quarry is evaluated as the follows:

Residual soil : It is unavailable for rock materials due to being composed of D class

Alt-1 : This unit is weathered at shallow portions and contains richer mudstone rather than sandstone, thus it is unavailable

Ss-1 : This unit consists mainly of hard sandstone (CH class) and has sufficient strength (UCS: over 600kgf/cm^2), thus it is available for rock materials in the outer zone of rock-fill dam. However the availability shall be finally judged after testing of abrasion resistance.

Alt-2·Ss-2 : This unit consists of alternation of sandstone (CM class) and mudstone (D-CL class) on an equivalent. Although the mudstone fragments will become finer in tamping, it is possibly available for inner shell of the rock-fill dam.

Md-1 : This unit consists mainly of massive mudstone which has sufficient strength as well as sandstone, however the drilled core samples indicate a sign of slaking, thus it is basically unavailable for concrete aggregate. On using rock materials for rock-fill dam, the pros and cons of the availability will be decided after executing the slaking test.

Ss-3 : This unit is underlain beneath the river elevation (EL.870-880m). Thus it is basically unavailable.

Table 3.2-11 Summary of Rock Testing for the Main Quarry in Laboratory

Stratigraphic Unit	Sampling Location	Sample Condition	Specific Gravity (g/cm^3)	Absorption (%)	Unconfined Compression Strength (MPa)	Loss by Abrasion (%)	Amount of material passing No.200 sieve (%)	Alkaline-Silica Reaction (Chemical method) Sc/Rc	Alkaline-Silica Reaction (Mortar-bar method)(Dilatability: %)
Quality Standard of JIS			**2.5<**	**3.0>**	**-**	**40>**	**1.0>**	**1.0>**	**0.1>**
Ss-1	RB-3: 17.5-17.8m	Sandstone, Fresh	2.82	1.26	68.38	-	-	-	-
Ss-2	RB-3: 27.5-28.0m	Sandstone, Fresh	2.64	1.63	69.55	-	-	-	-
Md-1	RB-3: 36.0-37.0m	Sandstone, Fresh	-	-	79.66	-	-	0.02 (harmless)	-
Md-1	RB-3: 36.0-37.0m	Sandstone, Fresh	-	-	88.00	-	-	0.02 (harmless)	-
Ss-1	Outcrop on quarry (ID.Q-1-1)	Sandstone, Somewhat weathered	2.65	3.81	45.13	-	-	-	-
Ss-1	Outcrop on quarry (ID.Q-1-2)	Sandstone, Somewhat weathered	-	-	47.38	-	-	-	-
Ss-1	Outcrop on quarry (ID.Q-2-1)	Sandstone, Somewhat weathered	2.64	3.50	71.12	-	-	-	-
Ss-1	Outcrop on quarry (ID.Q-2-2)	Sandstone, Somewhat weathered			55.43	-	-	-	-
Ss-1	QB-1: 19.5-20.0m	Sandstone, Fresh	2.57	2.27	64.65	-	-	-	-
Ss-1	QB-1: 21.0-21.5m	Sandstone, Fresh	2.61	2.43	63.96	-	-	-	-
Ss-2	QB-1: 28.4-28.8m	Mudstone, Fresh	2.78	2.69	35.71	-	-	-	-
Md-1	QB-1: 36.5-37.0m	Mudstone, Fresh	2.72	1.16	60.63	-	-	-	-

(d) Rock Properties of Alternative Quarry

i) Results of Rock Testing in Laboratory

In case that rock materials will probably run short in the main quarry, hard basaltic lavas will be expected as alternative source of rock materials around the Project site.

On the flat areas at EL. 880-890m around the dam site, basaltic lavas filled old valley in the Quarternary. According to past drilling surveys, extremely hard basalt appears beneath auto-brecciated sections which turn into lateritic soil. Table 3.2-12 summarizes the results of rock testing in laboratory with basalt samples.

Table 3.2-12 Summary of Rock Testing for Basalt in Laboratory

Stratigraphic Unit	Sampling Location	Sample Condition	Specific Gravity (g/cm^3)	Absorption (%)	Unconfined Compression Strength (MPa)	Loss by Abrasion (%)	Amount of material passing No.200 sieve (%)	Alkaline-Silica Reaction (Chemical method) Sc/Rc	Alkaline-Silica Reaction (Mortar-bar method) (Dilatability: %)
Quality Standard of JIS			**2.5<**	**3.0>**	**-**	**40>**	**1.0>**	**1.0>**	**0.1>**
Ba	RB-2: 19.50 -19.90m	Basaltic lava, Fresh	2.87	1.01	139.20	-	-	-	-
Ba	RB-2: 25.50 -25.90m	Basaltic lava, Fresh	2.90	1.21	179.52	-	-	-	-
Ba	Q-1: 13.20 -13.40m	Basaltic lava, Fresh	2.91	5.10	56.51	-	-	-	-
Ba	Q-1: 13.40 -13.60m	Basaltic lava, Fresh	2.93	5.30	59.06	-	-	-	-
Ba	Q-1: 13.70 -14.00m	Basaltic lava, Fresh	2.94	5.20	59.84	-	-	-	-

ii) Evaluation for Availability

As shown in Table 3.2-12, basalt lavas are estimated to be high strength. The value of UCS is at least about 60MPa. Although these physical properties differ at localities, there will be no problem on using rock materials for rock-fill dam.

There is large variance in the value of UCS and the absorption of the basaltic lavas among drilling cores extracted from different holes, RB-2 and Q-1, and the basalt samples of Q-1 do not satisfy the JIS standard relevant to absorption. The reason for the large variation in rock properties of basaltic lavas seems that their thicknesses or welding degrees differed at localities when their eruption.

In addition, chemical reactivity has regarding alkaline-silica reaction in basalt has to be checked in detail.

Collecting basaltic fragments is required as the follows:

1) A large trench is necessary for the mining works will and the trench may be covered with water from rainwater or groundwater during rainy season.

2) The workability of mining is inferior to the main quarry site because the constructor is compelled to conduct large scale blasting and pick up blasted fragments from lower elevation. Therefore, the alternative quarry site should be selected in which overburden is as thinner as possible in the Project area.

(4) Borrow Site

There are six potential borrow sites divided based on the positional relationship of 29 test pits excavated around the main dam site and the reservoir area in the previous studies during 2005 to 2013, as shown in Table 3.2-13 and Figure 3.2-17.

Table 3.2-13 Summary of Potential Borrow Sites around the Main Dam Site

Potential Borrow Site			Soil Type	Test Pit ID.
Reservoir	Borrow 1	Gentle slopes on the upstream reservoir area	Talus deposit	TPB-1, TPB-2, TPB-3
	Borrow 2	The vicinity of the saddle dam in the reservoir area	Laterite originating from basalt	TP-1, TP-2, TC-4
	Borrow 3	Riverbed on the main dam site	Laterite originating from basalt	TP-3, TC-7
Borrow 4		Basaltic lava plain on the downstream from the main dam site	Laterite originating from basalt	TC-3, TPB-7
Borrow 5		Main Quarry	Residual soil originating from sedimentary rocks	QPT-1, QPT-2, TPB-6, TPB-8
Borrow 6		Gentle slopes of the right bank of the main dam site on the downstream	Residual soil originating from sedimentary rocks and old riverbed deposits	TP-4, BTP-1, BTP-2, BTP-3, TC-1, TC-2, BTP-4, BTP-5, TPB-4, TPB-5, TPB-9, TPB-10, TPB-11, TC-5, TC-6

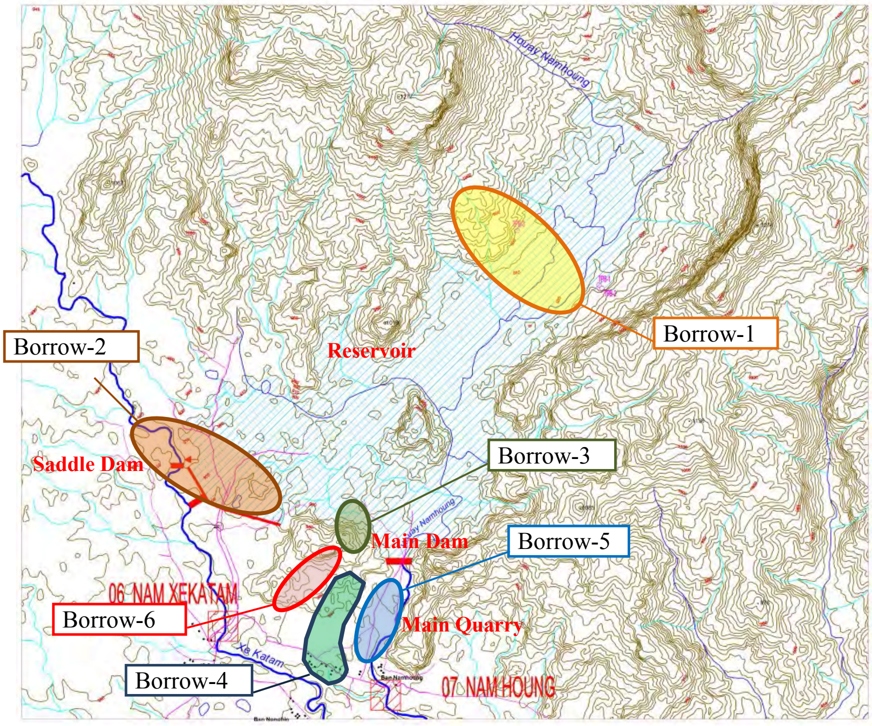


Figure 3.2-17 Locations of each Potential Borrow Site

(a) Results of Soil Testing in Laboratory

Property tests (grain size, atterberg limit, density, specific gravity and moisture contents: total five items) and mechanical tests (compaction, consolidation, triaxial compression strength as CU and permeability: total four items) were conducted using disturbed soil materials in each test pit around the dam site.

Table 3.2-14 summarizes all results of laboratory tests.

Table 3.2-14 Summary of Soil Testing Results

Test Pit	Borrow Site	Year	Sampling Depth	GSD percentage of passing in weight: Gravel >37.5	Gravel 37.5 - 25.0	Gravel 25.0 - 19.0	Gravel 19.0 - 9.5	Gravel 9.5 - 4.75	Gravel 4.75 - 2.0	Sand 2.0 - 0.425	Sand 0.425 - 0.075	Silt/Clay 0.075 - 0.005	Silt/Clay 0.005 - 0.001	Silt/Clay 0.001	Specific Gravity (g/cm3)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture Content (%)
				%											G_s	WL	WP	IP	W
TPB-1	Borrow 1	2009	2.5-3.3							3.4%	35.6%	27.3%	5.5%	28.2%	2.64	45.4%	21.8%	23.6%	19.0%
TPB-2		2009	2.5-3.2						0.7%	4.1%	33.1%	26.8%	5.9%	29.4%	2.65	45.0%	25.1%	19.9%	18.8%
TP-1-S1	Borrow 2	2005	1.0					0.2%	0.6%	6.2%	2.5%	90.5%			2.68	47.6%	35.8%	11.8%	30.4%
TP-1-S2		2005	2.0			2.8%	3.5%	7.0%	6.6%	7.9%	2.4%	69.8%			2.71	46.8%	37.6%	9.3%	32.4%
TP-1-S3		2005	3.0			1.4%	3.6%	4.4%	5.8%	14.3%	3.4%	67.0%			2.69	50.0%	40.7%	9.3%	35.2%
TP-2-S1		2005	1.0					2.8%	2.8%	8.1%	1.9%	84.4%			2.67	46.5%	35.5%	11.0%	28.6%
TP-2-S2		2005	2.0			5.8%	8.3%	9.6%	10.5%	15.3%	2.9%	47.6%			2.69	47.5%	37.0%	10.5%	27.8%
TP-2-S3		2005	3.0				15.0%	15.4%	10.5%	7.6%	1.9%	49.6%			2.71	48.0%	33.6%	14.4%	24.9%
TP-4-S1		2005	1.0				2.5%	6.2%	5.2%	15.7%	3.4%	66.9%			2.68	42.4%	34.8%	7.6%	31.9%
TP-4-S2		2005	2.0				0.9%	1.9%	4.2%	15.7%	5.3%	72.1%			2.69	44.2%	30.9%	13.3%	38.5%
TP-4-S3		2005	3.0			3.0%	15.5%	4.7%	5.8%	18.8%	2.6%	49.7%			2.71	45.3%	32.8%	12.5%	40.6%
TC-4-S1		2013	1.5		22.9%	21.5%	13.1%	5.5%	1.8%	4.5%	3.7%	11.2%	4.2%	11.6%	2.82	59.1%	41.2%	17.9%	49.1%
TP-3-S1	Borrow 3	2005	1.0				3.3%	8.0%	4.0%	14.8%	6.9%	63.1%			2.67	38.5%	26.4%	12.1%	15.0%
TP-3-S2		2005	2.0				2.5%	3.2%	2.0%	24.4%	8.3%	59.6%			2.71	35.4%	24.4%	11.0%	16.6%
TP-3-S3		2005	2.5				0.8%	2.1%	2.0%	41.5%	7.3%	46.4%			2.69	26.2%	20.6%	5.6%	12.9%
TPB-7	Borrow 4	2009	2.5-3.5						0.6%	1.0%	8.3%	29.5%	14.5%	46.1%	2.85	61.4%	45.5%	15.9%	43.2%
TPB-7D		2009	3.7-5.0	8.2%	0.1%	11.0%	10.6%	6.8%	2.6%	1.1%	18.7%	20.7%	3.5%	16.8%	2.87	57.6%	42.2%	15.4%	36.3%
TC-3-S1		2013	2.6				3.2%	5.0%	8.2%	4.4%	5.7%	24.8%	10.8%	37.9%	2.86	63.4%	42.9%	20.5%	43.5%
TC-3-S2		2013	3.3		2.9%	10.2%	9.7%	5.4%	2.6%	5.8%	5.6%	29.1%	8.0%	20.7%	2.84	62.2%	44.7%	17.5%	42.7%
TC-3-S3		2013	4.0		2.2%	6.2%	14.8%	9.2%	3.4%	2.4%	4.6%	27.2%	9.3%	20.7%	2.90	59.0%	41.8%	17.2%	46.2%
TC-3-(S1+S2)		2013	2.6-3.3						10.8%	9.3%	7.1%	28.4%	11.2%	33.2%	2.90	59.4%	42.0%	17.4%	
TC-3-(S1+S2+S3)		2013	2.6-4.0		1.6%	3.8%	10.6%	7.4%	1.4%	5.6%	5.6%	24.5%	10.3%	29.2%	2.91	62.7%	43.6%	19.1%	18.2%
TPB-6	Borrow 5	2009	2.5-3.5						0.5%	15.1%	49.9%	14.6%	3.3%	16.6%	2.64	34.9%	18.7%	16.2%	12.1%
TPB-8		2009	2.5							1.5%	17.2%	57.4%	5.6%	18.3%	2.73				13.2%
BTP-1	Borrow 6	2006	3.5	7.5%						18.1%		74.4%			2.67	35.4%	20.2%	15.1%	10.5%
BTP-2		2006	3.5	28.5%						4.5%		67.1%			2.66	25.1%	17.0%	8.1%	5.8%
BTP-3		2006	4.6	5.1%						10.0%		84.9%			2.68	32.5%	20.2%	12.3%	12.6%
BTP-4		2006	5.0	3.0%						37.6%		59.5%			2.65	32.7%	22.0%	10.7%	17.3%
BTP-5		2006	5.0	8.4%						37.8%		53.8%			2.65	32.8%	22.6%	10.2%	18.9%
TPB-4		2009	2.5-3.0						4.1%	53.0%	19.3%	10.9%	1.7%	11.0%	2.66	27.4%	19.2%	8.2%	7.6%
TPB-10		2009	4.0							7.0%	42.2%	20.5%	5.0%	25.3%	2.72				17.1%
TPB-11		2009	2.5							1.8%	12.5%	33.2%	10.4%	42.1%	2.79				22.9%
TC-1		2013	3.3								41.3%	36.4%	3.3%	19.0%	2.66	32.5%	18.7%	13.8%	18.6%
TC-5-S1		2013	2.2							10.3%	41.4%	23.9%	7.2%	17.2%	2.69	31.2%	17.4%	13.8%	15.1%
TC-5-S2		2013	2.8							12.3%	38.7%	23.2%	6.3%	19.5%	2.66	33.5%	18.0%	15.5%	10.0%
TC-5-S3		2013	4.0							8.3%	43.2%	25.0%	4.5%	19.0%	2.68	28.2%	15.6%	12.6%	10.7%
TC-6-S1		2013	2.2							9.9%	45.9%	20.8%	3.0%	20.4%	2.68	29.7%	16.1%	13.6%	15.0%
TC-6-S2		2013	3.0			11.4%	11.7%	5.7%	3.7%	8.9%	30.3%	14.1%	2.4%	11.8%	2.75	30.4%	17.0%	13.4%	17.9%

Test Pit	Bulk Dry (g/cm³)	Compacted: Optimum Moisture Content (%)	Compacted: Maximum Dry Density (g/cm³)	GSD >4.75mm: Moisture Content (%)	GSD >4.75mm: Density (g/cm³)	GSD >4.75mm: Dry Density (g/cm³)	Remolded Soil: Adjusted GSD > 4.75mm: Moisture Content (%)	Density (g/cm³)	Dry Density (g/cm³)	Adjusted GSD < 4.75mm: Moisture Content (%)	Density (g/cm³)	Dry Density (g/cm³)	Adjusted GSD < 19.0mm: Moisture Content (%)	Density (g/cm³)	Dry Density (g/cm³)	Degree of Saturation (%)	Porosity (%)	Void Ratio	Consolidation Coefficient x 10^{-3} (cm²/s)	Preconsolidation Pressure (kgf/cm²)	Triaxial Test (CU) Effective: Friction Angle (Degree)	Cohesion (kgf/m²)	Triaxial Test (CU) Total: Friction Angle (Degree)	Cohesion (kgf/m²)	Coefficient of Permeability (cm/s)
	ρ	Wop	ρdmax	W	ρsat	ρd	Wre	ρre	ρre-d	Wre	ρre	ρre-d	Wre	ρre	ρre-d	sr	n%	eo	Cv	σ	φ'	C'	φ	C	K
TPB-1																									
TPB-2																									
TP-1-S1																									
TP-1-S2																									
TP-1-S3																									
TP-2-S1																									
TP-2-S2																									
TP-2-S3																									
TP-4-S1																									
TP-4-S2																									
TP-4-S3																									
TC-4-S1	1.67	40.2%	1.26	38.0%	1.76	1.28							40.0%	1.72	1.23	87.0%	56.4%	1.30	1.36	1.24	18°15″	0.21	26°08″	0.31	1.70.E-06
TP-3-S1																									
TP-3-S2																									
TP-3-S3																									
TPB-7		42.2%	1.25							42.2%	1.75	1.23				91.0%	56.8%	1.32			13°28″	0.19	19°22″	0.27	3.50.E-07
TPB-7D		29.0%	1.54				28.6%	1.88	1.46	29.0%	1.99	1.54				97.0%	46.2%	0.86			17°51″	0.16	24°44″	0.19	3.70.E-05
TC-3-S1	2.40	35.7%	1.36	34.7%	1.91	1.42	35.5%	1.80	1.33							88.0%	53.6%	1.15	1.32	1.24	17°40″	0.38	24°59″	0.42	1.50.E-06
TC-3-S2	1.37	37.8%	1.31	33.0%	1.80	1.35							37.6%	1.76	1.28	88.0%	55.0%	1.22	1.20	1.12	19°01″	0.22	26°22″	0.30	6.50.E-07
TC-3-S3	1.16	35.7%	1.33	36.0%	1.81	1.33							35.8%	1.77	1.30	85.0%	55.1%	1.23	1.45	1.19	20°00″	0.26	26°23″	0.38	9.40.E-07
TC-3-(S1+S2)		35.5%	1.33				35.4%	1.76	1.30							83.0%	55.2%	1.23	1.23	1.04	16°53″	0.33	24°25″	0.37	1.20.E-06
TC-3-(S1+S2+S3)	1.45	37.3%	1.32	32.1%	1.93	1.46				37.2%	1.77	1.29	37.2%	1.77	1.29	86.0%	55.7%	1.26	1.52	1.39	19°11″	0.24	25°56″	0.35	1.10.E-06
TPB-6		19.2%	1.70							19.2%	2.00	1.68				88.0%	36.4%	0.57			17°00″	0.13	23°04″	0.15	1.10.E-07
TPB-8																									
BTP-1		16.1%	1.74																		4°50″	0.20	9°00″	0.26	1.83.E-07
BTP-2		10.2%	1.86																		13°00″	0.16	13°00″	0.21	6.65.E-07
BTP-3		16.9%	1.73																		17°00″	0.13	20°00″	0.18	3.65.E-07
BTP-4		16.6%	1.75																		38°00″	0.17	42°00″	0.23	1.64.E-07
BTP-5		17.9%	1.71																		46°00″	0.18	43°00″	0.22	1.84.E-07
TPB-4		15.9%	1.82							15.9%	2.06	1.78				85.0%	33.2%	0.50			18°00″	0.23	24°10″	0.27	4.00.E-06
TPB-10																									
TPB-11																									
TC-1	1.75	15.5%	1.80				15.3%	2.03	1.76							80.0%	33.8%	0.51	1.65	1.14	18°50″	0.24	26°49″	0.29	1.30.E-06
TC-5-S1		15.0%	1.86				14.8%	2.09	1.82							83.0%	32.3%	0.48	1.81	1.00	20°58″	0.23	27°13″	0.29	1.60.E-06
TC-5-S2	1.79	15.0%	1.83				14.6%	2.05	1.79							80.0%	32.8%	0.49	2.10	1.28	19°01″	0.22	26°50″	0.30	1.80.E-06
TC-5-S3	1.90	14.6%	1.87				14.5%	2.10	1.83							84.0%	31.6%	0.46	1.88	1.10	21°56″	0.21	28°17″	0.28	1.40.E-06
TC-6-S1	1.95	14.0%	1.87				14.0%	2.09	1.83							81.0%	31.6%	0.46	1.99	1.18	21°05″	0.19	28°25″	0.27	1.50.E-06
TC-6-S2	2.10	13.5%	1.91	7.5%	2.47	2.30							13.5%	2.12	1.87	79.0%	32.1%	0.47	1.88	1.29	20°23″	0.25	27°14″	0.31	1.30.E-06

(b) Evaluation for Availability

Based on the results of soil testing in laboratory and observation in test pits in the Project site, availability of earth materials at each potential borrow area is evaluated as mentioned below:

1) Borrow 1 (Gentle slopes on the upstream reservoir area)

Total three (3) test pits (TPB-1, TPB-2 and TPB-3) were excavated on the both banks, however many basaltic boulders (φ30-50cm) appeared at 3.0m in depth every pit. The soils consist mainly of fine materials.

2) Borrow 2 (The vicinity of the saddle dam in the reservoir area)

In the three (3) test pits (TP-1, TP-2 and TC-4: see Figure 3.2-17), many basaltic boulders appeared at 2.0m in depth every pits. According to the particle gradation, these soils include a lot of gravels (>50mm), but lacks sand particles (0.075-2.0mm). There are rich fine particles (<0.075mm) more than 50% among gravels.

3) Borrow 3 (Riverbed on the main dam site)

In TP-3 excavated upon the main dam axis, decomposed materials of basaltic lava comprise sub soil down to 2.5m in depth. These materials tend to become coarser with depth but contain rich fine particles (more than 40%) at the bottom in the pit. In TC-7 excavated at approx. 150m on the upstream from the dam axis, a bunch of basaltic boulders of 30-40cm in diameter appeared at only 50cm in depth and prevented man-made excavation.

The basaltic boulders supposed to be residual core-stones are spread over the reservoir area, thus works of separating these boulders will be required in mining soil. All soil materials in the test pits consist mainly of fine particles and high natural moisture. Therefore, the borrow areas in the reservoir area are inadequate borrow sites for the core materials.

4) Borrow 4 (Basaltic lava plain on the downstream from the main dam site)

On the downstream area, relatively thick basaltic laterite without boulders blankets on basaltic lavas. According to the result of one (1) drilling at Q-1, it is known that approx. 10m of the laterite is down to hard basalt rocks. The soils contain more than 40% of fine particles at TC-3 and TPB-7, and the measured maximum dry densities range 1.26-1.54g/cm^3 and the optimum water contents range 29.0-37.8%. To sum up, the Borrow 4 is an inadequate borrow site for the core materials.

5) Borrow 5 (Main Quarry)

On the quarry mountain, two (2) test pits (QPT-1 and QPT-2) on the ridge at approx. 300m downstream from the main dam axis and two (2) test pits (TPB-6 and TPB-8) on the south slope of the mountain were excavated. The soil properties at TPB-6 indicates that sand particles are included approx. 65% and fairly good compaction properties ($\rho dmax$ =1.70g/cm^3, wop =19.2%). The residual soil of TPB-6 originates from sandstone since a core-stone of weathered sandstone appeared at 3-5 m in depth. On the other hand, the soil sample extracted at TPB-8 where located at approx. 100m west from TPB-6 shows that composition of fine particles is more than 80% (compaction test was not done). According to the observation in the pit, it was considered that the soil originates from mudstone.

The soil properties of the quarry mountain strongly depend on the kind of basement rock just under the soil and these are uneven. Therefore, the Borrow 5 is an inadequate borrow site for the core materials.

6) Borrow 6 (Gentle slopes of the right bank of the main dam site on the downstream)

A Total of fourteen (14) test pits were excavated in the previous studies. Most soil samples contained rich fine particles more than 50%.
However only a sample of TC-6 indicates well graded soil containing fine particles less than 30% and good compaction properties as tabulated in Table 3.2-15.
Therefore, the soil on the gentle slope at 500-700m downstream from the dam site shows adequate properties for core materials although only one sample at TC-6 has been found out. However, execution of additional investigation regarding expanse of adequate soil is preferable because the existing soil data are not too sufficient to estimate potential volume with high accuracy.

Table 3.2-15 Soil Properties of the TC-6 Test Pit

Items	Test Result
Grain size gradation	- Proportion of particles passing No.200 sieve (<0.074mm) : 28.3% - Proportion of particles passing No.4 sieve (<2mm) : 67.5% - Coefficient of uniformly (C_u: D_{60}/D_{10}) : 580 - Coefficient of curvature (C_c: $D_{30}{}^{\wedge 2}/D_{60}{*}D_{10}$) : 11.6
Plasticity	- IP=13.4% (IP≥12: No concerns about piping)
Compaction	- ρ_{dmax}=1.91g/cm^3 - w_{op}=13.5% (Natural water content: 17.9%)
Permeability at w_{op}	- K=1.3×10^{-6} (in laboratory testing)
Shear strength at w_{op}	- Cohesion (total, c) : 30.41 MPa - Friction angle (total, φ) : 27º 14” - Cohesion (effective, c’) : 22.56 MPa - Friction angle (effective, φ’) : 20º 23”

(5) Borrow Site for Filter Materials

In the surroundings of the main dam site, adequate sand or gravel deposits for filter materials are not distributed. The closest source of filter materials is on sand-bars along the Sekong River located approx. 30km east from the dam site. However, Figure 3.2-18 shows the sands in Sekong River are too fine (generally less than 1mm) and poorly graded.

According to the site reconnaissance, there are gravel deposits in same of the sand-bar, but they lack sand particles less than 10mm in diameter and are small amount.

Consequently, there are no ideal materials for filter of the rock-fill dam in the Sekong sand-bars. Adequate filter materials shall be procured with two ways as follows:

1) Purchasing them
2) Producing them by crushing rock materials

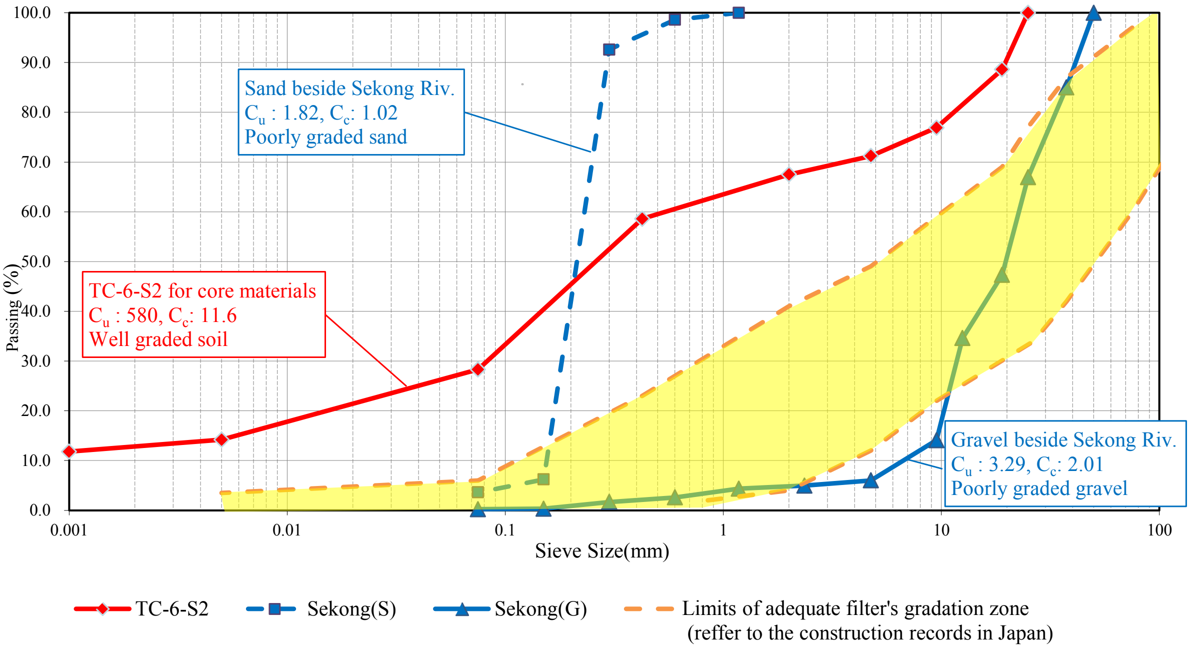


Figure 3.2-18 Grading Curves of Sand and Gravelly Materials nearby the Sekong River

(6) Diversion Weir

(a) Topography and Geology

The diversion weir and saddle dam are located on a basaltic lava plateau EL. 908-915m (see Figure 3.2-19). The plateau is almost flat but shallow hollows approx. 10m deep are locally distributed. Some of these hollows become marsh due to flooding in rainy season.

The basaltic lavas are exposed across the riverbed on the diversion weir whereas river deposits and residual soil overlay on the both banks. Rock surface of the lava may expand horizontally from riverbed up to at least the end of the area in which the weir is constructed.

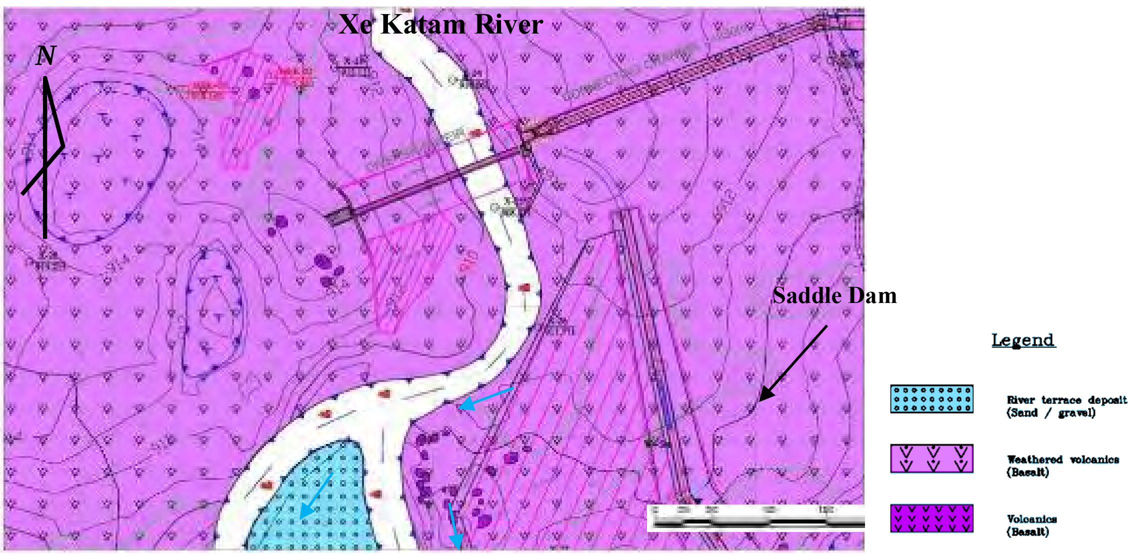


Figure 3.2-19 Geological Distributions around Diversion Weir and Saddle Dam

(b) Geotechnical Evaluation

If rock surface of basaltic lavas expands horizontally from riverbed, the foundation level of the weir and relevant structures is EL. 908m. The geotechnical evaluation follow below:

1) The weir, flushing gate will be placed on the hard basalt rocks

2) The connecting channel will be placed on the basalt rocks, but if residual soils still exist on designed foundation level, these shall be removed to prevent erosion at the contacts on the ground

(7) Intake Weir

(a) Topography and Geology

Two (2) intake weirs will be constructed on the Xe Katam River and the Houay Dakproung River 500m upstream from confluence of both rivers. A thin ridge between both rivers extends to south with declining in its own crest.

As shown in Figure 3.2-20, the riverbed of the Xe Katam River exposes basaltic lavas, however the left bank of the Dakproung River is composed of sandstone. The geological boundary may underlie beneath the riverbed deposits on the Dakproung River although bedrocks have been covered by deposits throughout.

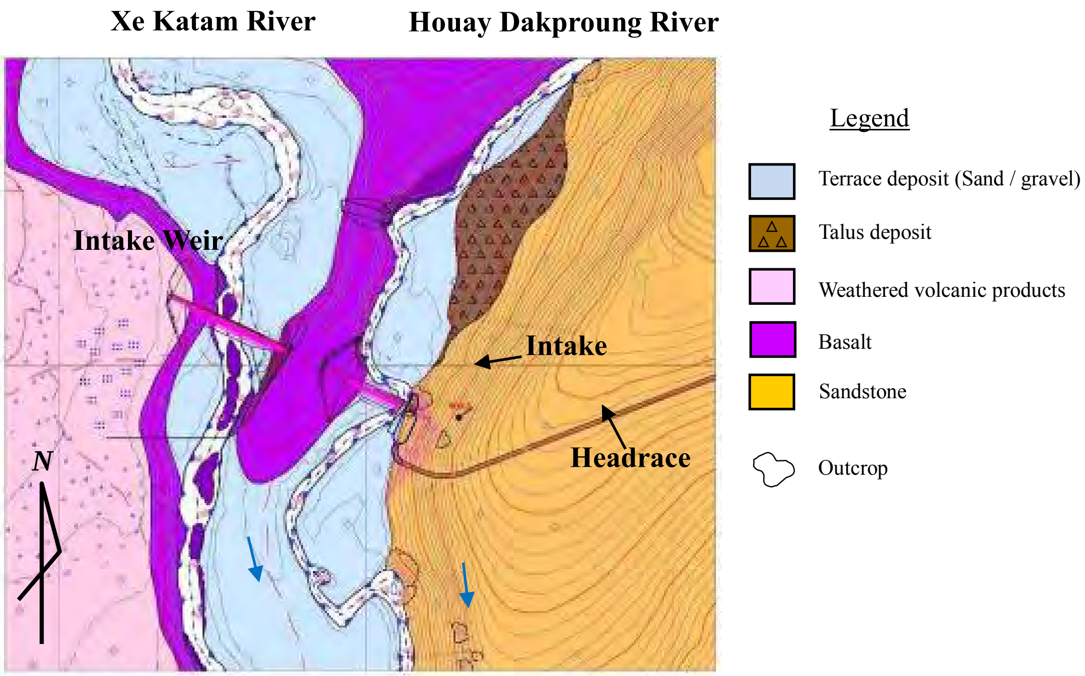


Figure 3.2-20 Geological Distributions around Intake Weirs

(b) Geotechnical Evaluation

1) At the location of the weir on the Xe Katam River, basaltic lavas are exposed, thus the adequate foundation rocks will be obtained in shallow excavation of 1.0-1.5m deep on the riverbed.

2) At the locations of the weir on the Dakproung River and the settling basin, sandstone boulders 1-3 m in diameter are accumulated on the riverbed and the bedrocks cannot be confirmed. To sum up, additional drillings are required to explore the firm rocks on the foundation of structures and for the gradient of cut-slope above the intake.

(8) Headrace and Head tank

(a) Topography and Geology

i) Headrace

The mountain ridge where the headrace tunnel goes through has low undulation (EL. 800-850m) but gradually declines up to the head tank.

According to two (2) drillings, WB-1 and WB-3, at the points of low overburden and one (1) line of seismic prospecting extended from the head tank on the tunnel route, the geological compositions of the headrace tunnel consist of sedimentary rocks belonging to Champa Fm. The strength of fresh sandstone section is expected to be 70MPa of UCS. The sedimentary sequence cumulates horizontally and relatively dense joints which cross bedding planes develop in the bedrocks

A geological profile along the lowest overburden section through the head tank based on seismic profile and WB-3 drilling is indicated in Figure 3.2-21.

1) The mountain reaches at top (EL.865m) 2km from the intake, and decrease elevation of the ridge gradually from the top. The lowest overburden corresponds to the saddle located at approx. 750m behind the head tank, and the saddle section of overburden down to the crest of the tunnel below 20m thick is a succession of approx. 250m.

2) According to rock conditions at WB-1, the tunnel sections in which the thickness of overburden down to the tunnel crest is under 30m generally consists of thin sub soil (less than 10m in depth) and thick sound rocks corresponding to CM-CH class in the ridges.

3) In the lowest overburden section, decomposed rocks corresponding to D class continue down to 24.8m deep at WB-3 drilling, thus it is suspected that these D class rocks will appear on the tunnel continuously in the lowest overburden section of approx. 240m.

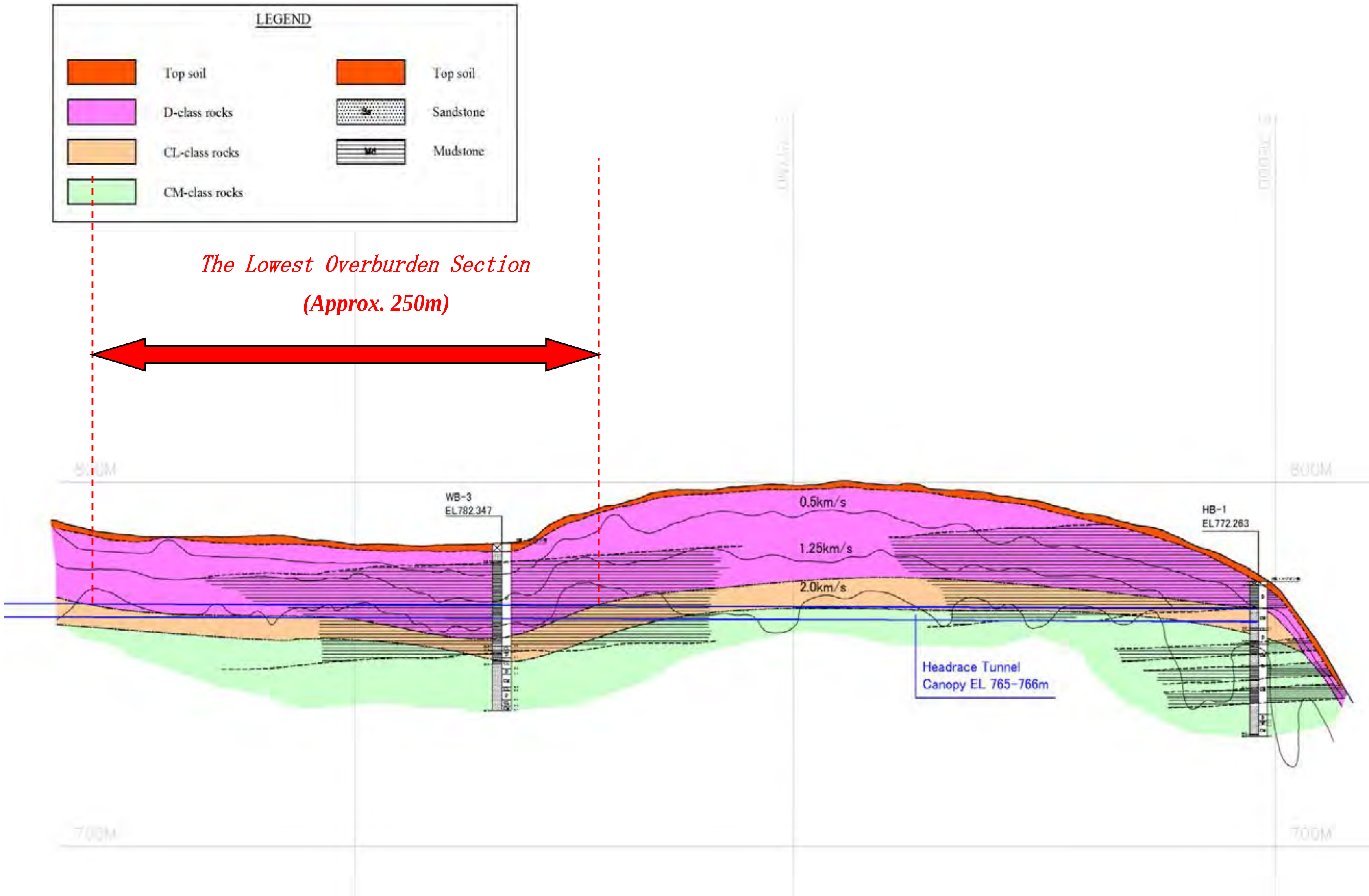


Figure 3.2-21 Geological Profile along Headrace Tunnel from the Saddle to the Head Tank

ii) Head tank

The headrace connects the head tank at the end of the mountain ridge. Figure 3.2-22 shows the geological conditions at the head tank according to the drilling result at HB-1. The CM class rocks of alternation of strata compose the underground beneath EL.755m.

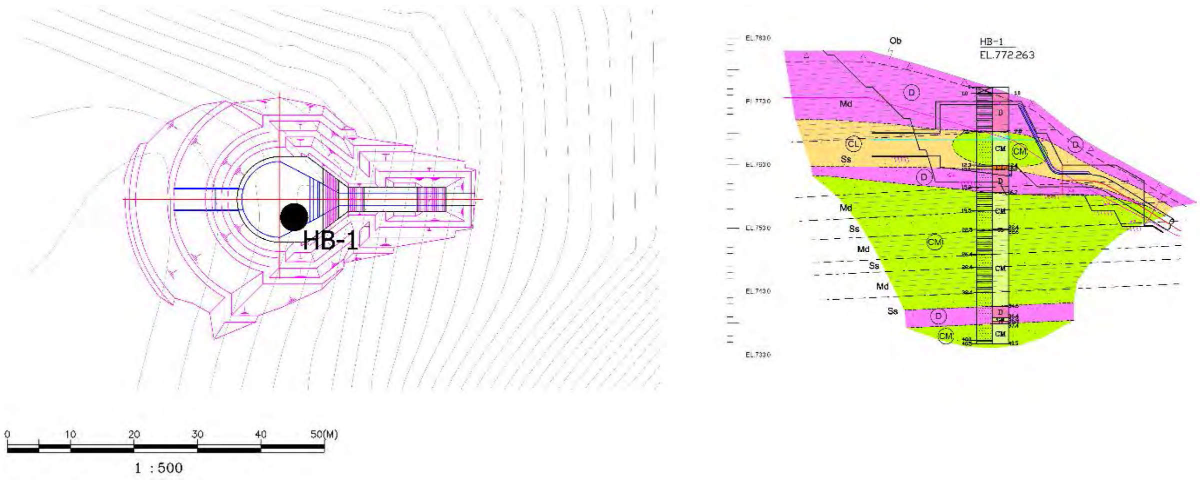


Figure 3.2-22 Geological Profile at Head Tank

(b) Geotechnical Evaluation

i) Headrace

According to rock conditions at WB-1, the tunnel sections in which the thickness of overburden down to the tunnel crest is under 30m generally consists of thin sub soil (less than 10m in depth) and thick sound rocks corresponding to CM-CH class in the ridges. The unpredictable spring which disturbs the excavation works or the erecting tunnel supports will not occur because the overburden is under 80m thick in these sections.

In the lowest overburden section, decomposed rocks corresponding to D class will appear the whole area on the tunnel faces in accordance with the result of WB-3 drilling. If the UCS (σc) of these rocks is 10 MPa and the unit weight (γ) of the overburden is 2.0 tf/cm^3, the competence factors (Fc: $\sigma c / \gamma H$, H (m) is the depth down to the tunnel canopy) in the section range from 2.5 - 3.1 which indicate somewhat unstable. The supporting program in the D – CL anticipated sections shall be chosen subsequently to advanced drillings.

ii) Head tank

The CM class rocks of alternation of strata compose the underground beneath EL. 765m. The head tank base shall be placed on the surface of CM class rocks. According to the seismic prospecting profile, the hard rock surface seems to horizontally extend, thus D or CL class rocks will be exposed on the cut-slope behind the head tank. Suitable slope protections against such a low graded rock are required.

(9) Penstock

(a) Topography and Geology

Figure 3.2-23 shows the geological profile along the penstock route based on four (4) drillings (PB-1, PB-2, PB-3 and P-1) and two (2) lines of seismic prospecting. The topographic / geological conditions on each section between anchor blocks of the penstock are mentioned as follows:

1) The Section between IP.1 and IP.3 (EL.615-757.4m)

The slope just under the head tank makes a series of scarp steeper than 45° inclination. Also outcrops of hard sandstone are scattered on the slope. Therefore, residual soil or talus deposits are 3m thick at most in this section.

2) The Section between IP.3 and IP.4 (EL.523-615m)

The slope of this section is a gentler gradient (30-40°) than the upper section and the low velocity zone (<1.25 km/s) gradually thickens downward on the slope. The lower limit of the zone is 20m deep at IP.4 anchor block. There are no drillings in this section.

3) The Section between IP.4 and IP.6 (EL.462-523m)

The enlarged profile of this section is shown in Figure 3.2-24. This section presents gentle landscape (less than 20° inclination), and a national highway passes across the section. Deep weathering drops to 40m deep at the points of PB-1 and P-1 although the lower limit of less than 1.25km/s is in the range from 15 to 20m in depth. Judging from the appearances of the drilling cores, the low velocity zone seems to be talus deposits. N-values range from 10 to 13 down to 3m in depth at P-1, but weathered soil deeper than 10m in depth has enough solidity because SPT ensures an N-value of more than 50.At the point of PB-3 drilling, volcanic breccia and auto-brecciated basalt (both layers are heavily weathered) underlies down to 20m deep and fresh basalt rocks appear at the deeper portion. The layer of volcanic breccia has various N-values (the range: 12-53, Ave: 29) regardless of the depth.

4) The Section between IP.6 and IP.8 (EL.348-462m)

The slope between IP.6 and IP.7 inclines with approx. 20° and the low seismic velocity zone (<1.25 km/s) deepens to 20m in depth. The slope just under IP.7 anchor block makes a series of scarp steeper than 45° inclination and outcrops of basaltic lava are scattered on the upper part of the slope. However, the low seismic velocity zone thickens on the lower part of the slope below EL.390m and the lower limit of the zone deepens down to 20m in depth at IP.8 anchor block.

5) The Section between IP.8 and the Powerhouse (EL.329-297m)

This section shows a very gentle slope less than 10° inclination. Many boulders larger than 1m in diameter are scattered on the slope. A series of scarp which fronts on the Xe Namnoy River has a 15-20m height above the river and exposes continuous outcrops of hard sandstone at the powerhouse site planned at the upstream. According to the drilling log of PB-4, the lower limit of 1.25km/s seismic velocity roughly corresponds to the rock surface of sandstone. Therefore, the assumed boundary between rocks and overburdens horizontally expands over this section.
According to a test pit PTP-1, soft volcanic brecciate layer appears 3.0-5.0m in depth. The bottom of this layer has not been immediately confirmed yet, but it seems to be corresponded with 1.25km/s of the seismic velocity. If it’s correct, the volcanic brecciate which consists of D class rock deepens down to 30m below ground surface.

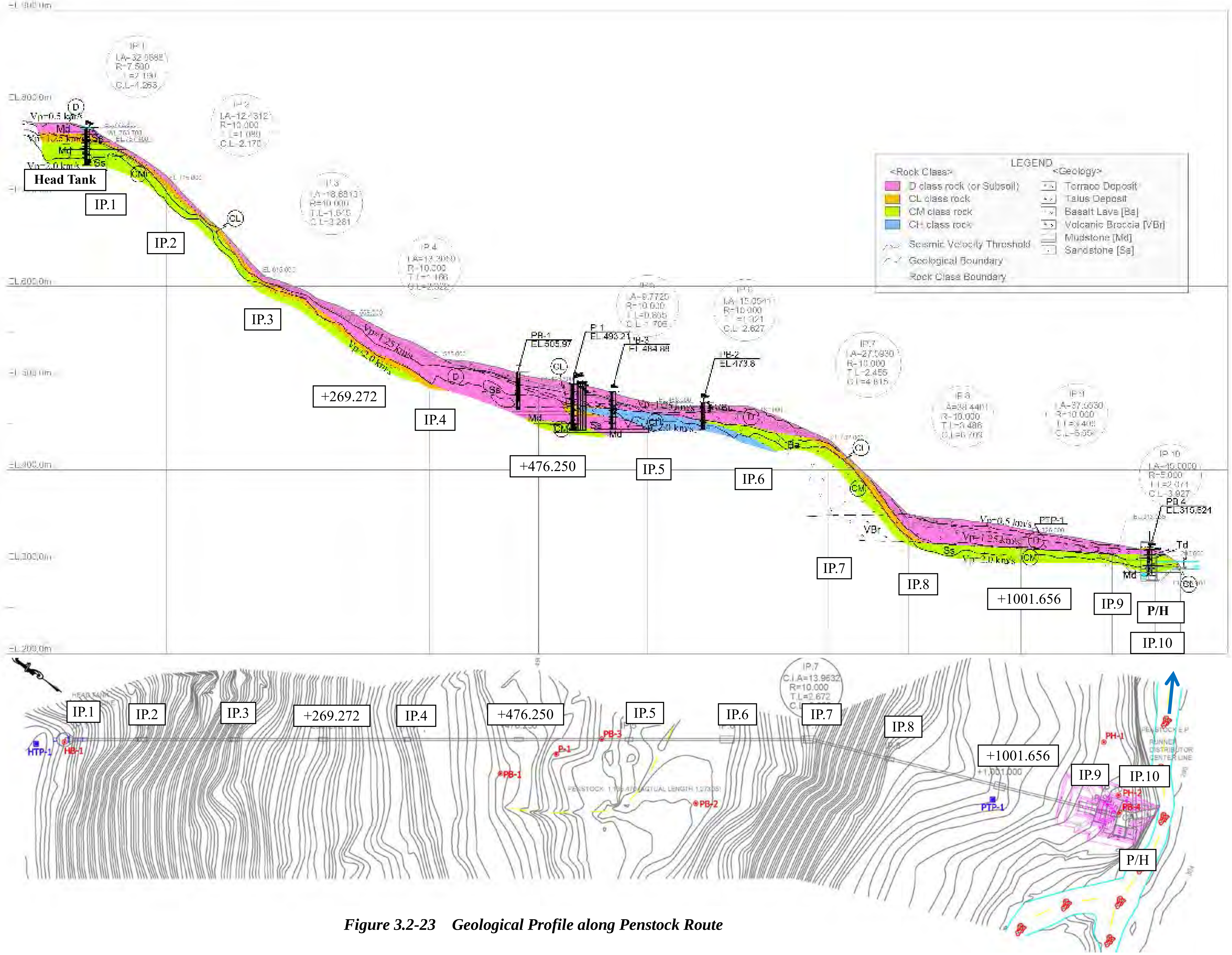


Figure 3.2-23   Geological Profile along Penstock Route

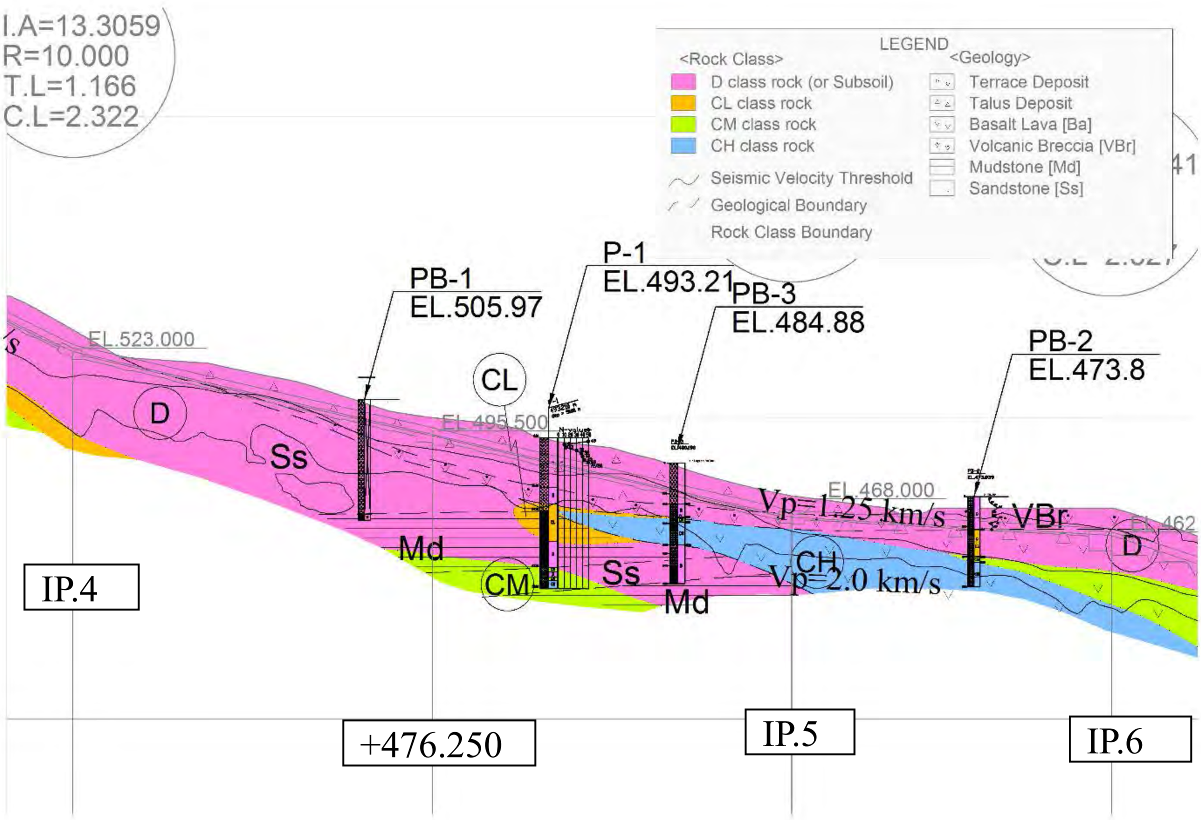


Figure 3.2-24 Geological Profile between IP.4 and IP.6 Anchor Block

(b) Geotechnical Evaluation

This report mentions ground stability evaluation of each anchor block (IP.1 – IP.9).

It is considered that water gushing will occur 10m in depth of excavation wherever blocks are placed on talus deposits, volcanic breccia and weathered basalt.

1) IP.1

The ground at the designed foundation level will be capable to bear the anchor block because CL-CM class sandstone will appear at shallow portions in accordance with HB-1 drilling and the seismic velocity profile.

2) IP.2

The block is planned on the mid of the steep slope. The ground at the designed foundation level will be capable to bear anchor block because some outcrops of CL-CM class sandstone exist and the seismic velocity profile indicates thin overburden on the slope.

3) IP.3

The block is planned on the foot of the steep slope. The designed block foundation stays within lower seismic velocity zone than 1.25km/s. However, the thickness of residual soil at the location seems to be thinner 10m, thus the excavation is preferable to deepen to the top of CL class rocks

4) Block at +266.272m

The designed block foundation stays at 1.25km/s of seismic velocity. Sound rocks, CL and CM class rocks corresponding to 2.0km/s or more of seismic velocity underlie deeper 10m from the foundation level, hence it would be difficult to place anchor block on CL class rock. The execution of an exploratory drilling including standard penetration tests is preferable on taking into consideration placing anchor block on D class rocks or talus deposits in advance.

5) IP.4

At the location, the lower seismic velocity zone than 1.25 km/s deepens down to 20m in depth, and spread foundation on CL class rocks will be unrealizable. The execution of an exploratory drilling including standard penetration tests is preferable on taking into consideration placing anchor block on D class rocks or talus deposits in advance.

6) Block at +476.250m

Deep weathering corresponding to D class rock deepens down to 40m in depth according to the drilling results at PB-1 and P-1. At the location, deep foundation on CL class rocks is unrealizable on the viewpoint of construction cost. Talus deposits are composed down to 16m in depth at the hole of P-1, but N value exceeds 30 at 3.0m in depth or deeper portions. If the ground which has bearing capacity corresponding to N=30 can bear an anchor block, spread foundation will be adopted at the designed elevation. If the foundation is conservatively designed on the ground which has enough large bearing capacity corresponding to over 50 of N value or D class rocks beneath talus deposits, piles should be installed from the design elevation down to 10m in the maximum depth.

7) IP.5

PB-2 and PB-3 drilling uncover that CM-CH class of basalt rocks underlie at EL. 453-462m around the anchor block site. The block foundation is preferable to be placed directly on the hard basalt.

8) IP.6

At the location, the lower seismic velocity zone than 1.25 km/s deepens down to 20m in depth, and spread foundation on CL class rocks will be unrealizable. According to PB-2 drilling, the designed block foundation stays in the volcanic breccia layer. There is somewhat concern the reason why the volcanic breccia has various N-values (the range: 12-53, Ave: 29) regardless of the depth within 11m in depth. However, there has still been possibility that auto-brecciated basalt which has sufficient bearing capacity would appears at shallow portions. The execution of an exploratory drilling including standard penetration tests is preferable in advance.

9) IP.7

Some basalt rocks are exposed on the top of the steep slope around the anchor block site. It is highly expected that the anchor block will be placed directly on CL-CM class rocks at the designed elevation.

10) IP.8

The block is planned on the foot of the steep slope. The lower seismic velocity zone than 1.25 km/s deepens down to 25m in the maximum depth, thus the block foundation will be not able to gain CL class rock or more at the location. The execution of an exploratory drilling including standard penetration tests is preferable in order to design foundation method and its depth.

11) Block at ＋1001.656m

The block is planned on the gentler slope than 10º, and the lower seismic velocity zone than 1.25 km/s deepens down to 20m in the maximum depth. The foundation design should be considered on the assumption that the foundation ground will be D class rocks or deposits to avoid excessive excavation.

12) IP.9

The block is planned on the gentler slope than 10º, and the lower seismic velocity zone than 1.25 km/s deepens down to 20m in the maximum depth. The foundation design should be considered on the assumption that the foundation ground will be D class rocks or deposits to avoid excessive excavation.

(10) Powerhouse

(a) Topography and Geology

The powerhouse site is planned on end of the gentle slope of the left bank of the Xe Namnoy River just downstream from the confluence joining the Xe Katam River. Three (3) drillings (PH-1, PH-2 and PB-4) were conducted. On the downstream area from the powerhouse site, talus deposits accumulate thicker than the upstream area and slope collapses occur in rainy season.

Continuous outcrops of hard sandstone (mainly CM-CH class) are exposed around the powerhouse site. According to the drilling log of PB-4 (the ground level: EL.315.624m), terrace deposits cover the hard sandstone at 6m in depth.

(b) Geotechnical Evaluation

1) The powerhouse and the tailrace will be placed on the sound sandstone rocks (CM class or more) within 10m excavation in depth.
2) Some seepage holes are formed at boundary between terrace deposits and sandstone in rainy season, thus the Contractor shall pay attention to risks that the seepage will bring instability on cut-slopes and flood the bottom of excavation.

3.3 Hydrological Analysis

The Xe Katam River originates in Bolaven Plateau and has a catchment area of 263 km^2 at the intake weirs. It flows toward southeast of plateau and finally into the Xenamnoy River, which stretches across the southeastern part of Bolaven Plateau. The Xenamnoy River turns eastward and flows into the Sekong River, a tributary of the Mekong River. Xe Katam site is located at the hill of Bolaven Plateau. Topography of the site significantly varies at the edge of the plateau with a steep and large vertical drop.

Purposes of hydrological analysis are to clarify design conditions of reservoir operation plan, power generation plan and structural design. Main components of hydrological analysis are;

- Collection of hydrological data
- Estimation of long-term sequence of daily inflow at intake points: low flow analysis
- Estimation of probable flood discharge and probable maximum flood: flood analysis
- Estimation of reservoir sedimentation
- Estimation of reservoir evaporation

Outline of hydrological analysis is shown in Table 3.3-1.

Table 3.3-1 Outline of Hydrological Analysis

Item	Methodology			Hydrological Data	Verification	Result
Low Flow Analysis	(1)	Basin Mean Rainfall	Correlation	Nikhon Nong Mek	Comparison of the runoff coefficient and specific discharge with other projects	(2) of the smallest discharge is selected
		Runoff Analysis (Discharge Estimation)	Tank Model	Nikhon Nong Mek		
	(2)	Discharge Estimation	Basin Area Ratio	Xe Set Nong Mek		
Flood Analysis	(1)	Rainfall Analysis (PMF)	Hershfield Method	Nikhon Nong Mek	Comparison of specific discharge with surrounding basins	(1) is judged as reasonable one.
		Rainfall Analysis (Statistic Rainfall)	Statistic Analysis	Nikhon Nong Mek		
		Hyetograph	Estimation from the existing rainfall data	Nong Mek		
		Runoff Analysis (Discharge Estimation)	Unit Graph Method	—		
Reservoir Sedimentation	(1)	Specific Sedimentation	Estimation based on the JICA F/S	Neighboring projects data (No observation data in the Xe Katam River)	-	The maximum value of neighboring projects is selected
Reservoir Evaporation	(1)	Annual Evaporation	Estimation based on the record of neighboring stations	Nikhon Pakse	Verification considering the difference of the elevation	The data of both stations are evaluated and determined

3.3.1 Hydrological Data Collection

(1) Hydrological Data surrounding Xe Katam Site

Location of the hydrological gauging stations surrounding Xe Katam site are shown in Figure 3.3-1.

There are three (3) rainfall gauging stations and two (2) discharge gauging stations in Xe Katam basin. There are also six (6) rainfall stations and two (2) discharge gauging stations in the surrounding area.

Regarding Xe Katam basin, Thongvay and Xe Katam rainfall gauging stations and Nong Hin discharge station had been installed by the JICA investigation team and been operated during 1991 - 1994 (Rainfall stations had been operated only 1991 - 1992). Nong Mek rainfall and discharge station has been installed and operated by KANSAI since August 2004.

Regarding the surrounding area, six (6) rainfall stations, Lak km42, Pakxong, Nong Hin, Nikhon km34, Houaykong and Attapeu has been operated by DMH – MONRE. Two (2) discharge stations, Xe Set and Attapeu has been operated. Although hydrological data in Xe Katam basin is observed in limited term, it can be obtained in long term at these stations in the surrounding area.

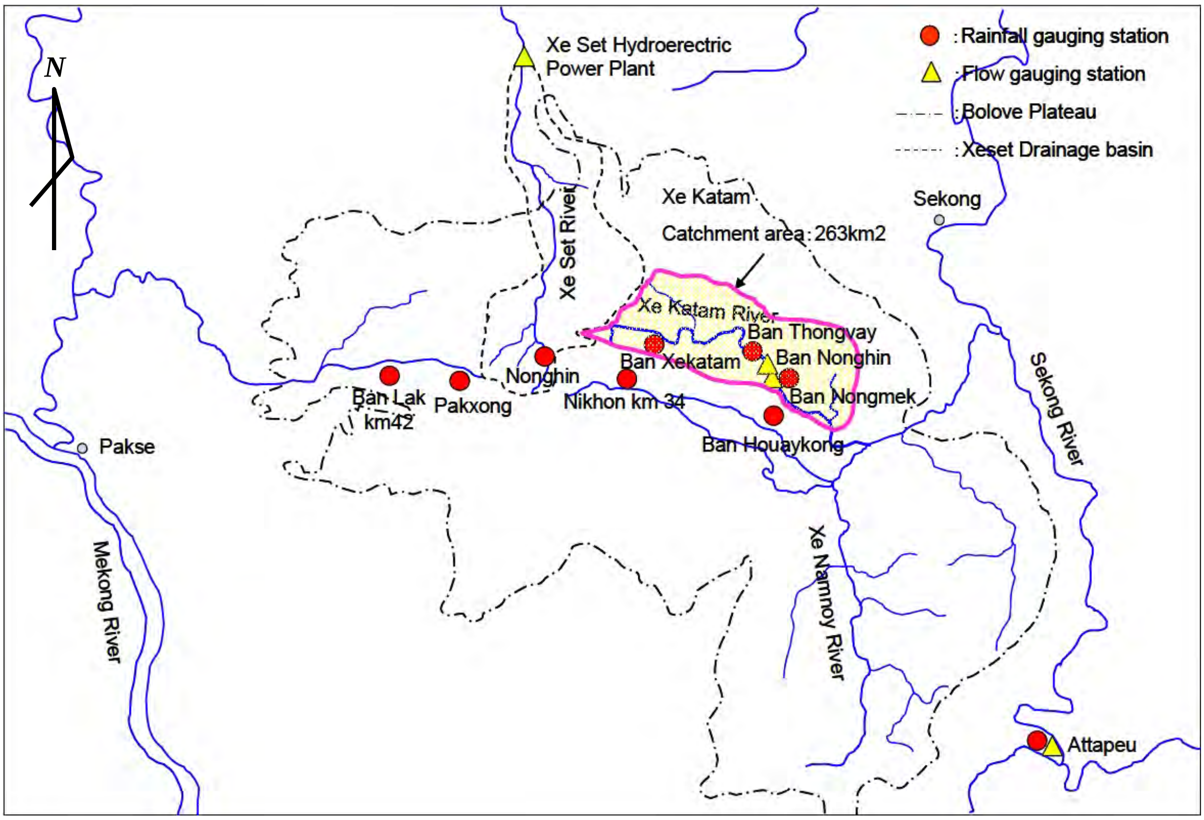


Figure 3.3-1 Hydrological Gauging Stations surrounding Xe Katam Site

In this study, hydrological data from 2008 – 2012 is newly collected to update and revise existing hydrological analysis. List of additional data from DMH and EDL is shown in Table 3.3-2. Summary of hydrological data collection at Xe Katam is shown in Table 3.3-3.

Table 3.3-2 Additional Hydrological Data

Item	Station Name	Type	Period	Availability	Remark
DMH – MONRE					
Precipitation	Lak km 42	daily	2008 - 2012	Not Available	Gauging station was closed in 2004.
	Pakxong	daily	2008 - 2012	Collected	
	Nong Hin	daily	2008 - 2012	Not Available	Gauging station was closed in 2007.
	Nikhon km 34	daily	2008 - 2012	Collected	
	Attapeu	daily	2008 - 2012	Collected	
Evaporation	Nikhon km 34	monthly	1979 - 2012		As observed data has problem in accuracy, it is not suitable for analysis.
	Pakse	monthly	1979 - 2012	Collected	
EDL					
Discharge	Xe Set 1	monthly	2008 - 2012	Collected	Xe Set 2 hydropower station has been commissioned since 2009 at the upstream of Xe Set 1. Therefore inflow of Xe Set 1 has been controlled by Xe Set 2 reservoir operation since then.

Table 3.3-3 Summary of Hydrological Data Collection

No	station	frequency	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	Ban Lak km 42	daily	-	-	-	-	-	-	-	-	○	○	○	○	○	○	○	○	○	○
2	Pakxong	daily	○	○	-	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○
3	Nonghin	daily	-	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○
4	Nikhon km 34	daily	-	-	-	-	-	-	-	-	-	-	○	○	○	○	○	○	○	○
5	Attapeu	daily	-	-	-	-	-	-	○	○	-	○	○	○	○	○	○	○	○	○
6	Ban Xekatam	daily													○	○ (92:monthly)				
7	Ban Thongvay	daily													○	△ (92:monthly)				
8	Ban Houaykong	daily													△	○ (92:monthly)				
9	Ban Nongmek	hourly																		
(observed discharge)																				
1	XeSet 1	monthly							○	○	-	-	○	○	○	○	○	○	○	○
2	Attapeu	daily							○	○	○	○	○	○	○	△	○	○	○	○
3	Ban Nonghin	daily													△	△	○	○		
4	Ban Nongmek	daily																		

No	station	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	Reference
1	Ban Lak km 42	○	○	○	○	○	○	○	○	-	-	-	-	-	-	-	-	-	-	Closed in 2005
2	Pakxong	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○			
3	Nonghin	○	○	○	○	○	○	○	○	○	○	○	-	-	-	-	-	-	-	Closed in 2008
4	Nikhon km 34	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○			
5	Attapeu	○	○	–	○	○	○	○	○	○	○	○	○	○	○	○	○			
6	Ban Xekatam																			
7	Ban Thongvay																			
8	Ban Houaykong																			
9	Ban Nongmek								△	○	○	○	○	○	○	△	○	○	○	Some observation data is missing.
(observed discharge)																				
1	XeSet 1	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△			
2	Attapeu	○	○	○	○	○	○	○	○	-	-	-	-	-	–	–	–	-	-	
3	Ban Nonghin																			
4	Ban Nongmek								△	○	○	○	○	○	○	△	○	○	○	Some observation data is missing.

○ : all date available △ : partially available ▭ Collected at this study

(2) Hydrological Observation at Nong Mek

As mentioned above, KANSAI has continued to implement hydrological observation such as rainfall gauging, water level gauging and discharge measurement at Nong Mek since 2004. Rainfall is recorded hourly by the tipping bucket type rain gauge. Water level is recorded twice in a day by automatic recording water gage. Discharge is measured at least twice in a month in dry season and several times in rainy season by current meters.

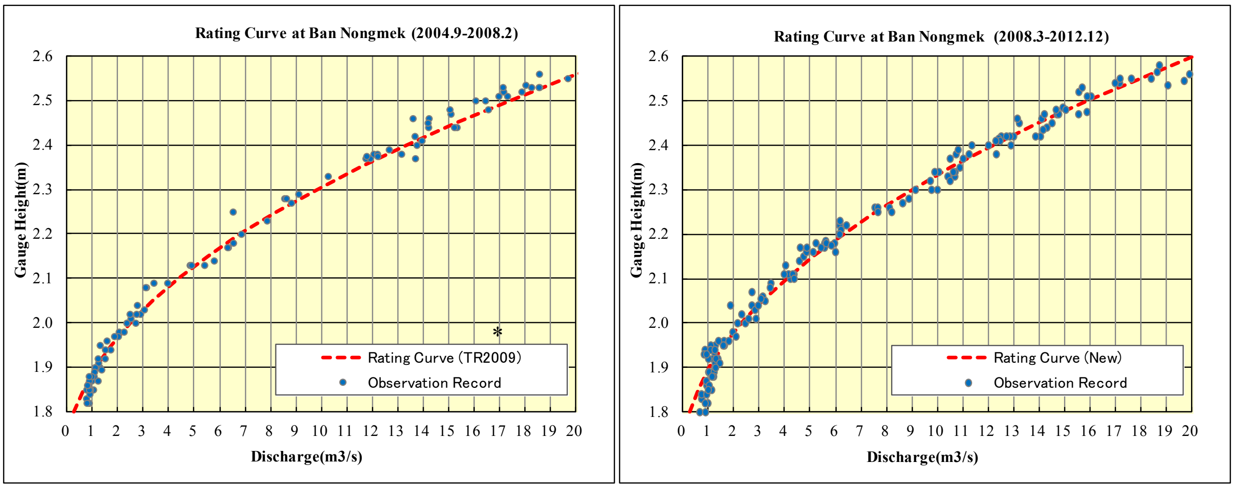
Monthly rainfall data at Nong Mek is shown in Table 3.3-4. Average annual rainfall from 2004 to 2012 is 2,222mm.

Figure 3.3-2 Water Level and Rainfall Gauging Station at Nong Mek

Table 3.3-4 Monthly Rainfall Data at Nong Mek

(Uni; mm)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	316.5	208.0	8.5	0.0	0.0	-
2005	0.0	0.0	47.0	116.5	262.5	328.5	615.5	760.5	436.0	30.5	21.5	102.5	2,721
2006	0.0	26.5	69.0	157.5	308.0	186.5	487.0	328.5	267.5	154.0	40.5	3.0	2,028
2007	0.5	1.0	118.0	111.0	174.5	337.5	586.0	319.0	316.0	304.0	24.0	0.0	2,291
2008	0.5	3.0	2.0	0.0	306.0	165.0	392.5	601.0	504.5	213.0	24.0	0.0	2,212
2009	0.0	30.0	43.5	205.5	291.0	186.0	649.5	419.5	375.5	170.5	34.0	3.0	2,242
2010	4.5	50.0	0.0	156.0	132.0	314.5	415.0	535.0	246.0	153.0	3.5	0.0	2,010
2011	0.0	6.0	0.0	0.0	168.5	226.5	399.5	332.5	451.0	277.5	15.0	0.0	1,877
2012	27.0	27.5	61.5	87.5	362.0	268.0	458.0	509.5	529.0	58.5	5.0	0.0	2,394
Ave	3.0	14.0	34.0	83.0	200.0	201.0	400.0	412.0	333.0	120.0	17.0	11.0	**2,222**



*:Technical Report, KANSAI 2009

Figure 3.3-3 H - Q Rating Curve at Nong Mek

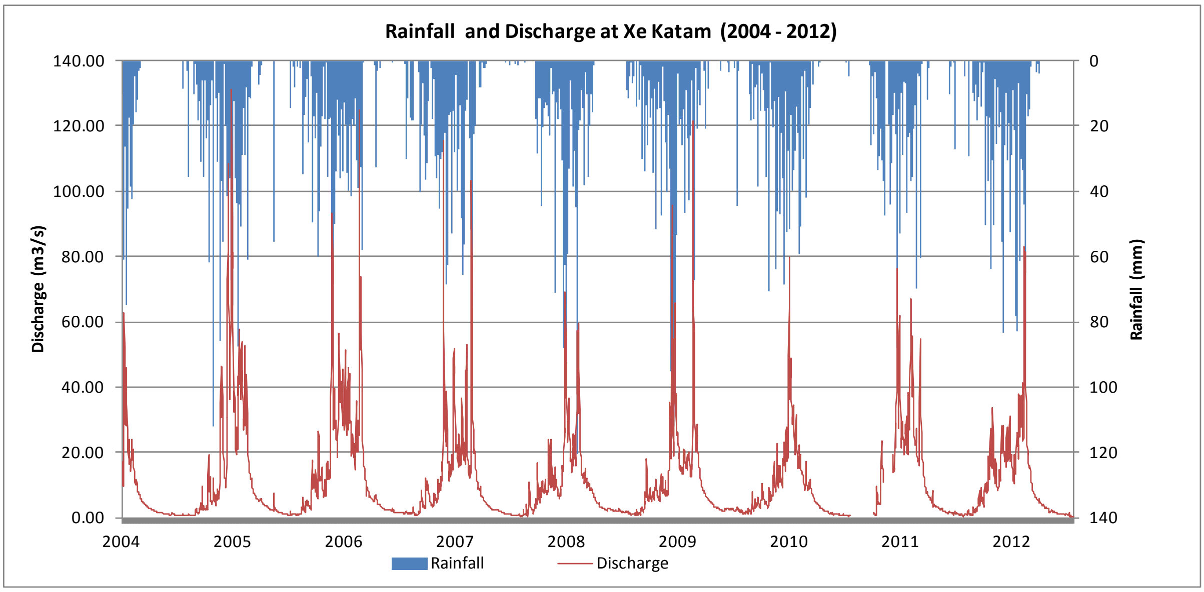


Figure 3.3-4 Daily Records of Rainfall and Discharge at Nong Mek (2004 – 2012)

To estimate daily discharge from water level records, H - Q rating curves are calculated from observed records of water level and discharge at Nong Mek. H - Q curve graphs are shown in Figure 3.3-3. As a result, daily records of rainfall and discharge at Nong Mek is shown in Figure 3.3-4.

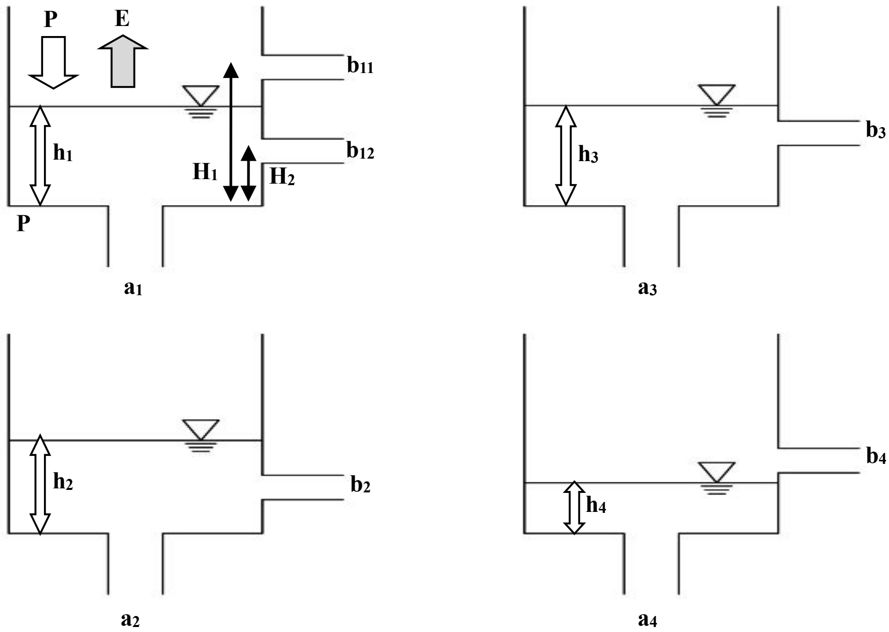
In addition, a global climate change with the warming is assumed in the long term, and the increase of the flood scale and increase of frequency of the drought are predicted about as qualitative influence on hydrology data. But we consider that the above phenomena falls within enough design scope and the range of the assumption risk.

3.3.2 Low Flow Analysis

There is no long term hydrological data in Xe Katam basin. However it can be obtained in the surrounding area as mentioned in Section 3.3.1. To complement discharge data during the absent period of observation in Xe Katam basin, low flow analysis by following methods is implemented with these long term hydrological data in the surrounding area.

(1) Tank Model

Based on the long term rainfall data and observed discharge data, Tank Model analysis is implemented. Tank Model is a kind of runoff analysis and is often used for low flow estimation. Basic concept of this model is to set series of tanks (normally four (4) tanks) with several outlets and to calculate inflow and runoff by each tank. Rainfall is given as an input inflow for the first tank. First tank outputs a1 (inflow to second tank), b11 and b22 (runoff). This cycle repeats until the lowest tank and summary of runoff is finally calculated as the discharge to outflow. Basic concept of Tank Model is shown in Figure 3.3-5.



Concept of Tank Model

$P + h - E < H$: $Qinf = a(P + h - E)$, $Qrun\text{-}off = 0$
$P + h - E > H$: $Qinf = a(P + h - E)$, $Qrun\text{-}off = b(P + h - E - H)$

Where,
P : Precipitation / Supply entering tank
E : Evaporation
H : Height of side outlet above the bottom on the tank
h : Previous water depth of the tank
a, b : Coefficient of each outlet

Figure 3.3-5 Basic Concept of Tank Model

Coefficients of outlets of each tank are determined by the trial-and-error method considering the balance between estimated values and observed records.

(a) Basin Mean Rainfall

Observed Rainfall in Xe Katam basin are;

- Averaged monthly record at Xe Katam and Thongvay from 1991 to 1992
- Daily record at Nong Mek from 2004 to 2014.

In addition, some long term rainfall records are available in the surrounding area. To check the applicability of the rain fall records in the surrounding area to complement rainfall records during the absent period, correlation between them are calculated as shown in Figure 3.3-6. As results, correlation coefficient of over 0.7 is obtained at each site.

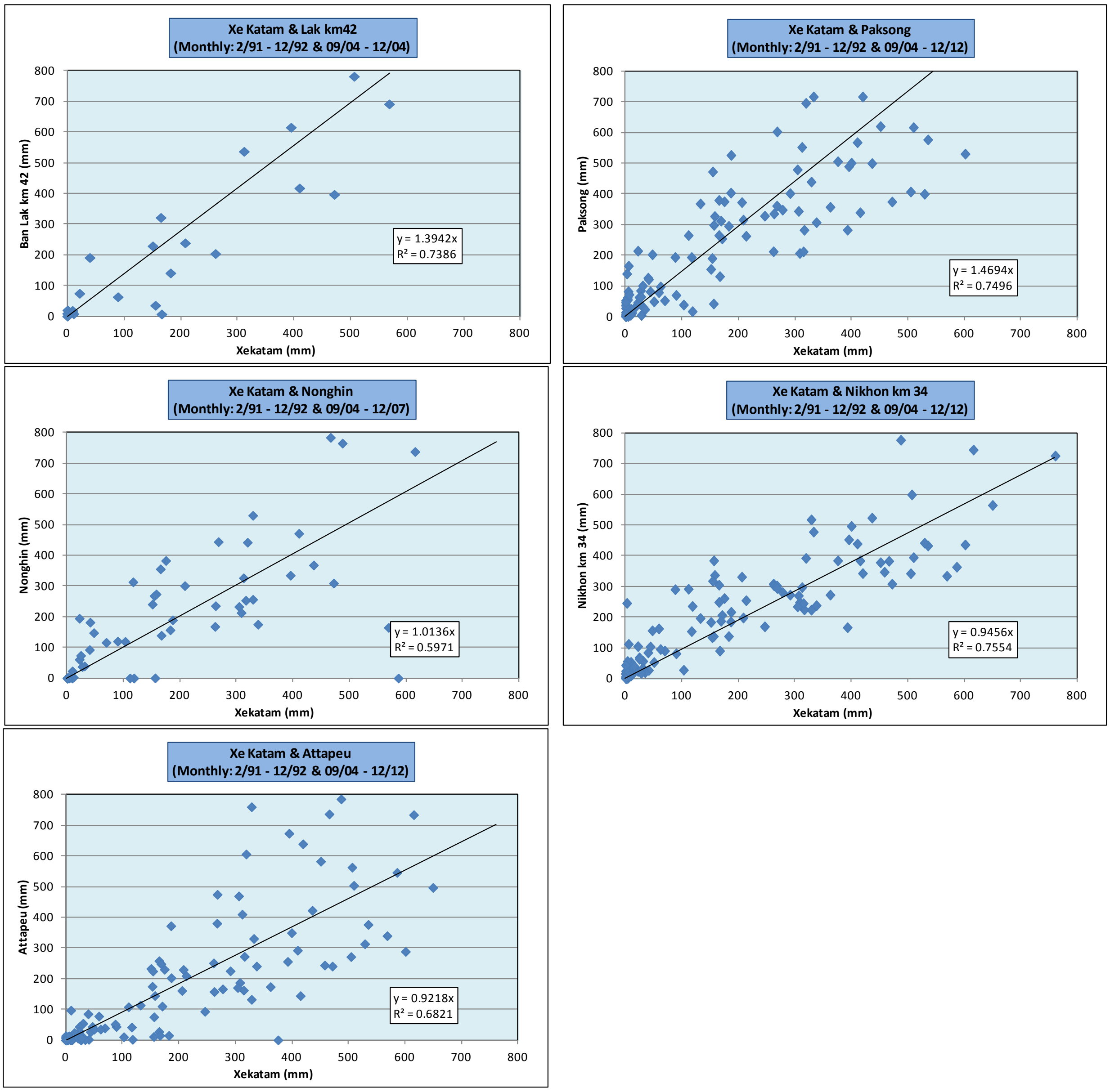


Figure 3.3-6 Correlation of Monthly Rainfall with Xe Katam

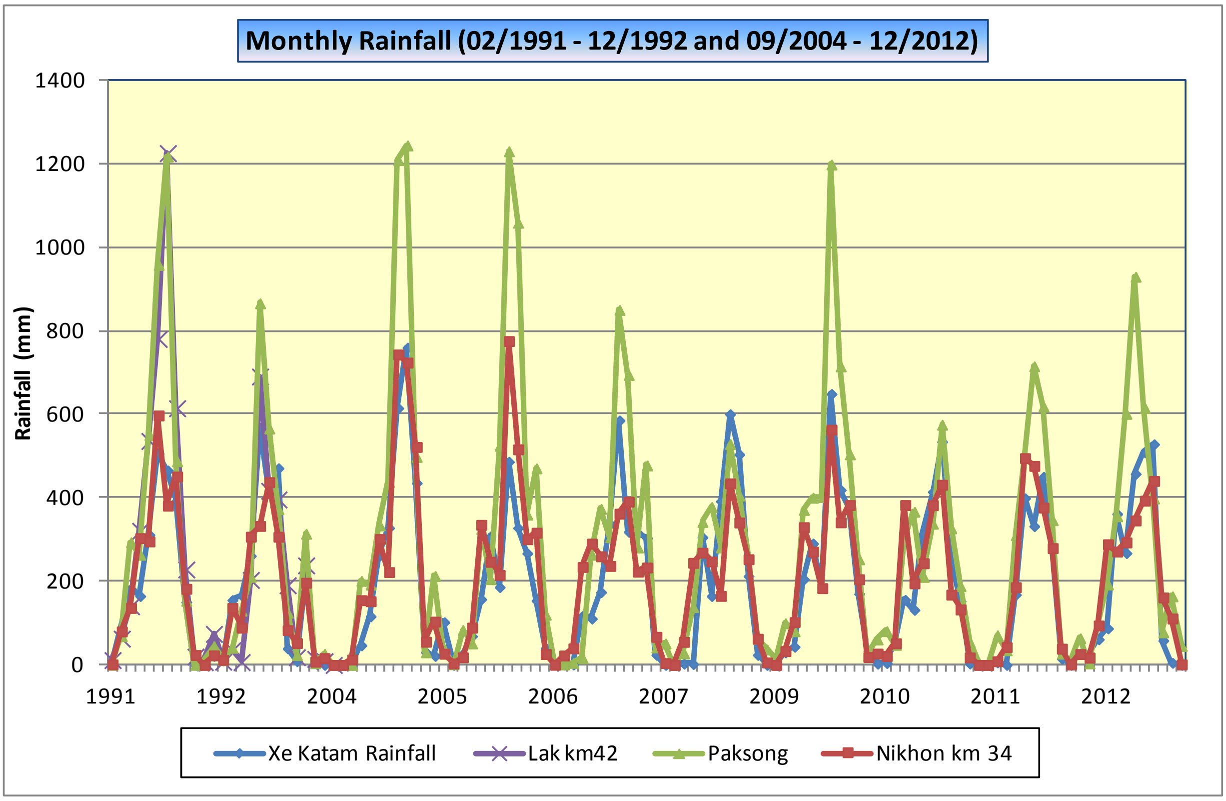


Figure 3.3-7 Monthly Rainfall Record (02/1991 – 12/1992 and 09/2004 – 12/2012)

Three observation stations Lak km42 (1987 - 2004), Pakxong (1979 - 2012) and Nikhon km 34 (1989 - 2012), which have the particularly strong correlation with Xe Katam are selected for candidates of the data completion. Monthly rainfall record (02/1991 – 12/1992 and 09/2004 – 12/2012) is shown in Figure 3.3-7. Consequently, Nikhon km 34 is selected for the alternative rainfall record during the absent period of Xe Katam because it is located adjacent to Xe Katam basin and has long term records with the strongest correlation.

Estimated basin mean rainfall is shown in Table 3.3-5. Basin mean annual rainfall for 23 years from 1989 to 2012 is estimated as 2,474 mm/year. It is smaller than 2,522 mm/year estimated in TR2009 (Technical Report, KANSAI 2009).

Table 3.3-5 Basin Mean Rainfall 1989-2012

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1989	18.6	0.0	405.6	278.1	393.4	182.2	369.2	310.1	241.6	72.9	0.0	10.0	2,282
1990	7.0	35.6	186.9	108.3	257.7	306.2	357.4	374.6	314.4	297.3	84.9	0.0	2,330
1991	55.9	4.0	89.3	182.3	165.0	312.0	506.5	466.0	395.0	150.8	0.3	1.3	2,328
1992	24.3	14.8	144.5	94.4	325.1	352.4	463.3	678.0	325.0	88.2	28.1	55.5	2,594
1993	0.0	18.9	118.4	116.0	395.1	248.8	474.5	382.4	483.7	45.1	1.2	6.8	2,291
1994	0.0	56.5	189.2	369.0	332.9	205.5	789.6	297.3	460.4	198.1	10.5	0.0	2,909
1995	8.7	13.3	265.4	97.3	384.8	227.2	595.3	398.1	206.7	142.7	29.6	18.1	2,387
1996	441.5	354.6	267.1	283.4	323.8	332.4	213.8	230.6	344.1	258.2	214.9	172.4	3,437
1997	62.4	7.4	151.2	520.3	463.2	282.4	607.0	603.8	354.3	171.3	81.4	11.6	3,316
1998	0.0	15.4	3.4	24.2	88.2	53.5	44.0	89.5	82.2	44.7	38.3	0.7	484
1999	47.6	10.6	140.7	261.2	527.7	471.7	700.1	591.2	469.5	356.4	58.2	1.1	3,636
2000	28.6	70.9	66.6	162.9	232.7	328.9	698.0	189.3	268.6	103.6	38.1	0.0	2,188
2001	44.4	46.5	114.2	313.0	320.4	404.0	410.3	606.0	446.3	195.6	29.6	0.0	2,930
2002	1.2	12.6	65.1	115.2	325.2	422.9	518.2	648.3	312.6	154.1	52.9	45.5	2,674
2003	0.4	104.6	150.4	324.9	372.4	193.6	445.7	490.6	412.5	90.4	18.4	0.0	2,604
2004	10.0	10.3	134.5	360.8	179.1	447.8	422.8	494.0	208.0	8.5	0.0	0.0	2,276
2005	0.0	0.0	47.0	116.5	262.5	328.5	615.5	760.5	436.0	30.5	21.5	102.5	2,721
2006	0.0	26.5	69.0	157.5	308.0	186.5	487.0	328.5	267.5	154.0	40.5	3.0	2,028
2007	0.5	1.0	118.0	111.0	174.5	337.5	586.0	319.0	316.0	304.0	24.0	0.0	2,292
2008	0.5	3.0	2.0	211.0	306.0	165.0	392.5	601.0	504.5	213.0	24.0	0.0	2,422
2009	0.0	30.0	43.5	205.5	291.0	186.0	649.5	419.5	375.5	170.5	34.0	3.0	2,408
2010	4.5	50.0	11.2	156.0	132.0	314.5	415.0	535.0	246.0	153.0	3.5	0.0	2,021
2011	0.0	6.0	0.0	354.1	168.5	431.6	399.5	332.5	451.0	277.5	15.0	0.0	2,436
2012	27.0	27.5	61.5	87.5	362.0	268.0	458.0	509.5	529.0	58.5	5.0	0.0	2,394
Ave	32.6	38.3	118.5	208.8	295.5	291.2	484.1	444.0	352.1	155.8	35.6	18.0	2,474
Max	441.5	354.6	405.6	520.3	527.7	471.7	789.6	760.5	529.0	356.4	214.9	172.4	3,636
Min	0.0	0.0	0.0	24.2	88.2	53.5	44.0	89.5	82.2	8.5	0.0	0.0	484

Observed Data at Xe Katam Basin (mm)

(b) Result of Tank Model Calculation

Low flow is estimated by Tank Model using basin mean rainfall. Results of estimation are shown in Figure 3.3-8. As reservoir capacity at Xe Katam site is relatively smaller compared with the annual inflow and the reservoir water level is usually full in rainy season, it is expected that low flow in dry season has a more impact on the calculation of annual power generation. Therefore calculation of Tank Model is focused on the adjustment of discharge in dry season.

As a result, an annual average inflow at the intake weirs (C.A.=263 km^2) from 1989 to 2012 has been estimated as 12.30m^3/s. Year 1998 is excluded from analysis because it was an exceptionally dry year and calculation results show abnormal values.

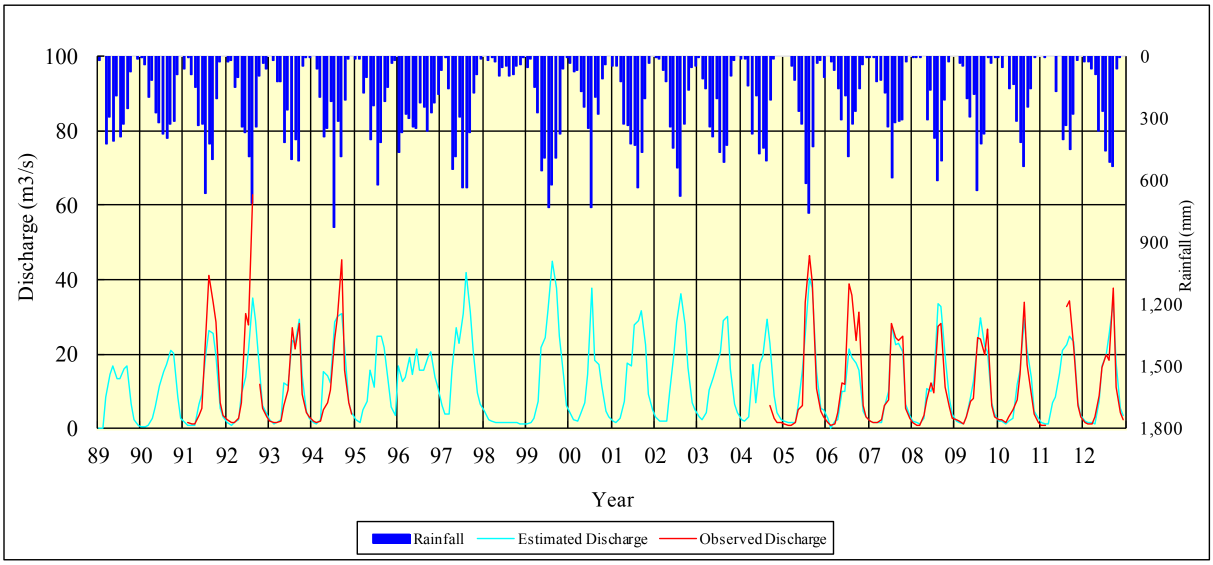


Figure 3.3-8 Results of Tank Model Calculation

(2) Correction by Xe Set Discharge Data

Xe Set basin is located adjacent to the northwestern border of the Xe Katam basin and has long term discharge record from 1985 to 2012. Xe Katam and Xe Set basins are located on the Bolaven Plateau and show similar climate conditions. Therefore, discharge data at Xe Set is expected to be used as the alternative records of Xe Katam basin.

There are two hydropower stations owned by EDL, Xe Set 1 and Xe Set 2. Xe Set discharge station is located at Xe Set 1 (C.A.= 324 km^2) which had been commissioned in 1991. Xe Set 2 was commissioned in 2008. Xe Set 2 is located at upstream of Xe Set 1 and implement the daily reservoir operation for power generation so that discharge records at Xe Set station cannot be used as natural inflow after the commissioning of Xe Set 2. In this study, Discharge records during 1985 – 2008 are used as same as existing study of TR2009.

Discharge records observed in the Xe Katam Basin during 1991-1994 and 2004-2008 are converted into specific discharge at the intake weirs (C.A. = 263 km^2). Comparison between this discharge and Xe Set records is shown in Figure 3.3-9. Then correlation between Xe Katam discharge and Xe Set is calculated as shown in Figure 3.3-10.

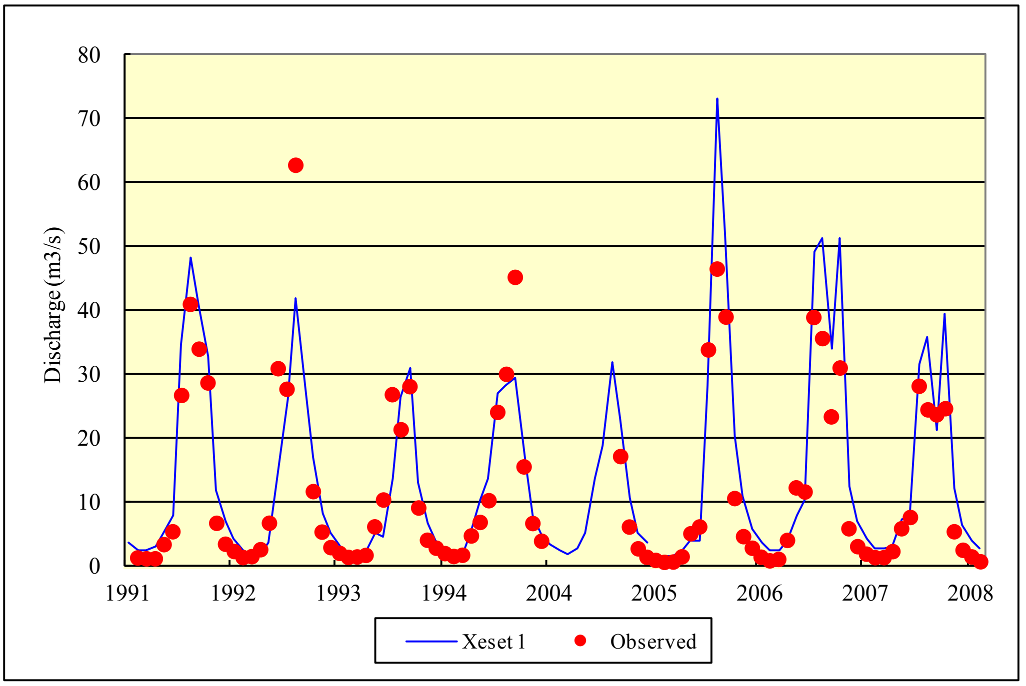


Figure 3.3-9 Monthly Discharge at Xe Katam and Xe Set

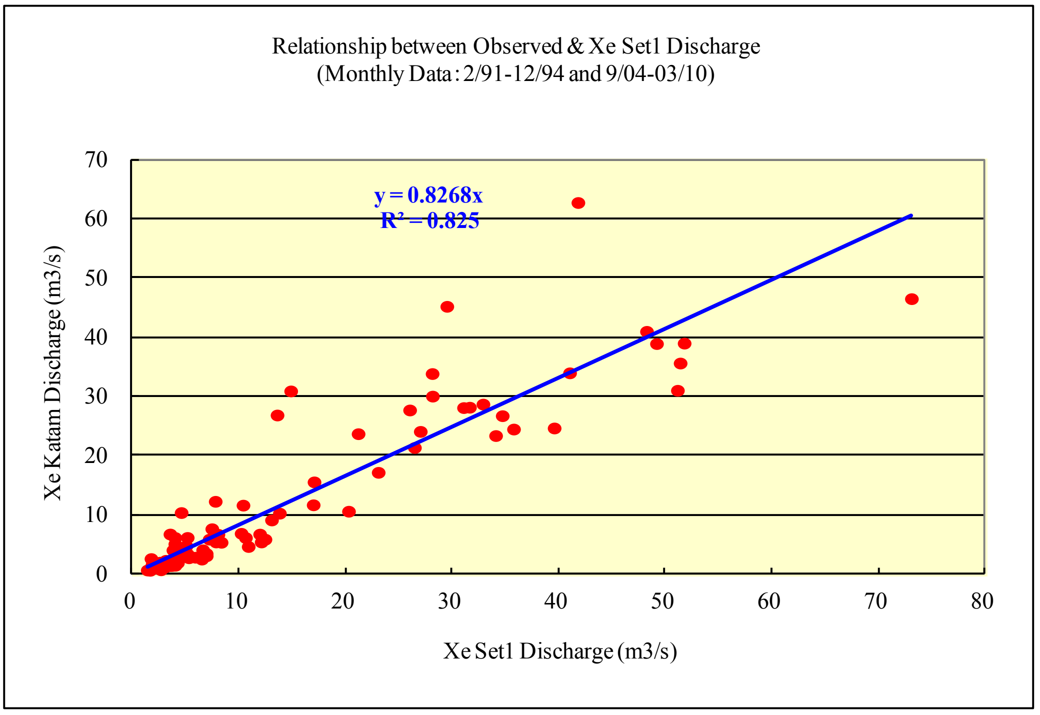


Figure 3.3-10 Correlation between Xe Katam and Xe Set

Correlation between Xe Katam and Xe Set is strong and monthly discharge also shows a similar tendency. Accordingly discharge data at Xe Set from 1985 - 2008 (data missing during 1987 - 1988 and data in 1998 are excluded) can be used for the estimation of low flow at Xe Katam site.

Table 3.3-6 Monthly Inflow at Xe Katam (C.A 263km^2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
1985	4.42	3.10	2.74	3.35	7.46	24.82	20.35	22.01	21.52	14.02	8.08	5.11	11.41
1986	3.48	2.61	2.08	2.89	7.69	9.29	10.83	26.35	23.84	16.78	12.96	6.04	10.40
1989	3.23	2.23	1.74	2.81	9.70	18.70	23.65	32.89	38.03	18.09	7.20	4.50	13.56
1990	2.93	1.59	2.20	2.25	5.30	6.28	12.24	16.54	23.27	31.65	16.90	11.18	11.03
1991	3.08	1.41	1.28	1.28	3.49	5.51	26.83	41.07	34.07	28.79	6.83	3.56	13.10
1992	2.42	1.47	1.62	2.70	6.84	31.01	27.79	62.83	23.07	11.79	5.45	3.03	15.00
1993	2.13	1.50	1.57	1.81	6.27	10.47	26.94	21.46	28.20	9.22	4.18	2.94	9.73
1994	2.09	1.64	1.84	4.86	6.97	10.37	24.18	30.13	45.30	15.65	6.80	4.03	12.82
1996	2.68	1.93	1.57	3.00	8.09	19.40	25.72	28.19	48.44	21.37	17.20	7.80	15.45
1997	4.68	3.32	2.74	3.33	6.27	7.12	20.12	44.63	20.68	17.54	8.22	4.48	11.93
1999	2.64	1.79	1.54	2.80	7.30	12.44	41.54	52.55	27.58	17.49	9.92	6.51	15.34
2000	3.79	2.76	3.28	4.68	5.78	8.03	39.03	33.59	41.94	18.49	11.23	5.08	14.81
2001	3.27	2.03	2.12	2.03	4.60	8.38	25.88	27.71	29.74	18.30	8.96	4.87	11.49
2002	3.08	3.13	1.55	2.01	3.89	6.56	25.35	43.94	34.16	19.17	10.62	5.78	13.27
2003	3.62	2.75	2.34	3.20	7.50	12.69	19.73	31.77	41.92	16.53	7.60	4.25	12.83
2004	2.82	2.04	1.57	2.34	4.35	11.19	15.62	30.38	17.27	6.25	2.84	1.52	8.18
2005	1.03	0.73	0.77	1.59	5.20	6.26	33.94	46.59	39.08	10.70	4.74	2.93	12.80
2006	1.53	0.96	1.18	4.16	12.37	11.73	39.01	35.72	23.48	31.12	5.97	3.18	14.20
2007	2.01	1.45	1.46	2.41	5.98	7.74	28.26	24.57	23.79	24.75	5.51	2.61	10.88
2008	1.57	0.81	0.74	3.33	7.62	12.20	9.76	27.38	28.13	10.92	5.67	2.71	9.24
2009	2.18	1.82	1.23	2.98	7.41	7.87	24.51	23.89	19.94	26.54	6.20	3.11	10.64
2010	2.31	2.42	1.62	3.10	5.04	7.80	14.62	33.82	17.20	9.22	3.78	1.68	8.55
2011	0.98	0.67	1.09	6.79	5.92	12.73	22.04	32.96	34.48	21.86	6.11	2.93	12.38
2012	1.56	1.03	1.05	2.97	8.80	16.27	19.83	18.42	37.61	11.19	4.19	2.17	10.42
2013	1.17	0.68	0.76	1.40	11.40	15.13	20.90	17.72	49.84	23.07	6.65	3.55	12.69
2014	2.08	1.35	1.50	3.17	10.82	24.17	35.57	37.87	38.45	10.73	4.89	3.08	14.47
Max	4.68	3.32	3.28	6.79	12.37	31.01	41.54	62.83	49.84	31.65	17.20	11.18	15.45
Average	2.57	1.82	1.66	2.97	7.00	12.47	24.39	32.50	31.19	17.74	7.64	4.18	12.18
Min	0.98	0.67	0.74	1.28	3.49	5.51	9.76	16.54	17.20	6.25	2.84	1.52	8.18

Tank Observe

Year 1995 is excluded from the results of the low flow analysis, because the average inflow showed that the year was the driest year in 28-years while it was expected to be a normal year according to observed precipitation and estimated inflow surrounding the Project site.

Results of low flow analysis are shown in Table 3.3-6. Finally, 12.1 m^3/s is obtained as annual average inflow at intake weirs in Xe Katam basin.

(3) Low Flow Analysis Result

Data availability for low flow analysis from 1985 to 2012 is shown in Table 3.3-7. Regarding the comparison between 1) Tank Model and 2) Correction by Xe Set, observed data is more reliable than estimated data. Therefore 2) Correction by Xe Set is applied for the complement of discharge data in absent period in Xe Katam Basin. Tank Model is applied in March – August of 2011 when both data is not available.

Table 3.3-7 Data Availability for Low Flow Analysis at Xe Katam Basin

Data		85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	Reference
Observed Data in Xe Katam Basin	Nong Hin							△	△	○	○																					
	Nong Mek																				△	○	○	○	○	○	○	△	○	○	○	Observation record is missing during March to August in 2011
Tank Model						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
Xe Set 1		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	※	※	※	※	※	※	※As Xe Set 2 HPP has been comissioned and started reservoir operation since 2009, discharge data can not be used as natural inflow sine then.

Data is not available ○ : all data available △ : partially available

3.3.3 Flood Analysis

(1) Overview

Flood analysis was conducted to estimate the probable maximum flood and probable flood discharge. It is essential to decide on a design flood water level required to determine the dam height at the planned sites of the major structures.

There is no flood date for long period, thus the probable maximum flood and probable flood discharge are estimated by the unit hydrograph method using the probable maximum precipitation and probable rainfall respectively.

(2) Estimation of the Probable Maximum Precipitation and Probable Rainfall

To estimate the probable maximum precipitation, the annual maximum daily rainfall in the period 1970-1978 for the Pakxong and 1989-2004 for the Nikhon point, which had a strong correlation in terms of rainfall with the Xe Katam basin, were used in Hershfield's method*. As a result, the probable maximum 24-hour, 48-hour and 72-hour precipitation in the Xe Katam basin are estimated to be 800 mm, 1,180 mm and 1,240mm respectively.

(* "Manual for Estimation of Probable Maximum Precipitation, Second Edition" published by the WMO in 1986)

The probable rainfall is estimated by using the frequency curve based on the annual maximum daily rainfall in the period 1970-1978 for the Pakxong and 1989-2004 for the Nikhon34 point and 2004-2012 for the Nong Mek point. For the probable rainfall, Gumbel's frequency curve is applied as a result of the estimation using four frequency curves. Results of the estimation of the probable maximum precipitation and probable rainfall are shown in Table 3.3-9.

As catchment area of the Xe Namnoy River occupy 70% of the area of powerhouse site, the precipitation is estimated with the correction by catchment area as shown in Figure 3.3-11.

Table 3.3-8 Results of Estimation of the Probable Maximum Precipitation and Probable Rainfall

(mm)

Probable Rainfall	24hr	48hr	72hr
2	112	154	186
5	159	215	252
10	190	255	295
20	220	294	337
30	237	317	361
50	258	345	391
100	287	382	431
200	316	420	472
500	354	470	525
1,000	382	507	565
10,000	478	632	698
PMP	792	1,178	1,232

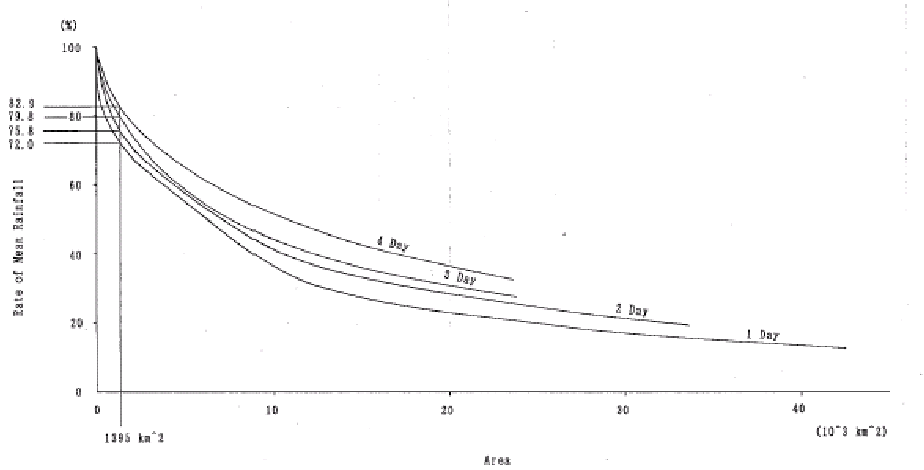


Figure 3.3-11 Correction of the Rainfall by Catchment Area

(3) Estimation of the Probable Maximum Flood and Probable Flood Discharge

The probable maximum flood and probable flood were estimated based on probable maximum precipitation and probable rainfall, rainfall distribution, base flow, and runoff, etc.

(a) Typical Rainfall Distribution

The hourly rainfall data for the Xe Katam basin has been observed only at the rainfall gauging station at Nong Mek since August 2004. For hyetograph estimation of the hourly rainfall in a storm, continuous rainfalls of over 50 mm in 24-hour precipitation were selected to determine a typical rainfall pattern in the Xe Katam basin. The typical rainfall distribution selected is shown in Figure 3.3-12:

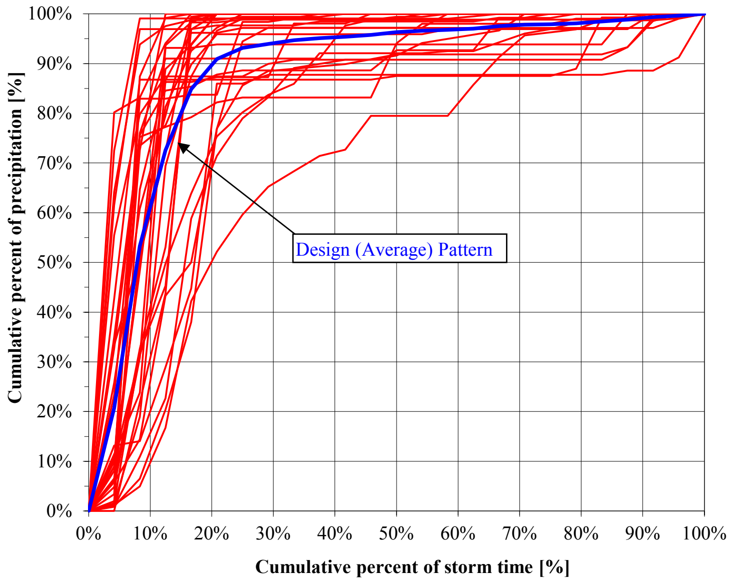


Figure 3.3-12 Typical Rainfall Distribution

(b) Base Flow

Based on the averaged discharge data during the rainy season from May to November which was estimated above, the base flow at the discharge measurement point is estimated to be 17.6 m^3/s. The value is used in multiplying by the ratio of the basin area to estimate the base flows at the planned sites of the individual structures.

(c) Runoff Coefficient

The runoff coefficient is estimated from records of existing flood hydrographs as shown in Figure 3.3-13. As flood discharge is larger, runoff coefficients tend to increase. Therefore, the equation to estimate the relation between land use and runoff coefficients mentioned in SCS is applied to estimate the runoff coefficient by each effective rainfall.

The runoff coefficient for the effective rainfalls is estimated by applying the relation between land use and precipitation and direct runoff by USC*. The direct runoff coefficient at the Xe Katam basin is estimated between 0.7 and 0.9 which is variable depending on the amount of rainfall.

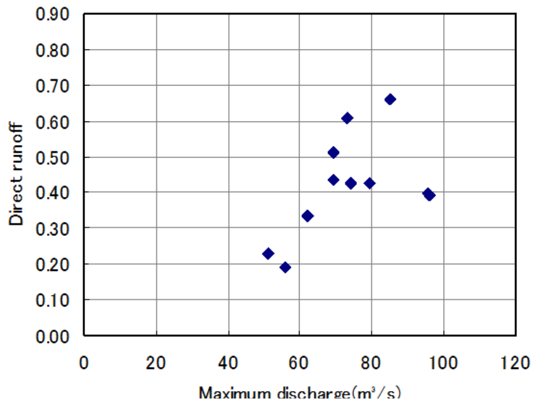


Figure 3.3-13 Runoff Coefficient from Exiting Flood Unitgraphs

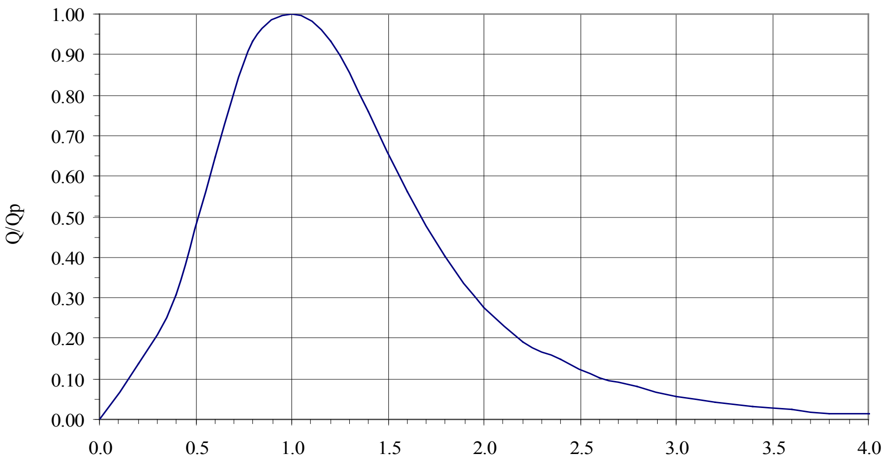
(*Agricultural land use curve number and SCS runoff equations by US Soil Conservation Service in 1972)

Table 3.3-9 Results of Estimation of Runoff Coefficient

	Rerurn Period	PMP	10,000	1,000	500	200	100	50	30	20	10	5	2
24-hr	24-hr Rainfall ; P [mm]	792	478	382	354	316	287	258	237	220	190	159	112
	P [inch]	31.2	18.8	15.0	13.9	12.4	11.3	10.2	9.3	8.7	7.5	6.3	4.4
	Direct Runoff; Pe [inch]	27.3	15.1	11.5	10.4	9.0	7.9	6.9	6.1	5.5	4.5	3.4	1.9
	Runoff Ratio (Pe/P)	0.88	0.80	0.76	0.75	0.72	0.70	0.70	0.70	0.70	0.70	0.70	0.70
48-hr	24-hr Rainfall ; P [mm]	1,178	632	507	470	420	382	345	317	294	255	215	154
	P [inch]	46.4	24.9	20.0	18.5	16.5	15.0	13.6	12.5	11.6	10.0	8.5	6.1
	Direct Runoff; Pe [inch]	42.4	21.1	16.3	14.8	12.9	11.5	10.1	9.0	8.2	6.8	5.3	3.2
	Runoff Ratio (Pe/P)	0.91	0.85	0.82	0.80	0.78	0.76	0.74	0.72	0.71	0.70	0.70	0.70
72-hr	24-hr Rainfall ; P [mm]	1,232	698	565	525	472	431	378	361	337	295	252	186
	P [inch]	48.5	27.5	22.2	20.7	18.6	17.0	14.9	14.2	13.3	11.6	9.9	7.3
	Direct Runoff; Pe [inch]	44.5	23.6	18.5	16.9	14.9	13.3	11.3	10.7	9.8	8.2	6.7	4.3
	Runoff Ratio (Pe/P)	0.92	0.86	0.83	0.82	0.80	0.78	0.76	0.75	0.74	0.71	0.70	0.70

(d) Unit Hydrograph

Creating a unit hydrograph requires hourly discharge observation data but no long-term discharge observation data for Nong Mek are available. For this reason, a dimensionless unit hydrograph offered by the United States Soil Conservation Service, which is shown below, is adopted as a unit hydrograph.



Source: US Soil Consevation Service

Figure 3.3-14 Unit Hydrograph

Based on the following equation, flood discharge at each facility is estimated by Snyder-Linsley formula with lag time and peak discharge. Coefficients for flood analysis by Snyder-Linsley Methods are shown in Table 3.3-10.

(Snyder-Linsley Methods)

Lag Time t_p : $t_p=C_t\,(LL_c/S^{0.5})^{0.38}$
L : Length of the main stream channel (mi) from the outlet to the divide
L_c : Length along the main channel (mi) from the outlet to a channel point nearest the watershed centroid
S : Channel slope
C_t : 0.72, Valley areas: 0.35 (The value of foothills is applied)

Peak Discharge Q_p : $Q_p = 640\,AC_p / t_p$
A : Catchment area (mile²)
C_p : Coefficients: Coefficients: 0.64 (The value of foothills is applied)

Table 3.3-10 Coefficients at Each Facility

Items	Unit	Reservoir	Diversion Weir	Intake Weirs	Powerhouse
L	mile	7.8	21.9	27.5	36.3
L_c	mile	4.5	5.9	10.0	17.5
S	-	0.0349	0.0091	0.0106	0.0121
t_p	hour	5.2	11.2	14.4	19.3
A	km^2	38	176	263	1093
	$Mile^2$	15	68	102	422
Q_p	$m^3/s/mm$	1.28	2.78	3.21	9.97

As the diversion weir (CA=176km²) is located near the Nong Mek (CA=178km²) at where flood measurement is implemented, 11.2hr of lag time at diversion weir is compared with existing flood measurement records.

Figure 3.3-15 shows an example of the estimation of lag time. Existing flood measurement records show lag time between 9hr - 13hr. As a conclusion, 11.2hr of this estimation is expected to be appropriate.

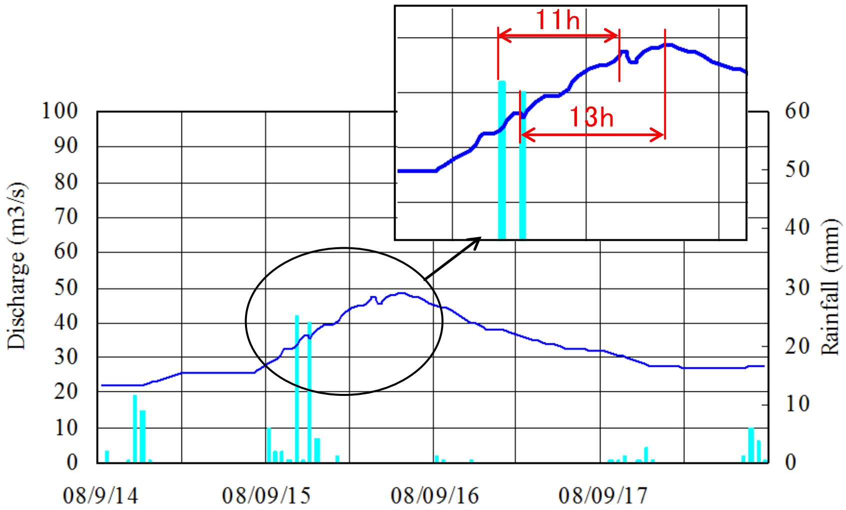


Figure 3.3-15 Estimation of Flood Lag Time (Observed during 14th – 17th of September, 2008)

(e) Estimation Result of Probable Maximum Flood and Probable Flood

To check change of the precipitation by duration of rainfall, correlation between duration and accumulative precipitation of probable precipitation and Probable Maximum Precipitation (PMP) is compared as shown in Figure 3.3-16. Precipitation increase gradually until 48hr and increasing rate becomes smaller around 48hr. Therefore, the effective accumulated precipitation is estimated to reach the peak around 48hr at Xe Katam basin.

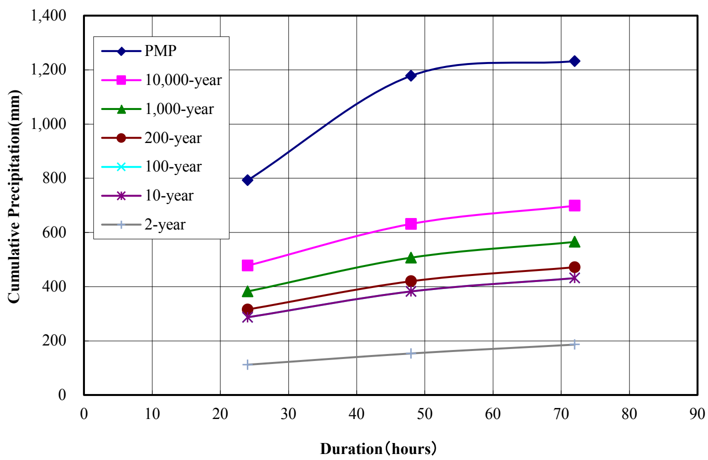


Figure 3.3-16 Comparison of Accumulated Precipitation

PMF and 1,000yr probable flood of 24 hour, 48 hour and 72 hour are estimated as shown in Figure 3.3-17 and Figure 3.3-18. As a conclusion, flood of 48 hour becomes the largest in all cases.

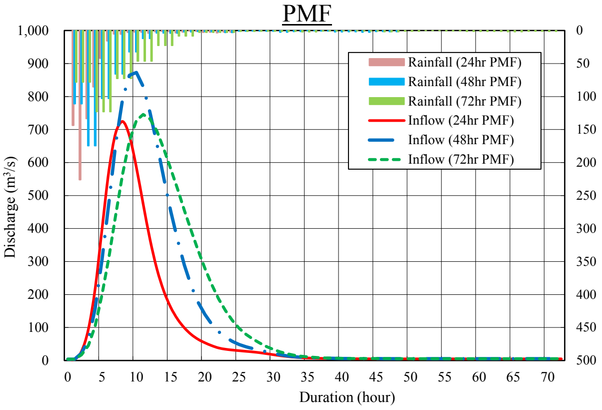


Figure 3.3-17 Probable Maximum Flood

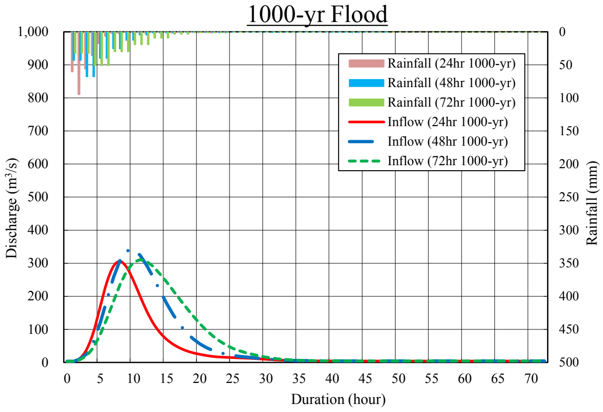


Figure 3.3-18 1,000-yr Probable Flood

High water level of the reservoir is estimated in cases of Probable Maximum Flood (PMF) and 1,000yr probable flood of 24 hour, 48 hour and 72 hour. In addition transition of the water level, inflow and discharge at the spillway is shown in Figure 3.3-19 and Figure 3.3-20. High water level at the main dam is also highest in case of Flood of 48 hour.

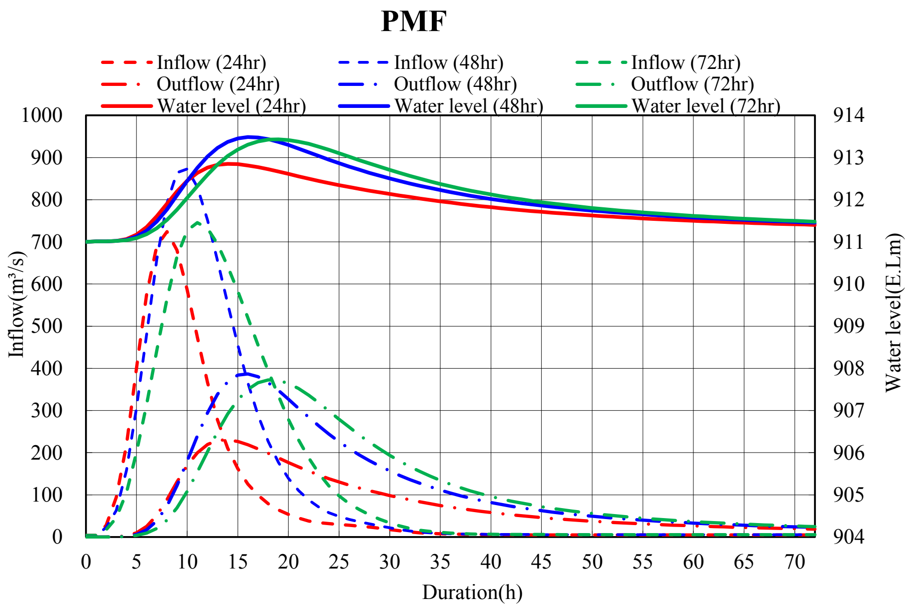


Figure 3.3-19 High Water Level of the Main Dam in PMF

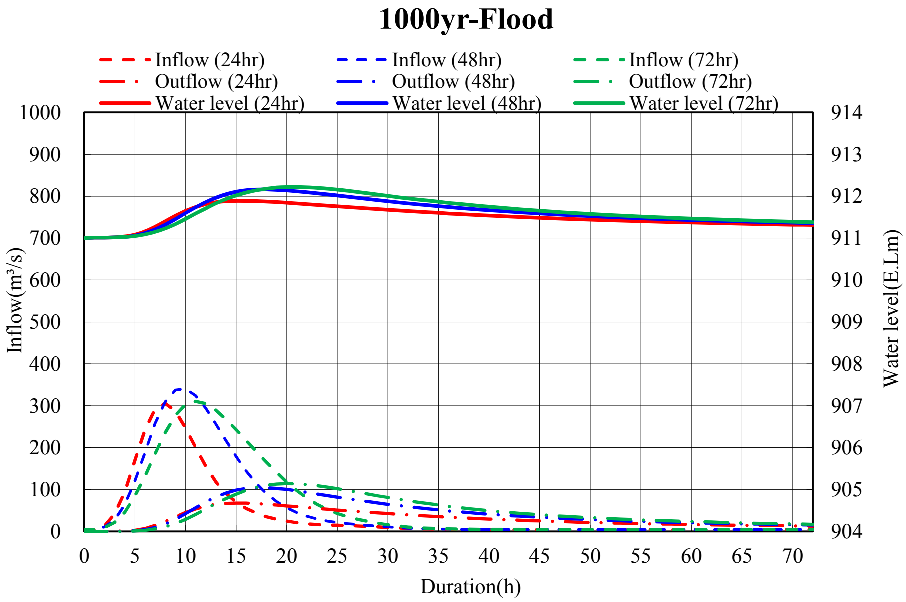


Figure 3.3-20 High Water Level of the Main Dam in 1,000yr Probable Flood

The peak discharge of 48-hour PMF has the highest value among three types of flood, therefore 48-hour flood was selected as a design flood. The probable maximum floods and probable flood discharges at the planned sites of the individual facilities are as shown in Table 3.3-11.

Table 3.3-11 Flood Analysis Results for the Sites of the Main Facilities

Year	Main dam C.A=38 km^2	Diversion weir C.A=176 km^2	Intake weirs C.A=263 km^2	Powerhouse C.A=1,093 km^2
PMF	880	1,910	2,210	6,680
10,000	440	970	1,120	3,360
1,000	350	750	880	2,630
500	310	680	800	2,400
200	270	600	700	2,100
100	250	540	630	1,890
10	150	340	390	1,200
5	130	290	340	1,030

The value of the specific yield are regarded as within reasonable values compared with that of surrounding area around Xe Katam basin as shown in the Figure below. For the design of civil facilities, return period and design flood are determined considering the importance of facilities.

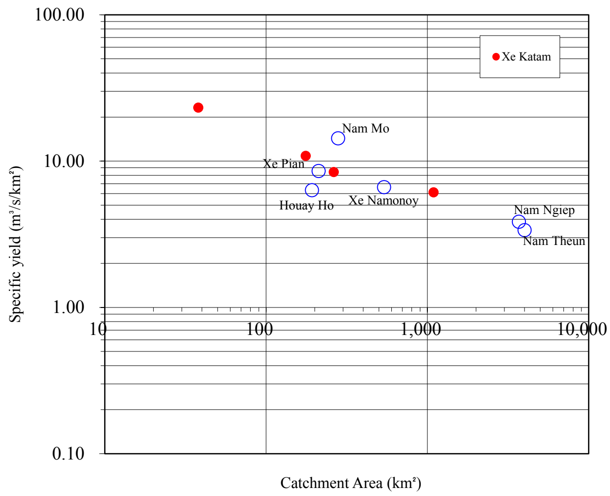


Figure 3.3-21 Specific Yield
(Probable maximum flood at the main dam)

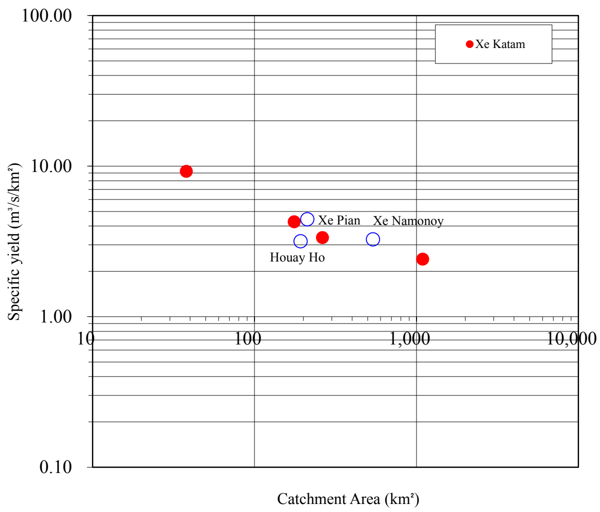


Figure 3.3-22 Specific Yield
(1,000-year probable flood at the main dam)

3.3.4 Reservoir Sedimentation

No observation of suspended load in floods has been conducted for the Xe Katam River. In the Study, the reservoir sedimentation is estimated based on the data for nearby the Nam Sai River, which was used in the Xe Set 1 project investigation along with JICA's FS, and the FS report on the planed sites in the vicinity. The sediment yield of the Nam Sai River is about 430 m^3/year/km² and the FS report on the planed sites in the vicinity estimates the sediment yield as between 300 and 430 m^3/year/km².

The Study has adopted 430 m^3/year/km², which uses the data for the Nam Sai River, and assumes that all sediment is fed to the reservoir by means of the diversion weir. The total of the catchment areas of the diversion weir (176 km^2) and main dam (38 km^2) is 214 km^2 and the sedimentation for the operation period of 25 years is estimated to be 2.3 Mm^3 (about 90,000 m^3/year).

3.3.5 Reservoir Evaporation

Although no evaporation observation has been conducted in the Xe Katam basin, evaporation has been monitored at Nikhon34 point (altitude: 1,150 m) located to the west of the basin and Pakse (altitude: 100 m) to the west of the Bolaven Plateau. A pitcher and a Class A pan have been used at Nikhon34 and Pakse respectively and observation with a pitcher is said to show smaller values than that with a Class A pan. While the average evaporation at Nikhon34 from 1984 to 1990 (data missing for 1987 and 1988) is about 570 mm/year, the average evaporation at Pakse from 1985 to 1998 (data missing for 1986, 1991 and 1993) is about 1,700 mm/year.

With the difference in altitude taken into consideration, the observed values for Pakse are estimated to average between 1,100 and 450 mm/year. The actual evaporation from a reservoir is generally said to be a value observed with a Class A pan multiplied by a correction coefficient of about 70 percent. Since the difference between the average altitude of the Xe Katam basin of 1,050 m and the altitude of Nikhon34 is negligible, the Study estimates annual evaporation of about 800 mm / year.

3.4 Site Reconnaissance of Xe Katam

3.4.1 Outline of Site Reconnaissance

Outline of site reconnaissance for the design of civil facilities and construction plan is described below.

(1) 1st Site Reconnaissance

1st Site reconnaissance had been implemented during 16/04/2013 – 15/05/2013. Purposes of reconnaissance are;

- Reconnaissance of main civil facilities (Diversion weir, main dam, saddle dam intake weirs, headrace tunnel, head tank, penstock, powerhouse and tailrace).
- Confirmation of existing road
- Hydrological data collection
- Instruction and supervising of the subcontractor for geological investigations (7 borings and 7 test pits)

Participants and schedule are shown in Table 3.4-1.

Table 3.4-1 Participants List and Schedule (1st Site Reconnaissance)

Position	Name	Affiliation	Schedule
Director of Design	Mr. Junichi MIZUTA	The Kansai Electric Power Co., Inc.	16/04/2013 – 27/04/2013 (12 days)
Environment / Civil Planning	Mr. Takumi MARUOKA	NEWJEC Inc.	16/04/2013 – 28/04/2013 (13 days)
Economic Survey / Civil Design	Mr. Takao SARUHASHI	NEWJEC Inc.	16/04/2013 – 22/04/2013 (7 days)
Civil Design / Environment	Mr. Sho SHIBATA	NEWJEC Inc.	16/04/2013 – 25/04/2013 (10 days)
Chief of Topography and Geology	Mr. Mitsuhiro TOKUSU	NEWJEC Inc.	16/04/2013 – 22/04/2013 (7 days) 08/05/2013 – 15/05/2013 (8 days)
Topography and Geology	Mr. Hirokazu UEDA	NEWJEC Inc.	24/04/2013 – 12/05/2013 (19 days)
Construction Planning	Mr. Kazunori KOBAYASHI	NEWJEC Inc.	16/04/2013 – 20/04/2013 (4 days)
Laos Counterpart	Mr. Phoulithad Virachack	Department of Energy and Mine in Champasak	18/04/2013 (1 day)
	Mr. Chansavanh	Department of Energy and Mine in Champasak	19/04/2013 – 20/04/2013 (2 days)
	Mr. Kham Sene	EDL Champasak	18/04/2013 – 20/04/2013 (3 days)

(2) 2nd Site Reconnaissance

2nd Site reconnaissance had been implemented during 06/10/2013 – 11/10/2013. Purposes of reconnaissance are;

- Reconnaissance of main civil facilities (Diversion weir, main dam, saddle dam intake weirs, headrace tunnel, head tank, penstock, powerhouse and tailrace).
- Plan of the construction road route
- Reconnaissance of the quarry candidate
- Confirmation of results of geological investigations

Participants and schedule are shown in Table 3.4-2.

Table 3.4-2 Participants List and Schedule (2nd Site Reconnaissance)

Position	Name	Affiliation	Schedule
Director of Design	Mr. Junichi MIZUTA	The Kansai Electric Power Co., Inc.	06/10/2013 – 11/10/2013 (6 days)
Chief of Topography and Geology	Mr. Mitsuhiro TOKUSU	NEWJEC Inc.	06/10/2013 – 11/10/2013 (6 days)
Laos Counterpart	Mr. Chansavanh	Department of Energy and Mine in Champasak	08/10/2013 – 10/10/2013 (3 days)
	Mr. Kham Sene	EDL Champasak	08/10/2013 – 10/10/2013 (3 days)

(3) 3rd Site Reconnaissance

3rd Site reconnaissance had been implemented during 23/03/2014 – 29/03/2014. Purposes of reconnaissance are;

- Reconnaissance of main civil facilities (Diversion weir, main dam, saddle dam intake weirs, headrace tunnel, head tank, penstock, powerhouse and tailrace).
- Confirmation of the construction road route
- Procurement survey for construction materials

Participants and schedule are shown in Table 3.4-3.

Table 3.4-3 Participants List and Schedule (3rd Site Reconnaissance)

Position	Name	Affiliation	Schedule
Director of Design	Mr. Junichi MIZUTA	The Kansai Electric Power Co., Inc.	26/03/2014 – 29/03/2014 (4 days)
Civil Design / Environment	Mr. Sho SHIBATA	NEWJEC Inc.	20/03/2014 – 29/03/2014 (10 days)
Topography and Geology	Mr. Hirokazu UEDA	NEWJEC Inc.	23/03/2014 – 29/03/2014 (7 days)
Construction Planning	Mr. Kazunori KOBAYASHI	NEWJEC Inc.	23/03/2014 – 29/03/2014 (7 days)
Laos Counterpart	Mr. Chansavanh	Department of Energy and Mine in Champasak	26/03/2014 – 27/03/2014 (2 days)
	Mr. Kham Sene	EDL Champasak	26/03/2014 – 27/03/2014 (2 days)

3.4.2 Reconnaissance of Main Civil Facilities

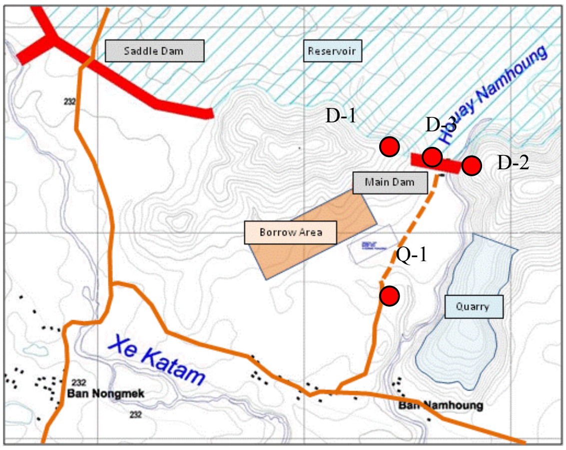
Based on the design drawings and geological maps, reconnaissance of main civil facilities had been implemented to obtain the change from existing studies and current topographical and geological conditions.

(1) Main Dam


Dam Axis (Left Bank)


Nam Houng River


Boring D-1



Main Dam

Item	Description
Accessibility	It can be accessible by 4WD cars until the 0.7km point during the dry season.
Land Use	There are farms by the burn agriculture and brush around the main dam site. The Nam Houng River flows across the dam axis.
Change from Existing Studies	Although landscape of the reservoir and main dam area was visible in the existing study in 2005, it is not visible at the site due to growth of the brush.
Topographic and Geological Investigations in this Study	Four (4) borings (3 holes along the dam axis and 1 hole at the downstream) and the soil laboratory test from six (6) test pits were implemented in this study.
Items to be Studied for Civil Design	Dam Excavation - In existing studies excavation line of the main dam is estimated at maximum 14m due to the weathering D class rock layer and high permeability layer at unconformity border based on RB-04 (EL. 886.03m). Foundation Treatment - Layers of the high Lugeon value are confirmed below 30m at D-1 and D-3. Depth of the groundwater is as same as the riverbed elevation at D-1. Range and depth of grouting plan should be particularly considered.

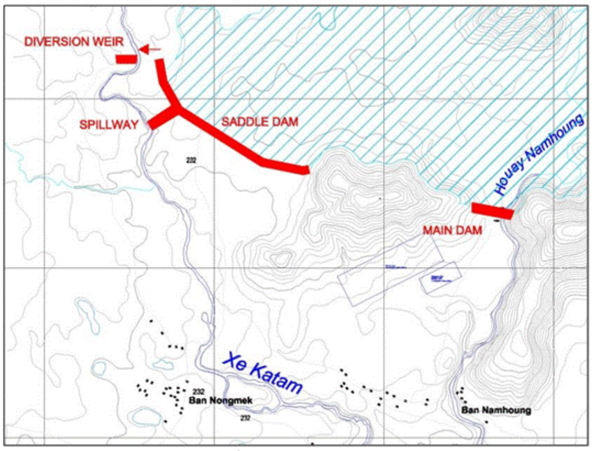
Item	Description
	<u>Embankment Materials</u> - Required volume of the core material is approximately 100,000m^3. Entire results of laboratory tests shows high proportion of fine sand and they are not suitable for the core. However the result of TC-6 which is obtained from the downstream of right bank of the main dam shows suitability. Therefore the area surrounding TC-6 is proposed for the candidate of borrow area. In addition, conversion of surface soil at the quarry site is expected to be studied in the future. - Required volume of the filter material is approximately 80,000m^3. Because of the high proportion of fine sand, gravel layer of the Sekong River which is proposed for the candidate is judged unsuitable. As it is difficult to procure materials around the project area, it is expected to be produced by the crushing plant on the site. - Required volume of the rock material is approximately 340,000m^3 for Rockfill and 420,000m^3 for CFRD. In existing studies, the quarry site is proposed at the downstream of left bank of the main dam. Based on the revision of geological investigations, available amount of rock material is estimated at 680,000m^3 of the sandstone. If concrete aggregates are produced on site by crushing the rock materials, it may be insufficient. Therefore utilization of the alternation strata of mudstone and sandstone which is adequately available at the quarry site for the dam body by the zoning shall be studied.
Items to be Studied for Construction Plan	<u>Construction</u> - Dam embankment works are expected to be implemented by the zoning of the sandstone and alternation strata. As core and filter are also embanked during the rainy season, countermeasures for rainfall is required <u>Construction Road</u> - It is easy to arrange the construction road because of the flat topography around the site. Construction road to the main dam site are arranged by two routes, from the national road and quarry site. The route from the national road is passed across plantation area and is necessary to install the bridge at the Xe Katam River. <u>Temporary Facility</u> - Temporary yard including the crushing plant is arranged at the flat area of the downstream of the main dam axis. Stockpile for the core material is arranged near the borrow area located at the downstream of right bank.

(2) Saddle Dam


Saddle Dam Area


Spillway Area

Intersection of Spillway and the Xe Katam River

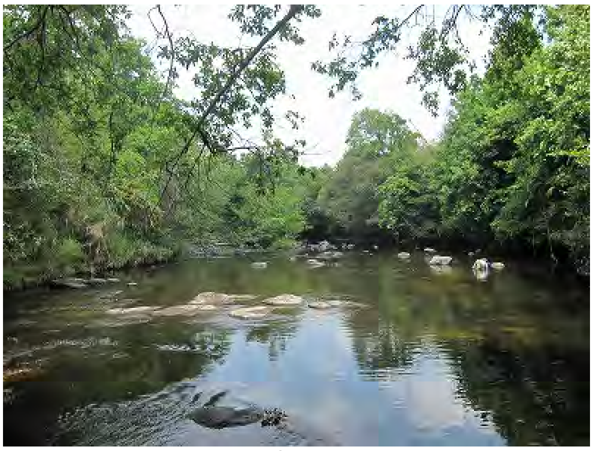


Saddle Dam

Item	Description
Accessibility	It can be accessible by the 4WD car during dry season.
Land Use	Farms by the burn agriculture are located in front of the right body of saddle dam where is proposed for the embankment by the disposal soil.
Change from Existing Studies	Although landscape of the saddle dam area was visible in the existing study in 2005, it is not visible at the site due to growth of the brush. Farm land reclamation has been developed.
Topographic and Geological Investigations in this Study	None
Items to be Studied for Civil Design	Topography of Right Bank - Crest of the saddle dam is EL. 914.5m. As the saddle dam is located at the flat ground, it is difficult to confirm the actual elevation by site reconnaissance. However the elevation of saddle dam and diversion area is confirmed by the new topographic survey by satellite topographs. Embankment Materials - Required volume of soil for the embankment is approximately 550,000m^3. Conversion of surface soil of the quarry is expected to be studied in the future. Excavation Line of Spillway - As boring investigations were not implemented around the spillway area, foundation of the spillway is planned to be excavated until the elevation of Xe Katam riverbed where outcrops of the basalt are confirmed.
Items to be Studied for Construction Plan	Construction Road - It is easy to arrange the construction road because of the flat topography. Construction road to the saddle dam site are arranged by two routes, from the national road via borrow area and quarry site via reservoir area. After the completion of saddle dam construction, access road for the diversion weir is arranged through the saddle dam body. Disposal Area - Disposal soil excavated from the main dam, quarry site, saddle dam and diversion weir is will be embanked in front of the downstream of saddle dam body.

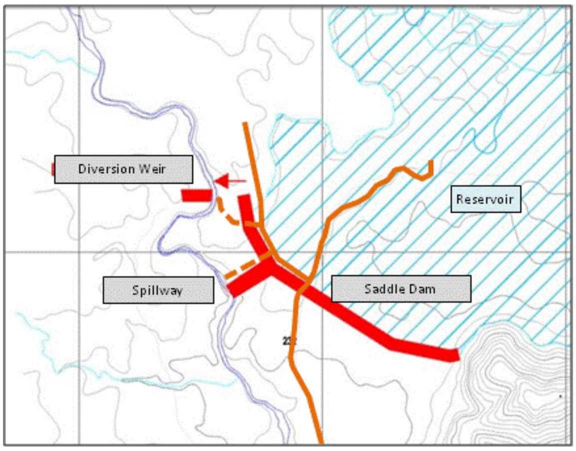
(3) Diversion Weir

Dam Axis of Diversion Weir



Upstream of Diversion Weir

Fishery Pond at the Upstream

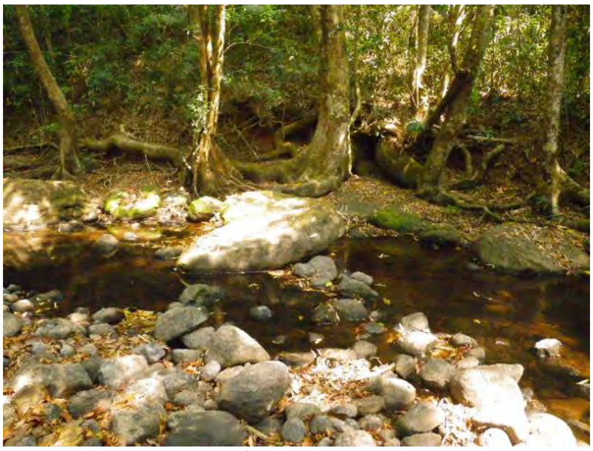


Diversion Weir

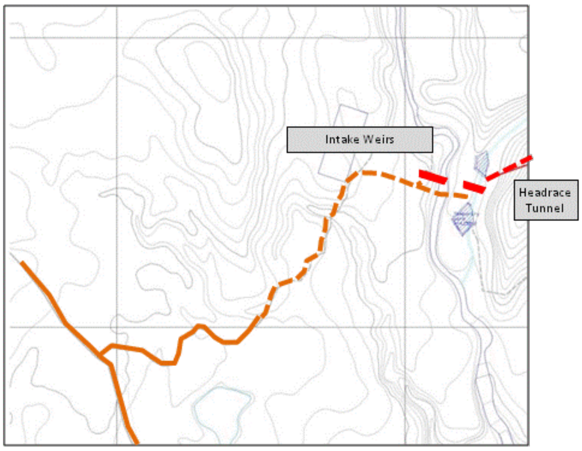
Item	Description
Accessibility	It can be accessible by 4WD cars until the 0.8km point during the dry season. Crossing of the Xe Katam River by the bulldozer for farm reclamation is observed at the 0.9km upstream of diversion weir.
Land Use	There are farms by the burn agriculture and brush. West side of the existing unpaved road is comparatively opened and small fishery pond is confirmed.
Change from Existing Studies	Farm land reclamation has been developed.
Topographic and Geological Investigations in this Study	Soil laboratory test from a test pit at the left bank of diversion weir was implemented in this study.
Items to be Studied for Civil Design	<u>Topography of Diversion Weir and Connecting Channel</u> - Width of the Xe Katam River at diversion weir is approximately 20m. River channel is separated and jogged at the 100m downstream. This topographic feature is matched with the exiting topographic map. Connecting channel area is mildly sloped and is expected to be easily designed and constructed. <u>Excavation Line</u> - Outcrop of the basalt is observed at the riverbed. Surface soil of both bank is thick. Crest length is planned as 144.2m and it is necessary to excavate the right bank massively.
Items to be Studied for Construction Plan	<u>Construction Road</u> - Construction road to the diversion weir is arranged by two routes, from the national road via saddle dam and quarry site via reservoir area. After the completion of saddle dam construction, access road for the diversion weir is arranged through the saddle dam body.

(4) Intake Weirs, Intake and Settling Basin

Intake Weir (Right bank :Xe Katam River)


Intake Weir (Left bank :Dakproung River)


Rest House for Farmers



Intake Weirs

Item	Description
Accessibility	It can be accessible by cars until the 1.0km point. The Dakproung River where the intake is planned can be accessible by crossing the Xe Katam River by foot during dry season.
Land Use	There are farms by the burn agriculture and brush. Residents house are also located along the timber road.
Change from Existing Studies	Farm land reclamation has been developed. Burning of the trees was confirmed at the right bank of the Xe Katam River in the 3rd site reconnaissance on March 2014.
Topographic and Geological Investigations in this Study	None
Items to be Studied for Civil Design	<u>Topography of Intake Weirs</u> - Intake weirs are constructed at the Xe Katam River and the Dakproung River. 100m Upstream of the Xe Katam River is jogged and topographic features are matched with the exiting topographic map. - Weir axis of the Dakproung River is located at the winding point of the channel and river width is approximately 10m. Intake, settling basin and connection to headrace tunnel are arranged at the left bank. Topographic features are matched with the exiting topographic map. <u>Excavation Line</u> - Outcrop of the basalt is confirmed at the Xe Katam River and it is possible to construct the concrete gravity weir with height of 9.5m. Although outcrop is not confirmed at the Dakproung River due to the surface soil, it is seem to be possible to contact with the bedrock by 2m excavation from the surface soil
Items to be Studied for Construction Plan	<u>Construction Road</u> - Construction Road is arranged from the national road via plantation area and connected to intake weirs from the right bank of the Xe Katam River. Temporary bridge is required at the Xe Katam River.

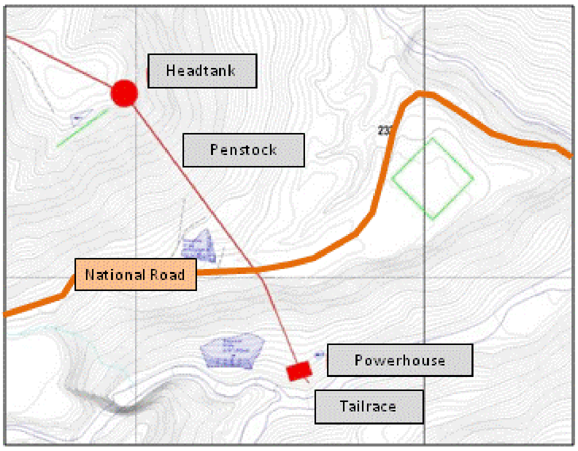
Item	Description
	- As Old Nong Hin located at the upstream of intake weirs is planned for the alternate farm of reservoir area, access road from Nong Mek to Old Nong Hin is arranged for local residents. It is also used for the maintenance of intake weirs and intake. Temporary Yard - Concrete plant is planned at right bank of the Xe Katam River. Two yards for intake weirs and tunnel works are located at the left bank of the Dakproung River.

(5) Penstock

Planned Site of Xe Namnoy 6 Hydropower Plant


Route of the Penstock


Boulders around EL. 480m



Penstock

Item	Description
Accessibility	It can be accessible from the national road which is connected between Houaykong and Sekong.
Land Use	There are the national road with two traffic lane around EL. 470m. This road has been developed by MPWT.
Change from Existing Studies	Improvement of National Road - Topography around the EL. 470m was changed by the excavation of the slope for the construction work of national road. Xe Namnoy 5&6 Mini Hydropower Station - Xe Namnoy -5 (5MW) and Xe Namnoy -6 (5MW) hydropower projects has been developed on the Houay Mackham River which flows along the west side of Head Tank – Penstock route. Construction of the base camp for workers was confirmed in 3rd site reconnaissance on March 2014.
Topographic and Geological Investigations in this Study	A talus deposit layer was confirmed around EL. 580 – 480m in existing geological investigations. Boulders with diameter of over 2m are confirmed around excavated slope of the national road. Boring P-1 was implemented to confirm the thickness of this layer in this study.

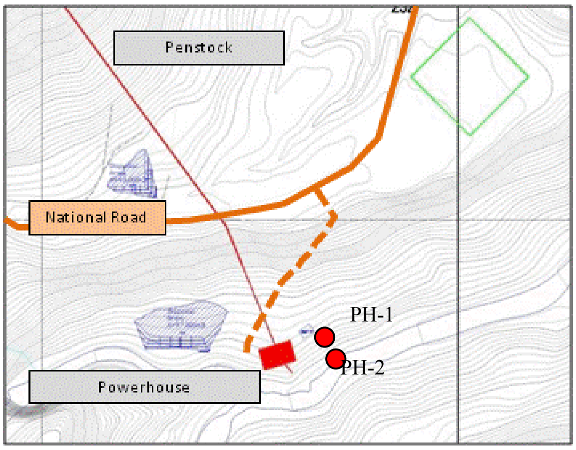
Item	Description
Items to be Studied for Civil Design	Foundation Type - Four (4) concrete piles (D=1.7m x L=28m) by the casing construction were adapted for the foundation at the talus deposit layer in existing studies. However based on the revision of geological investigations, it is proposed to be changed to the anchor block type. Profile of Penstock - Topography has been changed from exiting studies because of construction of the national road and hydropower projects. Especially, the base camp of hydropower projects may be affected to the construction of penstock.
Items to be Studied for Construction Plan	Construction - Construction works of penstock is implemented with cable cranes among EL. 370m – EL. 450m and EL. 520m – EL. 760m where steep slopes are. As the extension length of 1273.6m is long with much excavation volume, construction works are divided into three sections. Construction Road - Construction road is arranged from the national road to the mountain side around EL. 500m. Temporary Yard and Disposal Area - Temporary yard is arranged near head tank. Disposal area is arranged near the construction road to dispose the excavated soil.

(6) Powerhouse


Xe Katam River (Upstream)

Xe Katam River (Downstream)

Xenamnoy River at the Downstream of Powerhouse



Powerhouse

Item	Description
Accessibility	It can be accessible by cars until the 1.0km point from the national road.
Land Use	None
Change from Existing Studies	Xe Katam 1 & Xe Namnoy 2 hydropower project has been developed.
Topographic and Geological Investigations in this Study	Boring PH-1 and PH-2 are implemented to confirm the depth of surface soil.
Items to be Studied for Civil Design	Topographic Map near the Powerhouse - Powerhouse is planned to be located at the 50m downstream from the confluence point of the Xe Katam and the Xenamnoy Rivers. There are steep gradient parts within approximately 200m section. As there is a small creek at the middle part of this section, it is necessary to avoid it for the location of powerhouse. Powerhouse Location - As the landslide was confirmed at the planned powerhouse location in TR2009 at the 2nd site reconnaissance on October of 2013, it is necessary to revise the location. Candidates for relocation are the 100m upstream (Location in FS2005) and 100m downstream from the original location. Based on the comparison study, the 100m upstream plan is selected Excavation Line - Semi-underground type for Francis is applied for the powerhouse. CM rock class was confirmed 6m below the ground surface in PB-04 and outcrops of sandstone are confirmed at the left bank slope and riverbed.
Items to be Studied for Construction Plan	Construction - Foundation rock of powerhouse is fresh sandstone and it is expected to be excavated by the vertical shaft method. Riverbed excavation around tailrace should be implemented during dry season. Waterstop countermeasures are required during rainy season. Construction Road - Construction road of 2km is arranged from the national road along the left bank of the Xenamnoy River. Temporary Yard and Disposal Area - Temporary yard is arranged at the west side of powerhouse and disposal area is arranged at the east side.

3.4.3 Procurement Survey of Construction Materials

Interview with an officer of the public construction company of national road was implemented to collect the current situation of construction materials procurement at Xe Katam site. This company had installed the crushing plant to produce crushing stones for the road subgrade at the 3km point from Houaykong. Rock material for the crushing stone is taken from the quarry near the plant by ground excavation. This plant will have been operated until 2014 and transferred to other place after the completion of road construction.

Materials	Procurement Situation
Rock	Rock materials of sandstone and basalt can be obtained from quarries. There are no suppliers of rock materials around Xe Katam due to few demand.
Crushing Stone (Aggregates, filter material and so on)	As there is little demand of crushing stone around Xe Katam site, there is only one crushing plant at Attapeu approximately 80km away from the site. Therefore, crushing stones are usually transported from Pakse. Unit price to purchase stones from the national road company are 35USD/m^3 (0–40 mm) and 15USD/m^3 (Over 40 mm). It is possible to discount in case of the purchase in bulk.
Sand (Fine aggregates)	As it is difficult to procure sand for fine aggregates of concrete, it is obtained and transported from the Mekong River at Pakse. Unit price at Pakse is 3.75USD/m^3 and transportation fee is also added.
Cement	Cement of Thailand is transported from Pakse.

Crushing Plant (1)

Crushing Plant (2)

Quarry of Basalt near the Crushing Plant

Concrete Mixing Factory at Pakse

CHAPTER 4

DESIGN

CHAPTER 4 DESIGN

4.1 Power Generation Study

In this Chapter, the optimization of power generation plan is implemented by determination of the general layout, preparation of the reservoir operation plan, selection of turbine types and optimization of the power generation scale. Salient features of the power generation plan in existing studies are shown in Table 4.1-1 and revisions from TR2009 are shown in Table 4.1-2.

Table 4.1-1 Salient Features of Existing Studies

Item	Year	Capacity (MW)	Discharge (m/s^3)	Effective Head (m)	Power Generation (GWh)	Power Supply
JICA	1992	6.0	4.8	162.0	40.0	Rural Electrification
HEC	1995	100.0	25.0	458.0	327.0	EDL
KANSAI F/S	2005	60.8	16.0	450.2	380.0	EGAT
KANSAI TR2009	2009	61.6	16.0	455.3	381.0	EGAT/EDL

Table 4.1-2 Revisions from TR2009 on Power Generation Plan

<table>
<tr><th>Item</th><th>KANSAI TR2009</th><th>This Study</th></tr>
<tr><td rowspan="2">Reservoir Operation
(Regulating reservoir Operation)</td><td rowspan="2">Study period: 20 years (1986–2007 except 1987, 1988 and 1998)
Annual average inflow: 12.2 m^3/s
NWL: 911 m</td><td>-Study period:26 years (1985–2014 except 1987, 1988, 1995 and 1998)
-Annual average inflow: 12.1 m^3/s</td></tr>
<tr><td>- Reservoir : NWLL: 911m
- Regulating reservoir: NWL: 771m (Run-of-River)</td></tr>
<tr><td>Power Supply</td><td>EGAT
EDL</td><td>EDL</td></tr>
<tr><td>Turbine Type</td><td>Vertical Pelton</td><td>Vertical Pelton
Vertical Francis</td></tr>
<tr><td>Power Discharge (m/s^3)</td><td>12, 14, 16, 18, 20m^3/s</td><td>16, 18, 20, 22, 24 m^3/s</td></tr>
</table>

4.1.1 General Layout

General layout of Xe Katam had been studied considering the layout comparison of alternatives in FS2005 and TR2009. Based on existing studies, general layout is determined. Outline of civil facilities (TR2009) are shown in Table 4.1-3.

Table 4.1-3 Outline of Civil Facilities of Xe Katam Site

Item	Dam and Waterway Type	Run-of-River Type
Diversion Weir	A diversion weir located at northwest part of the saddle dam diverts the Xe Katam River flow into the reservoir in the Nam Houng tributary. After diversion the water flows through the Nam Houng River. Height and crest level of the diversion weir are 3.2 m and 144.2 m respectively. An automatic discharge control gate is installed in the diversion weir to release environmental flow of 0.356 cu.m / sec to the Xe Katam River.	Omitted
Reservoir and Dams	Reservoir of Xe Katam project is located in a depression area of the Nam Houng River. Proposed reservoir area is a flat plain and requires a main dam and a saddle dam to impound water. Dam height and crest elevation of dams are 41.6 m and 449.8 m for the main dam and 15.3 m and 1,313 m for the saddle dam. Normal water level of the reservoir at full supply level (H.W.L) will be EL 911 masl and minimum operating level 890.5 masl. Its storage capacity is approximately 121 million m^3. Considering construction and procurement of embankment materials around the dam site, a Rockfill dam type for the main dam and a homogeneous earthfill dam type for the saddle dam are selected. A diversion tunnel with 4.5~4.6 m in diameter and 246 m in length is arranged in the left bank of the main dam. This tunnel will be utilized as a discharge facility with valves after completion of the dam construction works. A spillway will be placed on the main part of the saddle dam to release flood water.	Omitted
Intake Weirs	Water discharged from the reservoir through the discharge tunnel flows along the Nam Houng River and the Nam Houng River joins the Xe Katam River again at 5 km downstream. Intake weirs are located at approximately 6km downstream from the main dam where the Xe Katam River changes its river gradient from mild to steep. Two intake weirs are constructed at the Xe Katam River and the Dakproung River separated by the ridge. A channel is excavated to connect both rivers. Height and length of the both weirs are 9.8 m and 106.0 m for the Xe Katam River and 8.5 m and 73.0 m for the Dakproung River.	
Headrace Tunnel	Water for power generation flows into a headrace tunnel via an intake installed on the left bank of intake weir and a settling basin. The headrace crosses two streams where the route is selected so that earth cover of 30 m at the minimum can be provided. For a certain section where geological conditions deteriorate, a culvert is adopted. Total length of the tunnel with the diameter of 3.9 m is approximately 4.9 km and total length of the culvert is approximately 1.0 km. No pressure is applied under normal condition. In the emergency case including an accident at the power station, etc. however, hydraulic pressure corresponding to water level elevation in the head tank is applied. Support pattern of the tunnel shall be so designed as to secure safety under the hydraulic pressure and geological conditions.	
Head tank	Head tank which connect the headrace tunnel and penstock is located on the flat area at the edge of the left bank ridge of the Xe Katam River. A head tank is to adjust the flow in case of emergency stop and start of the powerhouse.	
Penstock	Penstock is aligned on the steep bank from head tank to powerhouse. The elevation of the water turbine center line is EL.285.40m. Generally it is desirable to align the penstock route in the shortest distance. However, there exist some areas with thick layer of talus deposits and terrace deposits along the slopes The alignment, particularly in the steep slope section, is set to traverse these areas in the shortest distance. Exposed type with anchor blocks is applied to the penstock. Length and diameter are 1273.6m and 2.2m respectively. Anchor blocks for foundation are placed on approximately every 150 m and saddle supports approximately every 18 m. Box culvert is installed at the crossing point with national road.	
Powerhouse	Powerhouse is located approximately 200 m downstream of the junction of the Xe Katam and the Xe Namnoy Rivers where the river course enters the Sekong River plains. Powerhouse building will be 14.5m × 29.0m and 42.55 m in height constructed as a semi-underground type. Switching facilities are located on the mountain side upstream of the powerhouse. Generated electricity will be sent to the Pakxong by a 115 kV transmission line along a route that follows the penstock and headrace tunnel into the Xe Katam valley then follows an alignment west to the Pakxong substation.	

4.1.2 Reservoir Operation Plan

In this survey, two (2) options have been studied. One is the concept with dam and another is the concept "Run-of-River" without dam and both are based on the layout of TR2009. The operational model of the reservoir and the daily regulating reservoir will be discussed in the following paragraphs.

(1) Water Balance Model of Reservoir Operation

Water balance of reservoir operation is shown in Figure 4.1-1. The main dam is generally located on the main stream and the intake is installed near the dam site. However Xe Katam site has unique features that the main dam is located on the tributary and the intake is located at the 6km downstream.

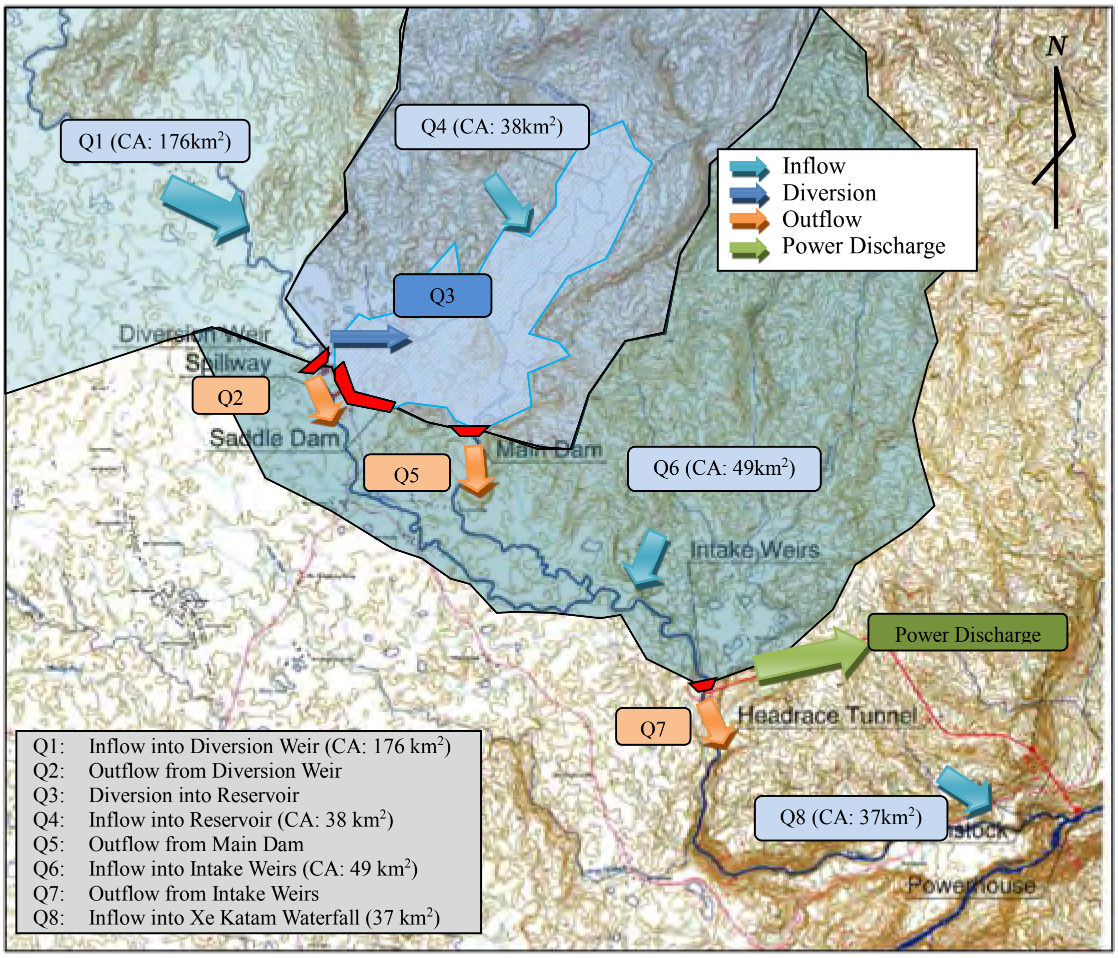
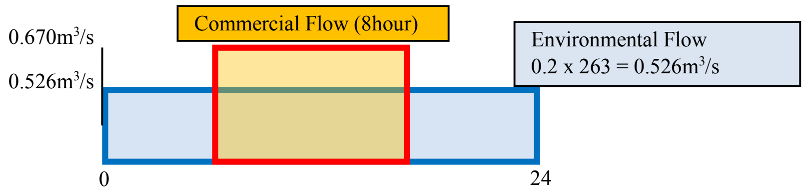


Figure 4.1-1 Water Balance Model for Reservoir Operation

Inflow (Q1) from the Xe Katam River is diverted into the reservoir (Q3) at the diversion weir. Discharge for power generation (Q5) is released to the downstream of reservoir and taken at intake weirs located at the 6km downstream (Power Discharge). Power Discharge flows into the powerhouse through 5.6km headrace tunnel, head tank and 1.3km penstock.

Input conditions for reservoir operation are shown in Table 4.1-4.

Table 4.1-4 Input Conditions for Reservoir Operation

Item	Input Condition
Inflow into Project Area	Annual Average Inflow: 12.1 m^3/s Period: 26 years (1985–2014 except 1987, 1988 ,1995 and 1998)
Maintenance Flow	Maintenance flow for downstream is composed of Environmental Flow and Commercial Flow. Environmental Flow: $0.2m^3/s/100km^2$ To maintain the minimum river flow for aquatic fauna and flora and livelihood of local residents Commercial Flow: $0.67m^3/s$, 8hour per day To ensure the minimum river flow for Xe Katam Waterfall 

(2) Water balance model of daily regulating reservoir (Run-of-River)

Figure 4.1-2 shows water balance model of daily regulating reservoir.

In the case of the option without dam, river water directly flows into the intake weir because there is no reservoir upstream (Q1). In the case that amount of water flowing into the intake weir exceeds the maximum power discharge, the balance between amount of inflow and the maximum power discharge in addition to maintenance flow is discharged to downstream. On the other hand, in the case that the amount of inflow is below the maximum power discharge, river water is stored in the daily regulating reservoir for peak operation. Input conditions are the same as in the case of the option with a dam.

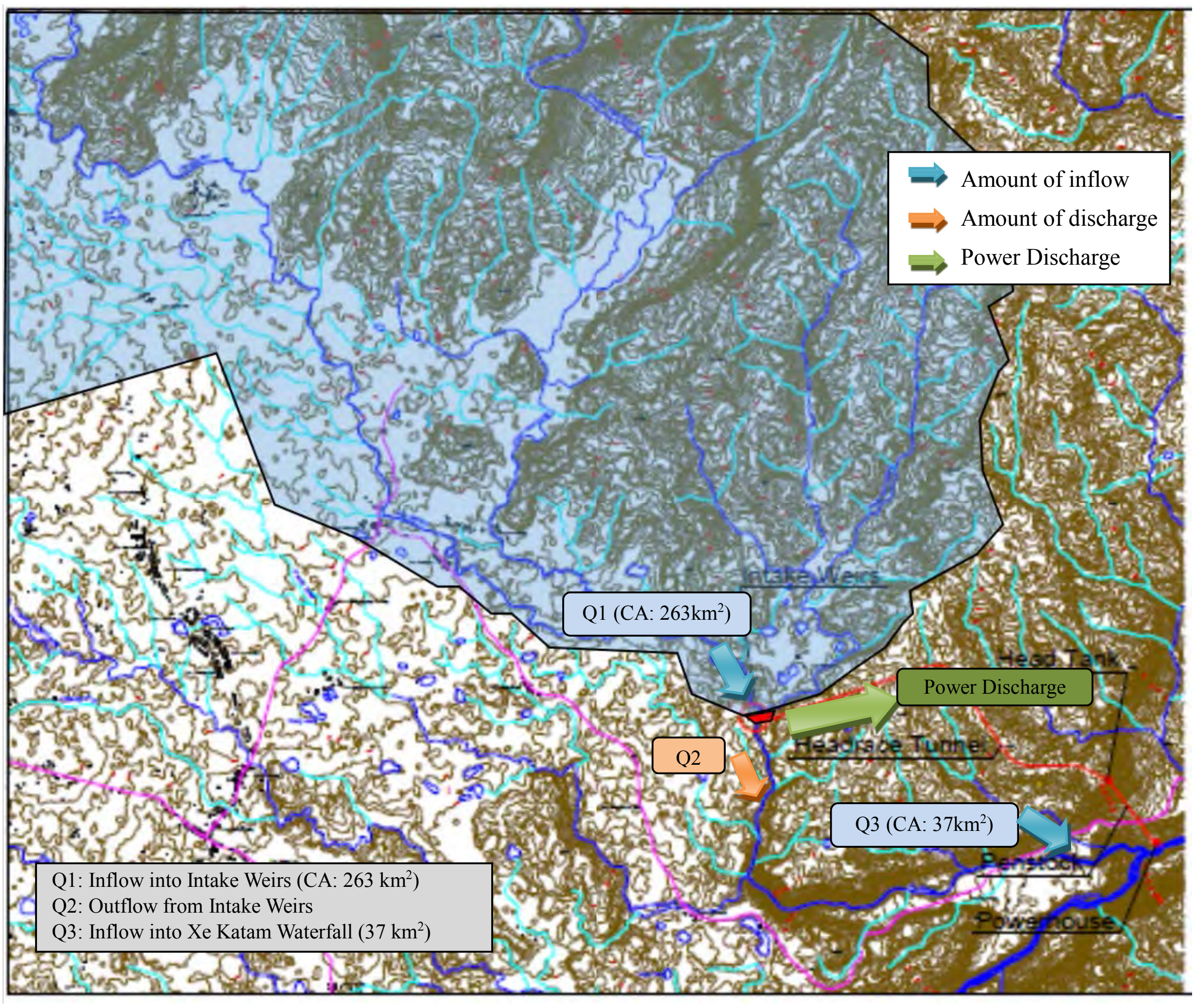


Figure 4.1-2 Water Balance Model of Daily Regulating Reservoir Operation

(3) Operation of Power Station

As this power station generates power during peak time zone, duration of peak time is set as 6 hours and water stored in a reservoir or daily regulating reservoir is used. Basic concept of operation of the power station is shown in Figure 4.1-3.

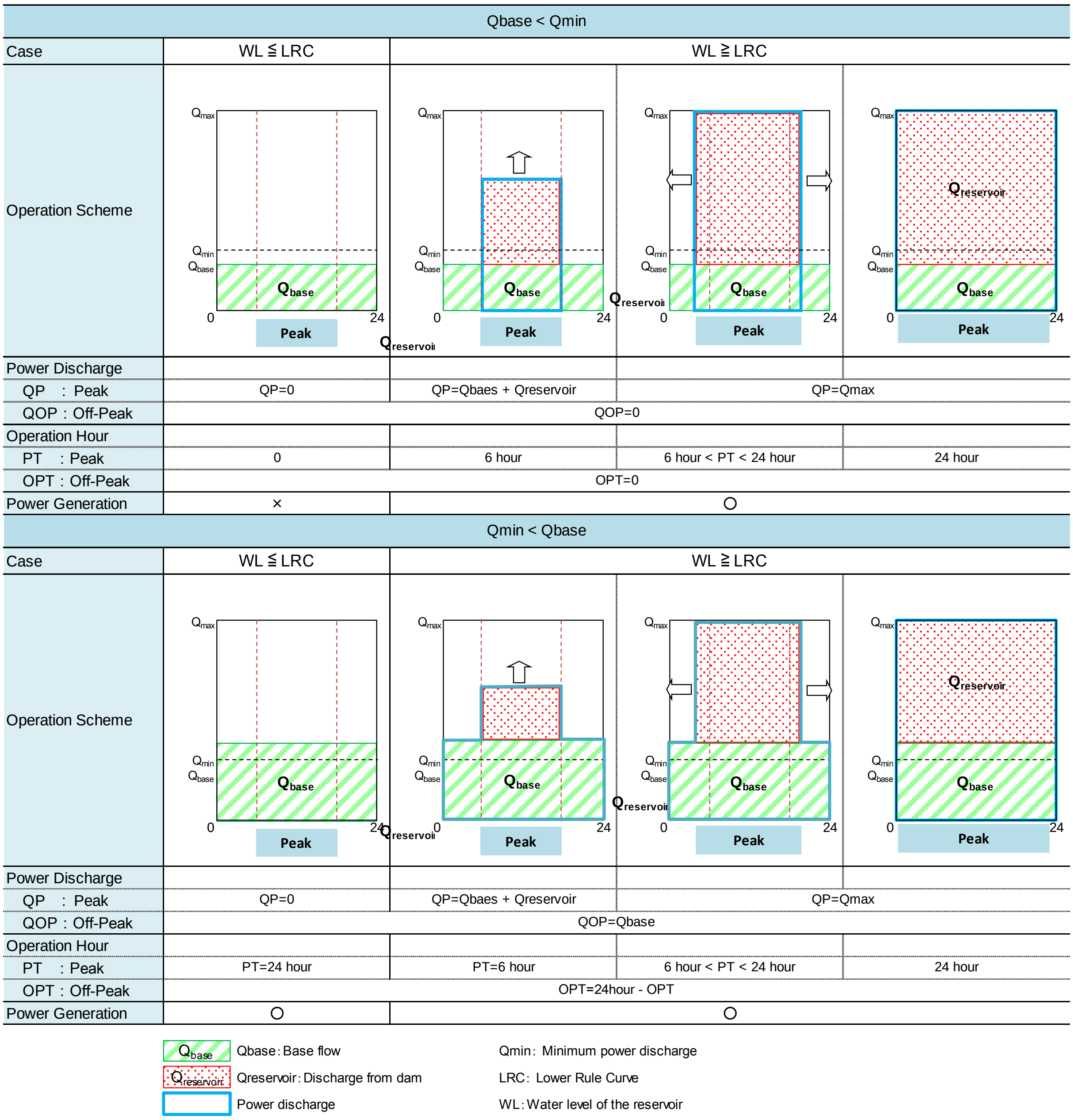


Figure 4.1-3 Concept of Operation of Power Station

4.1.3 Comparison Study of Turbine Types

(1) Outline of Turbine Types

Only Pelton type had been adaptable for Xe Katam project in existing studies. However, vertical Francis type can be adaptable for high head sites due to the latest improvement of manufacturing technology. Turbine type for Xe Katam site is determined through the comprehensive comparison considering power generation and construction cost.

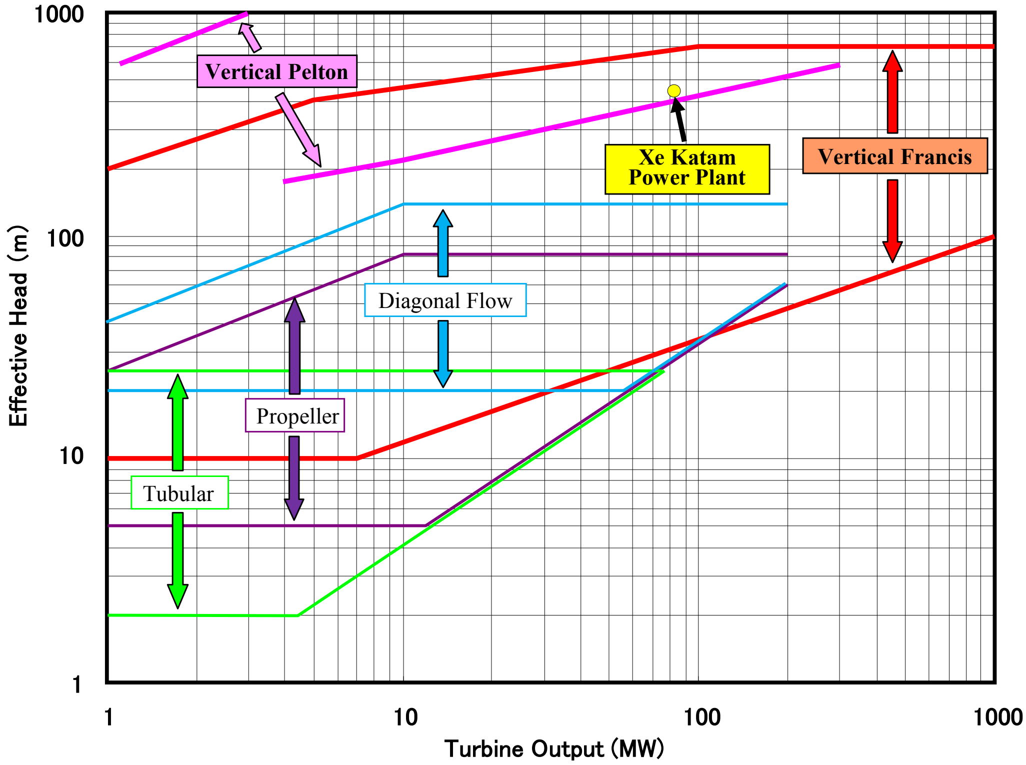
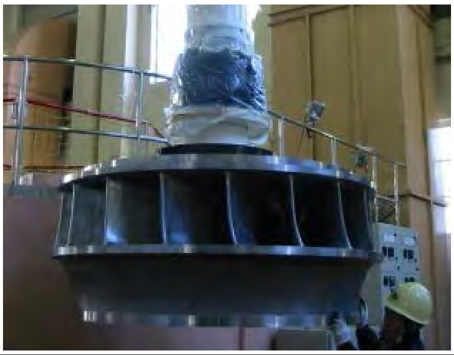
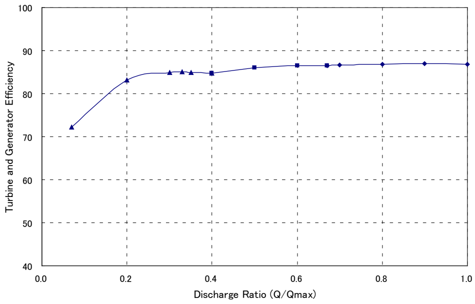
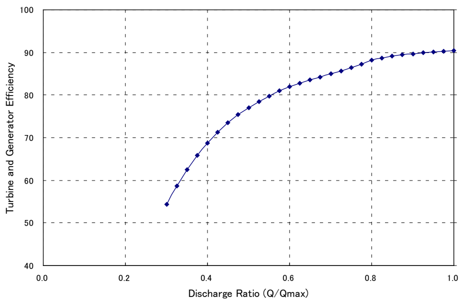


Figure 4.1-4 Turbine Selection Diagram

Table 4.1-5 Main Features of Pelton and Francis Turbines

		Pelton	Francis
Type of Turbine			
Output and power energy			
Output (Effective Head)		Fair (455.3m)	Good (458.0m)
Efficiency	Maximum Efficiency	Fair (86.3%)	Good (90.9%)
	Minimum Operational Discharge	Good (6.9%)	Fair (30.0%)
	Decrease of Efficiency by discharge	Good (flat)	Fair (strongly drop)
	Efficiency Curve of Turbine and Generator		
Construction Cost			
Turbine Equipment Cost		Fair (high cost)	Good (low cost)
Scale of Powerhouse		Fair (large)	Good (small)
Ancillary Facility (Spillway)		Good (no necessary)	Fair (necessary)

(2) Countermeasures for Overflow in Emergency Accidents

Although Pelton turbine can discharge the overflow by deflector release in case of sudden accidents such as emergency shutdown of equipment, countermeasures for overflow such as a spillway are necessary for Francis turbine. Following plans of countermeasures layout are proposed for Francis;

1) Discharge the over flow to the Xe Namnoy River through a spillway of box culvert laid in parallel with the penstock
2) Spillway omission by temporary pressured headrace tunnel

Outline of both plan is shown inTable 4.1-6.

Table 4.1-6 Outline of Countermeasures for Overflow

Plan	(a) Spillway of Box Culvert	(b) Spillway Omission
Feature		
Spillway	Installed	Not installed
Countermeasures	A spillway, which is conduit type, will be installed along the penstock. Excess water due to rapid shutdown will be discharged through the spillway to the box culvert.	Excess water will go upstream through the headrace tunnel so as to flow out at the settling basin.
Release Point	Near the Powerhouse	Intake
Additional Works for Facilities		
Headrace Tunnel	No Modification (Non pressure tunnel)	Additional tunnel support may be necessary to reinforce the tunnel against water pressures of the excess water.
Head Tank	Installation of the overflow section and raising of head tank wall	Raising of head tank wall against water level rising.
Spillway	Overflow section and box culvert	—

(a) Installation of the Spillway

Comparison between (1) and (2), (1) is assumed to be favorable in aspects of construction cost and works. However Xe Namnoy 5 and Xe Namnoy 6 hydropower projects have been developed by the Chinese company at the Houay Mackhan River. Therefore (2) is adopted in this study.

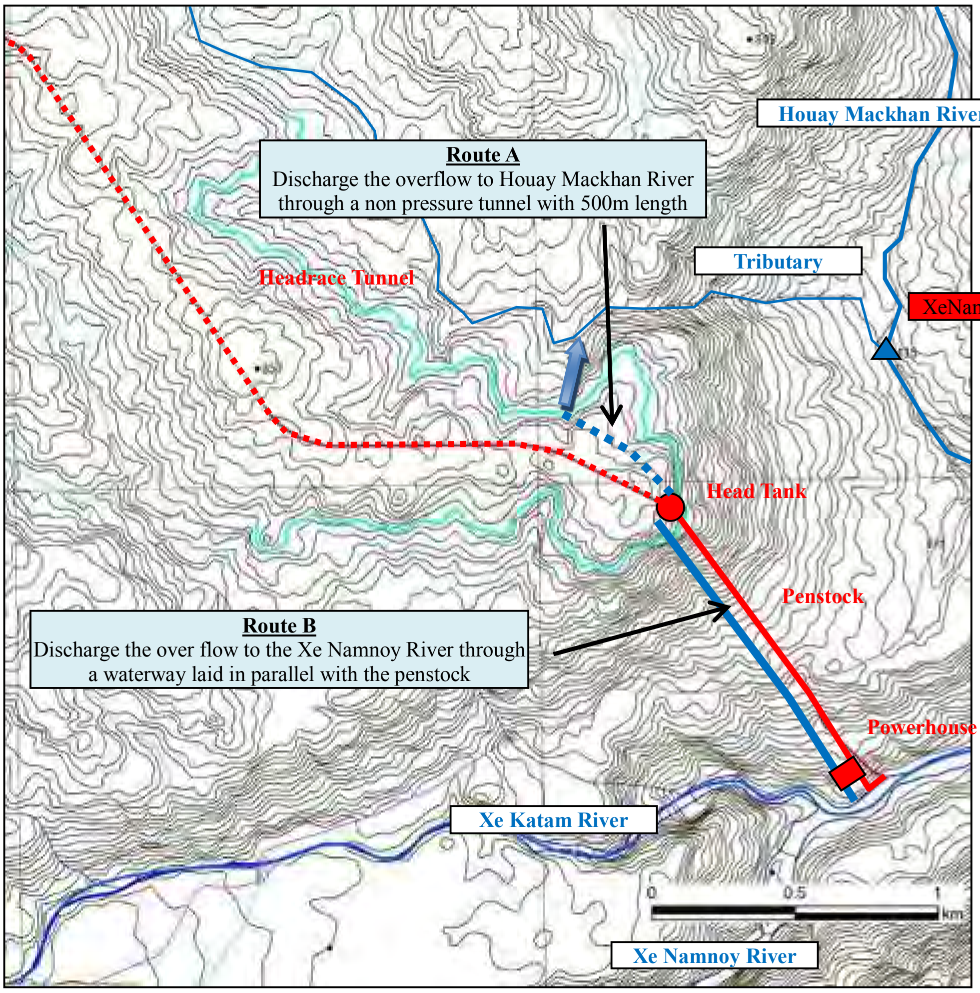


Figure 4.1-5 Plans for Spillway Route

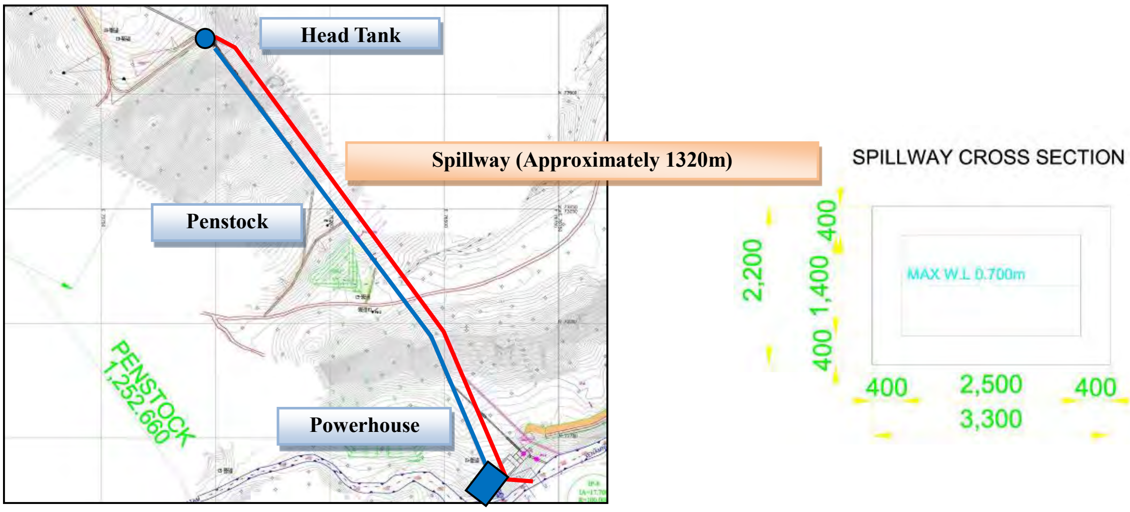


Figure 4.1-6 Plan of Spillway for Head Tank

(b) Spillway Omission

Generally, excess water due to rapid shutdown will be released by the spillway. In spillway omission plan, flows backward to the headrace tunnel and it finally reach to the water level of the settling basin. This method has been adapted to hydropower projects with high head in Japan.

Although reinforcement of tunnel supports is required against the temporary water pressure, construction cost is expected to be reduced drastically compared with the spillway construction. Details of reinforcement of tunnel supports are described in Section 3.2.4.

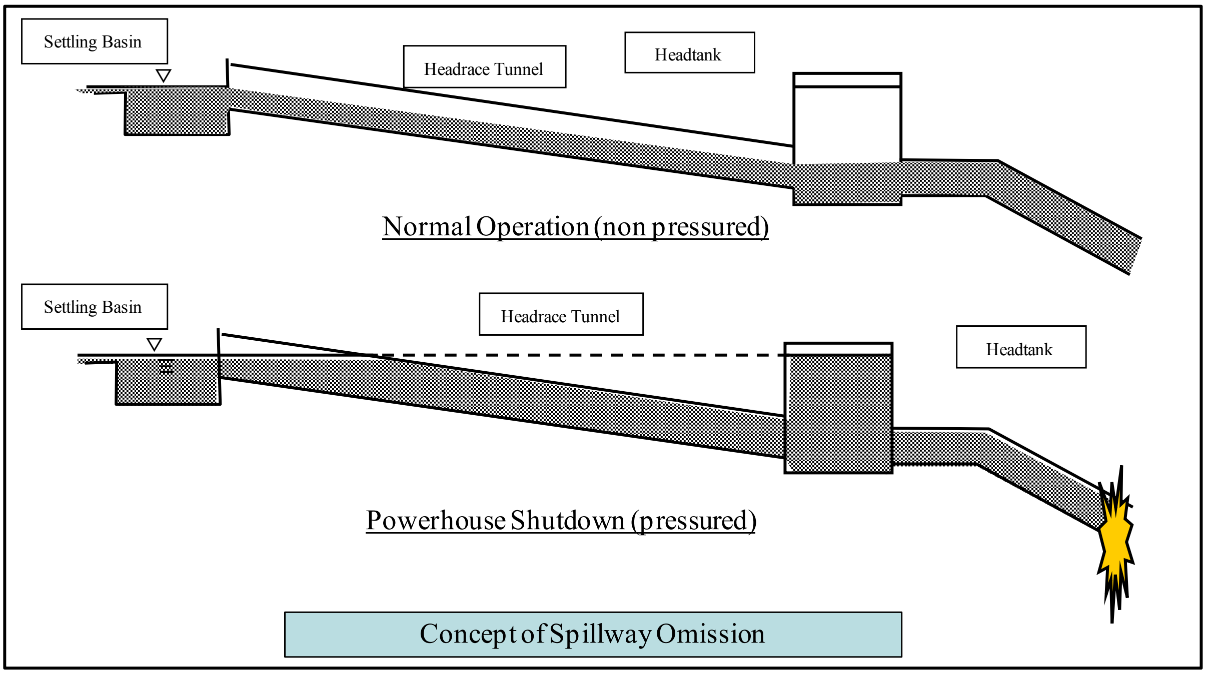


Figure 4.1-7 Concept of Spillway Omission

(c) Comparison of Countermeasures for Overflow

Results of the comparison of countermeasures for overflow are shown in Table 4.1-7. As spillway route is aligned on the steep topography, topographic risks such as the land slide are very high. Reinforcement of tunnel supports against water pressure is superior in construction and spillway omission is selected as the countermeasure for overflow at Xe Katam site.

Table 4.1-7 Comparison of Countermeasures for Overflow

Item		(a) Spillway by Box Culvert	(b) Spillway Omission
Cost		Poor	Good
Topography and Geology		Geological and topographic risks are significant, because the spillway will be installed along the penstock even though the area is narrow and steep.	Additional supports will be necessary, if the geology of the tunnel is poorer than estimated.
Overflow		Released at the vicinity of powerhouse.	If the overflow reaches to the intake, it released to the downstream of intake weirs.
Construction	Schedule	The installation of the spillway will be conducted in parallel to the other works and no significant impact will be given on the schedule.	A little impact will be given on the schedule due to additional works, if any, but the tunneling is not critical path.
	Works	Construction works are expected to be hard	None
Comprehensive Evaluation		Poor	**Good (Applied)**

(3) Comparison of Turbine Types

Annual power generation is estimated based on following conditions which are applied in TR2009.

Pelton and Francis are evaluated by the economical index of Rgc (Generation cost ratio: Project Cost / Annual Power Generation) which is calculated from the annual power generation and rough estimation of construction cost including overflow countermeasures.

Reservoir Operation: Refer to Table 4.1-8
Daily Operation: 24 Hour Operation and Peak Operation
Power Discharge: 16.0m^3/s

Table 4.1-8 Basic Parameters of Pelton and Francis

Turbine Type	Output (kW)	Effective Head (m)	Maximum Efficiency (%)	Minimum Operational Discharge Ratio (%)
Vertical Pelton	61,600kW	455.3 m	86.3%	6.9%
Vertical Francis	64,700kW	458.0 m	90.2%	30.0%

Table 4.1-9 Comparison between Pelton and Francis

Turbine Type		Pelton	Francis
24 Hour Operation	Annual power energy (GWh)	362.5	**358.7**
	Rgc	*1.00	**0.95**
Peak Operation	Annual power energy (GWh)	360.2	**373.6**
	Rgc	1.01	**0.911**

* Rgc of Pelton in 24 Hour Operation is set 1.0 as a standard value

As shown in Table 4.1-9, concerning the comparison of operation scheme, the annual power generation of 24 hour operation is slightly more than Peak operation in Pelton type which has low decrease of power generation efficiency by discharge fluctuation. Meanwhile, Peak operation is 4% more than 24 hour operation in Francis type which has high decrease of power generation by discharge fluctuation.

Concerning the comparison of turbine types, although annual power generation of Pelton is more than Francis in 24 hour operation, Rgc of Francis is evaluated than Pelton in both schemes. As a conclusion, Francis type is determined to be applied to the turbine type of Xe Katam site.

In this survey, turbine type was determined after comparison between peak operation and 24-hour operation. In view of power generation efficiency characteristics of Francis type, however, peak operation is desirable from the viewpoint of optimization of power generation.

4.1.4 Optimization of the Project Scale including Design of Civil and Electro-Mechanical Facilities

To determine optimum project scale for Xe Katam project, optimization study by using Rgc and kW unit cost (Project Cost / Installed Capacity) is implemented for each discharge in accordance with following conditions.

Reservoir Operation:	Refer to Table 4.1-4
Turbine Type:	Vertical Francis
Power Discharge:	16.0, 18.0, 20.0, 22.0, 24.0 m^3/s
Evaluation Criteria:	Rge (20 m^3/s in the case of the option with a dam is adopted as the reference.) Unit price/kW (20 m^3/s in the case of the option with a dam is adopted as the reference.)

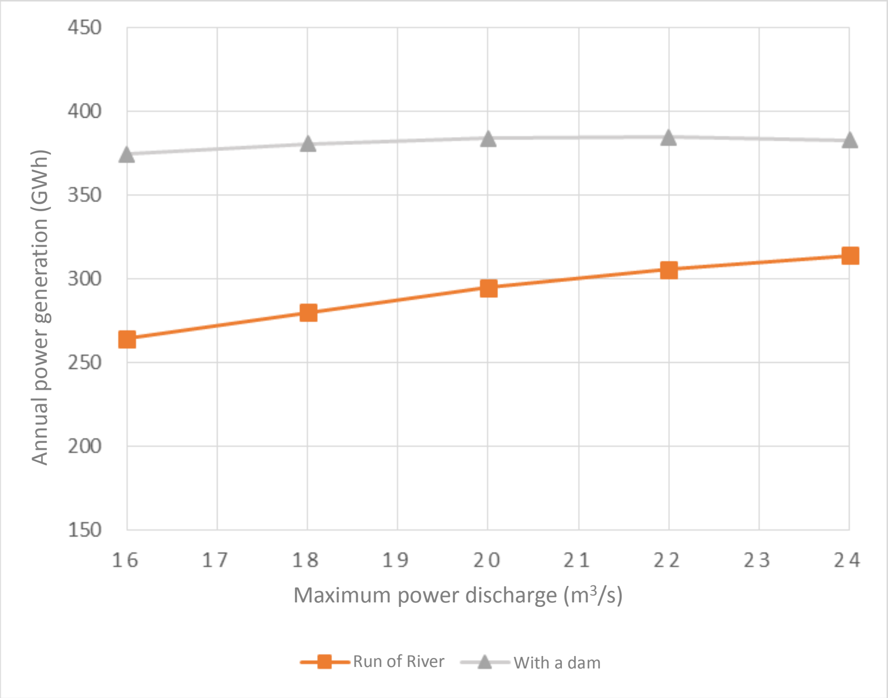


Figure 4.1-8 Annual Power Generation

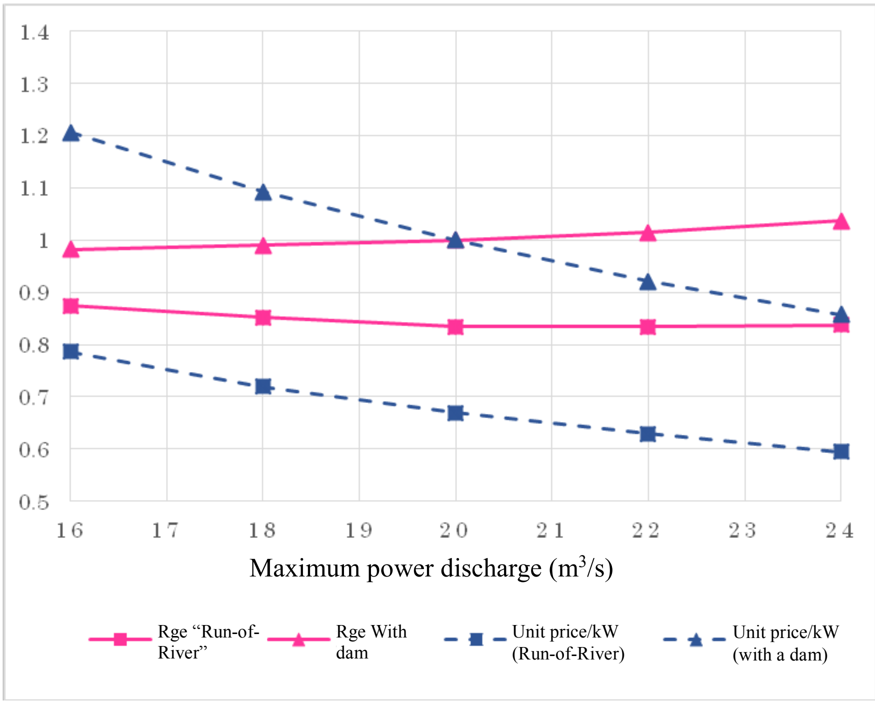


Figure 4.1-9 Results of Optimization Study (Rgc and kW Unit Cost)

Figure 4.1-8 and Figure 4.1-9 show annual power generation and results of calculation of economic viability assessment, respectively.

In the case of the option with a dam, the power plant can generate power during dry season with annual regulating. Therefore, the annual power generation is larger in the case of the option with a dam than that without dam.

The project cost is smaller in the case without dam because the facilities related dam and reservoir can be omitted in the case.
The value of economic indicator, Rge in the case of the option with a dam is smaller than that without dam. On the other hand, regarding amount of generated electricity during dry season, the option with a dam shows greater figure.
Based on the above results, the option without dam (daily regulating type) which is economically the most viable and the maximum power discharge of 20 m^3/s (81MW) were selected as an optimum project scale for Xe Katam project.

In the selected case, the effective head, turbine efficiency and generator efficiency under operating with maximum power discharge is 457m, 92.62% and 97.30%.

Table 4.1-10 Comparison of Two Cases of Same Maximum Power Discharge

Dam and Waterway Type			Run-of-River Type		
Maximum power discharge	:	$20m^3/s$	Maximum power discharge	:	$20m^3/s$
Annual power generation	:	383GWh	Annual power generation	:	299GWh
Project cost	:	100%	Project cost	:	64%
Rgc	:	1.00	Rgc	:	0.83

4.2 Design of Civil Facilities

Designs of civil facilities are implemented in this section. Major modifications from existing studies are as shown below.

- Change of power generation type (reservoir type → daily regulating type)
- Revision of Design Flood Discharge and High Water Level
- Revision of Geological Analysis
- Change of Turbine Type from Pelton to Francis
- Shift of Power Discharge from 16 m^3/s to 20 m^3/s

Basic characteristics of major structures are as shown below:

Table 4.2-1 Basic Characteristics of Major Structures

Name of structure	Item	Unit	Parameters
Intake weir	The size of a catchment area	km^2	263
	Annual average inflow	m^3/s	12.1
		mill.m^3	380.3
	Dam type	-	Gravity
	Dam height (Main River)	m	9.8
	Crest length (Main River)	m	106.0
	Dam height (Branch)	m	8.5
	Crest length (Branch)	m	73.0
Headrace Tunnel	Design flow rate	m^3/s	20
	Length of tunnel	km	4.9 (Non Pressure during normal operation)
	Inner diameter	m	3.9 (Hood shape)
	Length of culvert	km	1.0 (Non Pressure during normal operation)
	Width	m	3.2
	Height	m	3.0
Penstock	Type	-	Exposed steel pipe
	Length of steel pipe	m	1,263
	Inner diameter	m	2.2
Powerhouse	Type	-	Semi-underground type
	Design discharge	m^3/s	2,630
	Gross head	m	475.4
	Effective head	m	457
	Type of water turbine	-	Francis
	Rated output	MW	81
	Annual power generation	GWh	299

4.2.1 Intake Weirs

(1) Location of Intake Weirs

Intake weirs are located at 500 m upstream of the junction of the Xe Katam River and the Dakproung River from the following reasons.

- Intake weirs are installed just before the river gradient of the Xe Katam River becomes steep, to get the head effectively between the intake and powerhouse.
- Water of the Dakproung River (catchment area: 49 km^2), a tributary of the Xe Katam River, can also be diverted.
- Crest length of intake weirs can be shortened separating weirs by the ridge between the Xe Katam and the Dakproung Rivers.
- There is the topographically and geologically suitable site for the intake, settling basin and portal of the headrace tunnel on the left bank of the Dakproung River.

Crest length of the Xe Katam River side is 106.0 m and that of the Dakproung River side is 73.0 m. Since the intake is installed on the left bank of the weir at the Dakproung River, a connecting channel is placed at the ridge to divert the inflow of the Xe Katam River to the intake. Layout Plan of intake weirs is shown in Figure 4.2-1.

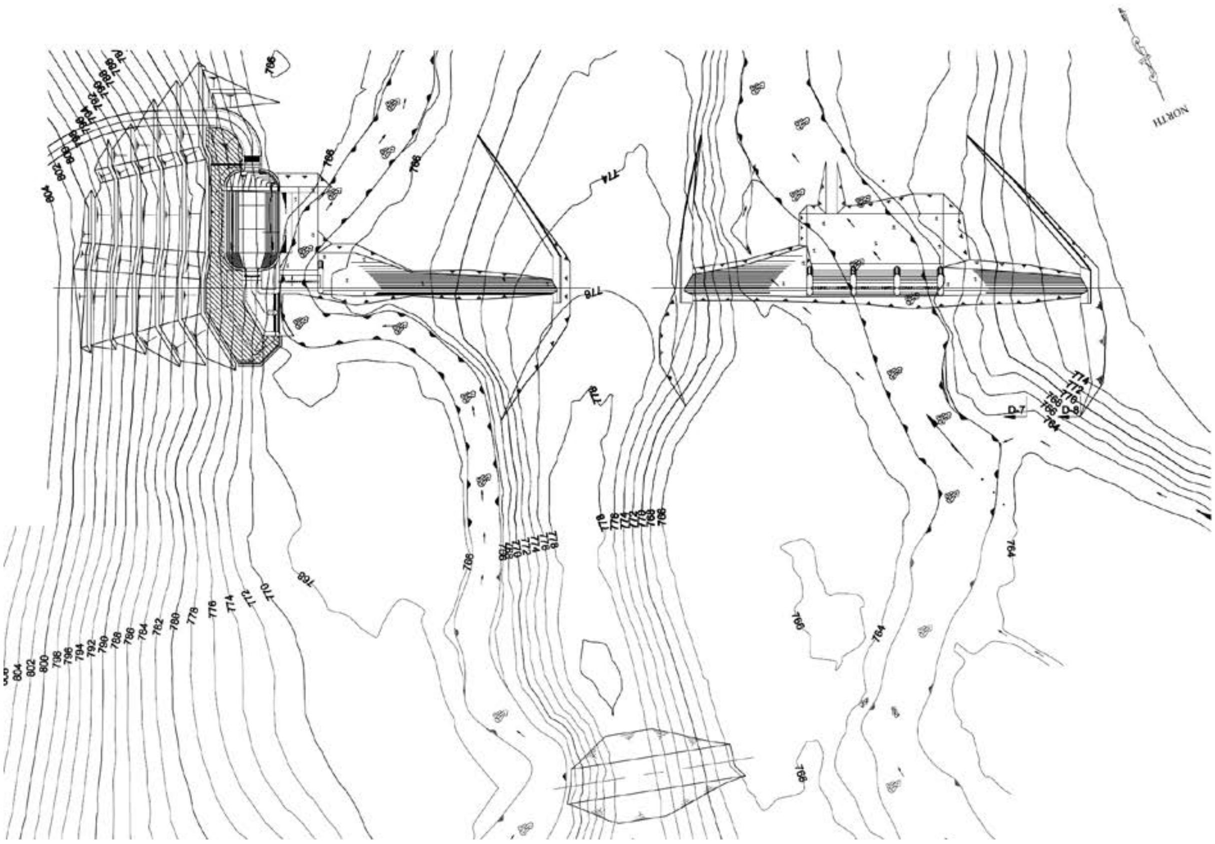


Figure 4.2-1 Layout Plan of Intake Weirs

(2) Type of Intake Weirs

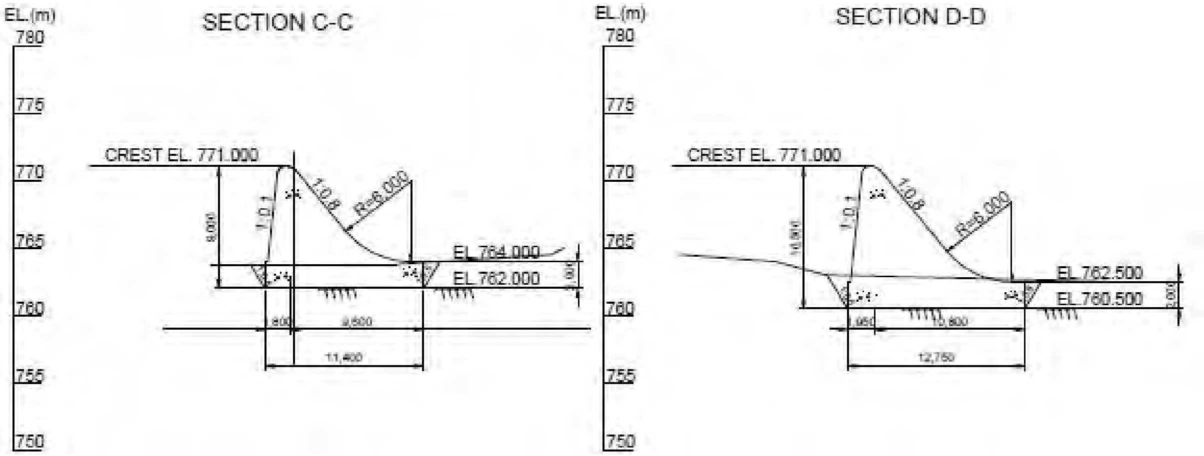
At the selected place, rock outcrop of basalt was observed on the riverbed. Since the weirs are of relatively small scale as the height of both weirs is 8.5 m (left weir) and 9.8 m (right weir), respectively, gravity type concrete intake weir is adopted. Since it will be operated as a daily regulating reservoir, three (3) spillway and scour gates shall be installed on the right bank and one (1) spillway and one (1) scour gate shall be installed on the left bank.

(3) Basic Design of Intake Weirs

There are hard basalt 1.0 - 1.5 m beneath from the ground surface around riverbeds of the Xe Katam and the Dakproung Rivers. However, abutments of both banks are deeply weathered. Accordingly, both abutments shall be excavated down to around 5 m, to contact with the bedrock that is assumed to be in the lower part of the weathered layer. Typical cross sections of weirs are shown in Figure 4.2-2.

Crest elevation and the intake water level are planned to be EL. 771 m in consideration of the permeability of the right bank of the Xe Katam River. Depending on the geological condition, foundation treatment by grouting or replacement with impermeable materials is required. Design discharge at the weir intake was set at 890 m^3/s which is the discharge of 1000-year probable flood.

It is confirmed that there is no problem with stability on overturning, sliding, and bearing capacity of both weirs.



(Dakproung River) (Xe Katam River)

Figure 4.2-2 Typical Cross Sections of Intake Weirs

(4) Appurtenant Facility

As mentioned in Section 3.2, it is assumed that the amount of sediments at the site Xe Katam is small. Taking increase of inflow sediments due to future change of land use at upstream area and maintenance after commencement of operation into consideration, however, one (1) scour gate with the width of 10 m and the height of 5.0 m shall be installed at the side of the Dakproung River and three (3) same gates shall be installed at the side of the Xe Katam River. Sill level of the flushing gate is planned to be 1 m lower than the sill level of the intake. The flushing gate will also be utilized to discharge environmental flow to downstream including the inflow for the preservation of landscape at Xe Katam Fall.

4.2.2 Intake

(1) Location

The intake is located on the left bank of the Dakproung River just upstream of the intake weir as shown in Figure 4.2-3.

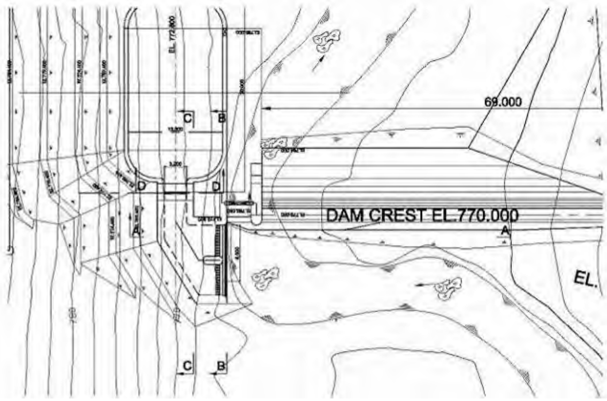


Figure 4.2-3 Layout Plan of the Intake

(2) Basic Design of the Intake

The side intake method is adopted, whereby maintenance is easy and intake is secured.

Weathered sandstone is distributed at the intake site and its thickness is assumed to be around 3 - 4 m. Bottom of the intake structure is placed to contact with the sound sandstone beneath the weathered one by approximately 3 - 4 m excavation from the ground surface.

In order to facilitate the debris removing work of the screen, it is preferable to reduce flow velocity less than 1.0 m/s. For this purpose, the shape of the intake is planned to be 5.0 m in height, and 10.0 m in width, which controls the flow velocity of 0.7 m/s at the maximum plant discharge of 20 m^3/s. Sill level of the intake is EL. 766 m. Front view of the intake is shown in Figure 4.2-4.

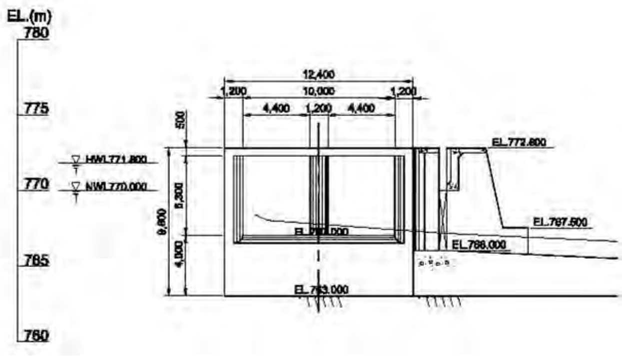


Figure 4.2-4 Front View of the Intake

(3) Appurtenant Facility

In front of the intake, a screen shall be equipped to prevent any driftwood, trash, etc. from flowing into the settling basin. In addition, at the back of the intake screen, one (1) intake gate with automatic discharge control device of 3.2 m in width and 3.2 m in height is installed.

4.2.3 Settling Basin

Considering the increase in sediment inflow as mentioned above, a settling basin is installed for the purpose of preventing any sediment inflow into the headrace. When sediment is accumulated in the settling basin, the sediment is to be discharged through a sand flushing gate.

(1) Location

The settling basin is located at downstream of the intake, in parallel with the river channel. This location enables to discharge the sediment deposited in the settling basin easily to the downstream of the weir and to reduce the amount of cutting slope at the eastern side. Layout plan and cross section of the settling basin are shown in Figure 4.2-5.

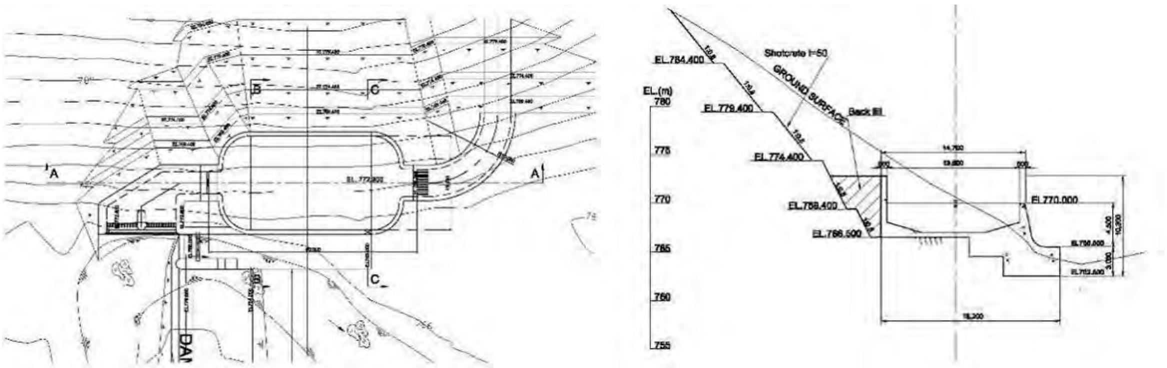


Figure 4.2-5 Layout Plan and Cross Section of the Settling Basin

(2) Basic Design of the Settling Basin

The settling basin is a facility used for settling suspended load by its own weight. In order to increase the settling effect, it is required that the flow velocity be reduced and the disturbance in flow be made smaller. Generally it is said that the settling effect is high if the flow velocity becomes around 0.3 m/s. Furthermore, as the limit sedimentation rate (Vg) for the finest sand grain to be settled down, it is said that around 0.1 m/s of the flow velocity is appropriate for the normal grain diameter of d = 0.5 ~ 1.0 mm.

For this reason, its shape is planned to be 13 m in width, 5 m in height, and 30 m in length, and the flow velocity in the settling basin to be around 0.3 m/s.

$$
\begin{aligned}
L &\geq (h / Vg) * u \\
&\geq (5 / 0.1) * 0.3 \\
&\geq 15.0 \text{ (m)}
\end{aligned}
$$

where, L : Minimum length required for the settling basin (m)
h : Water depth in the settling basin (m) = 5 m
(Determined by N.W.L and the shape of the settling basin)
u : Average flow velocity in the settling basin (m/s) = 0.3 m/s
Vg : Limit sedimentation rate for the finest sand grain to be settle down (m/s) = 0.1 m/s

Practically, length of the settling basin shall be set more than double of the length calculated by the above formula in consideration of the effect of the side stream, and be 30 m (= 15m * 2).

Based on the relation of $Q \leq b*h*u$,

$$
\begin{aligned}
b &\geq Q / (h * u) \\
&\geq 20.0 / (5 * 0.3) \\
&\geq 13.3 \approx 13.5 \text{ (m)}
\end{aligned}
$$

where, b : Width of the settling basin (m)
Q : Maximum plant discharge (m^3/s) = 20.0 m^3/s
h : Water depth in the settling basin (m) = 5 m
u : Average flow velocity in the settling basin (m/s) = 0.3 m/s

(3) Appurtenant Facility

In order to discharge the sediment deposited in the settling basin to the downstream river, a flushing gate of 1 m in width and 1 m in height shall be installed. Its sill level shall be EL. 765 m.

At connecting point with the headrace tunnel, to prevent any inflow of debris that could not be removed with the intake screen, a screen of 3.9 m in width and 3.35 m in height shall be installed.

4.2.4 Headrace Tunnel

(1) Alignment of Headrace

Headrace tunnel is aligned along the ridge extending eastward of the intake. The head tank is located approximately 5.9 km away and on EL. 770.0m. Headrace tunnel alignment is determined considering the utilization of head between the intake sill of EL. 766.335 m and powerhouse and overburden above the tunnel.

(2) Type of Headrace Tunnel

Figure 4.2-6 shows the headrace alignment. Along the headrace alignment, drilling work (WB1) is carried out at the gully about 1.3 km east of the intake. According to the drilling results, it is expected to be covered with an approximately 10m ground surface overburden layer of weathered sandstone and to be a sound sandstone layer below it.

As a result of geological reconnaissance, it is assumed that there is the same geological condition along the alignment with enough thickness of overburden. As the tunnel can basically be passed through the sound sandstone layer, tunnel type is selected for the headrace of Xe Katam site.

There are several sections where the overburden and/or rock cover becomes 30 m or less with around 870 m in length. In addition there exist a few sections where the overburden becomes 20 m or less around 400 m in total.

Meanwhile, the softened bedrock by weathering is confirmed at around 32 m in depth according to the drilling works (WB-3) in thin overburden area (thickness around 20 m) where is located at the around 0.4 km upstream from the head tank. It is planned that the thin overburdened sections of 870 m will be excavated by the conventional method using steel ribs and laggings, and lined with concrete to reinforce the tunnel.

In order to mitigate geological risk as far as practicable in the section where the earth covering is not more than 30 m, the comparison study between the options of tunnel and culvert was performed. Table 4.2-2 shows the results of this study. Based on the results of this study, a plan that the headrace of 5.9 km shall consist of a tunnel of 4.9 km and a culvert of 1.0 km is adopted.

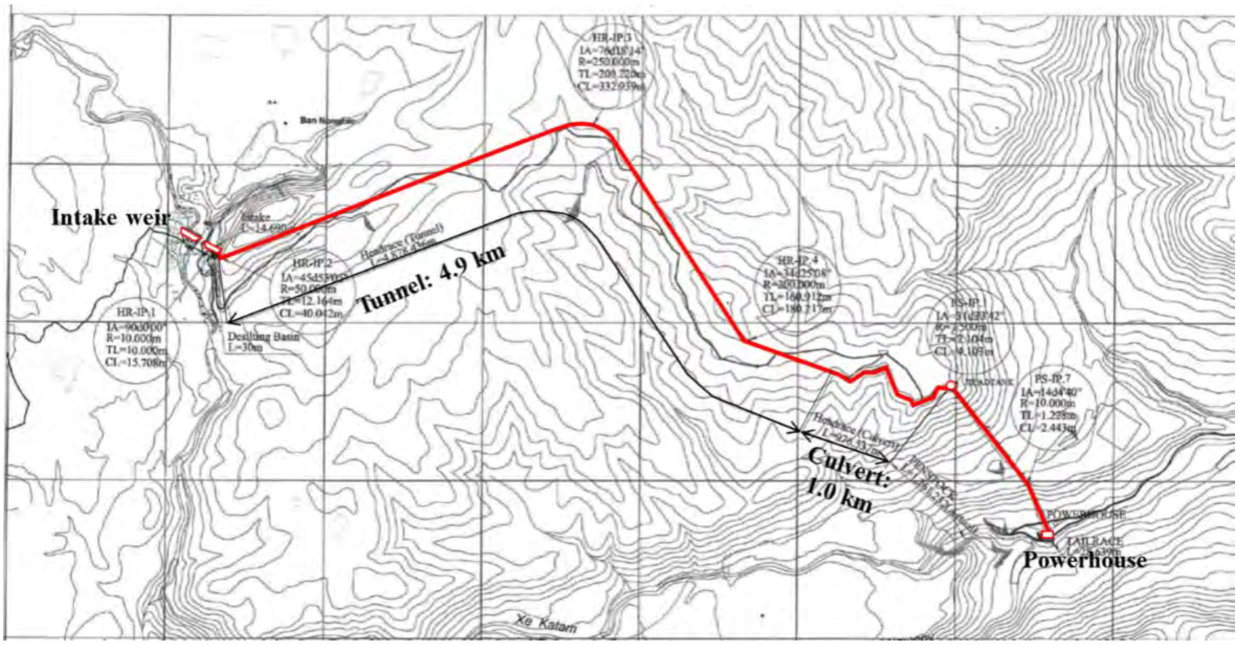


Figure 4.2-6 Headrace Tunnel and Culvert Route

Table 4.2-2 Comparison Study of Options

Item	"Tunnel" Option		"Tunnel + Culvert" Option	
	Parameters	Cost*	Parameters	Cost
Tunnel	5.6 km	1.0	4.9 km	0.8
Lateral pile	2 places	1.0	1 place	0.5
Culvert	-	-	1.0 km	1.0
Volume of generated soil	97,000 m^3	1.0	153,000 m^3	1.6
Evaluation	×		○ (Adopted)	

* Suppose the reference value in the case that the "Tunnel" Option is adopted for the entire part as 1.0.

(3) Basic Design of the Headrace Tunnel

(a) Typical Section

The maximum plant discharge for power generation is 20 m^3/s. Tunnel gradient is 1/1,000 and the roughness coefficient is 0.0125 in the concrete section and 0.025 in the shotcrete section. Flow velocity is calculated to be 1.7 m/s by using Manning's equation to determine the flow cross-sectional area of the headrace.

Based on the above cross-sectional area, the shape of the tunnel is planned to be of a "D" shape of 85% in water depth, 3.90 m in width, 1.95 m in upper radius, and 1.95 m in lower rectangular height.

The discharge area of culvert was determined, assuming that the gradient is 1/1,000 and the roughness coefficient of concrete is 0.0125 in the way similar to that for the tunnel and the dimension of its rectangular cross section was determined to be W = 3.2 m and H = 3.0 m at water depth of 80%.

(b) Tunnel Support

Tunnel excavation is implemented by NATM method during sections of sound geological conditions. Tunnel support patterns such as the thickness of shotcrete, number of rock bolts and length are arranged based on actual conditions. As mentioned in Section 4.1.3, spillway omission is applied to the countermeasure of overflow in case of emergency accidents at the powerhouse.

Therefore tunnel supports should be designed considering the temporary water pressure which occurred by the backward flow to the tunnel and water level rising at the head tank. The maximum operating head of internal hydraulic pressure is EL.770.8 m which is equivalent to overflow water depth of sediment basin spillway, approximately 8 m from the height above the sea level of crest exit of headrace, EL. 763.382 m.

Typical tunnel support patterns for each section are designed based on the frame structure analysis considering following matters

- Water pressure at each section
- Resistance of the shotcrete lining against the water pressure (Type A, B, C and C-1)
- Resistance of the concrete lining against the water pressure (Type D)
- Required thickness of shotcrete and concrete lining
- Steel bar arrangement if necessary

Concept of the frame structure analysis and water pressure is shown in Figure 4.2-7 and typical support patterns are shown in Table 4.2-3.

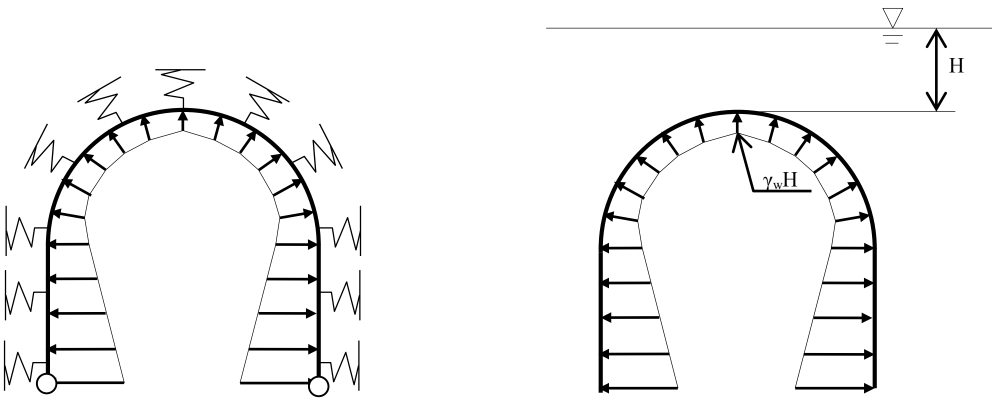
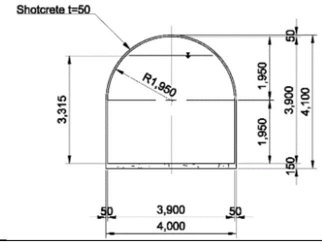
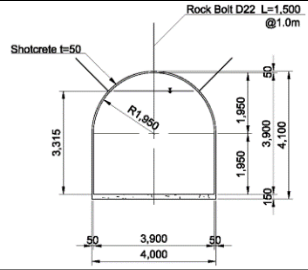
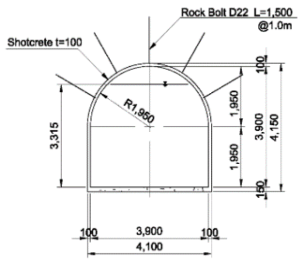
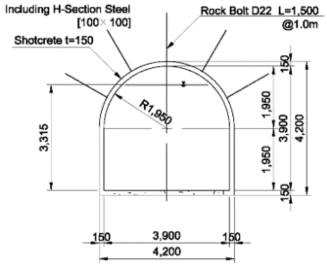
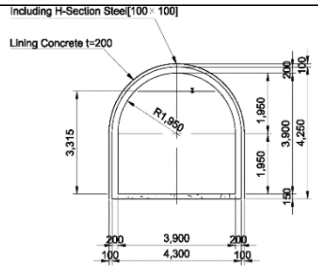
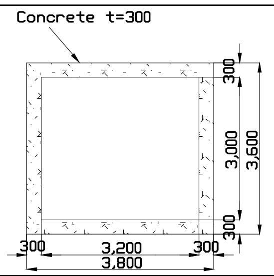


Figure 4.2-7 Concept of Frame Structure Analysis Water Pressure

Table 4.2-3 Support Patterns of Headrace Tunnel

Support Type (Rock Class)	Design of Open Channel (non pressure)	Spillway Omission: Design	Spillway Omission: Water Pressure H*	Example of Support Pattern
Type A (CH Class) only Shotcrete	Shotcrete Thickness :5cm	Shotcrete Thickness :5cm	0m ≤ H ≤ 7m	
Type B (CM Class) Shotcrete and Rock Bolt	Shotcrete Thickness :5cm	Shotcrete Thickness :5cm	0m ≤ H ≤ 4m	
		Shotcrete Thickness :10cm	4m < H ≤ 7m	
Type C (CM-CL Class) Shotcrete and Rock Bolt	Shotcrete Thickness :10cm	Shotcrete Thickness :10cm	0m ≤ H ≤ 6m	
		Shotcrete Thickness :15cm	6m < H ≤ 7m	
Type C-1 (CL Class) Shotcrete, H-Section Steel and Rock Bolt	Shotcrete Thickness :10cm	Shotcrete Thickness :10cm	0m ≤ H ≤ 4m	
		Shotcrete Thickness :15cm	4m < H ≤ 6m	
		Shotcrete Thickness :20cm	6m < H ≤ 7m	
Type D (D Class) Lining Concrete and H-Section Steel	Lining Concrete Thickness :20cm	Lining Concrete Thickness :20cm	0m ≤ H ≤ 5m	
		Lining Concrete Thickness :20cm + Steel bar 2×D16@ 250	5m < H ≤ 7m	
Culvert	Thickness of concrete: 30 cm	Thickness of concrete: 30 cm + Reinforcement bar D25@250	7m < H ≤ 8m	

*: H (m) is shown in the head of tunnel crown

(4) Appurtenant Facility

There are one adit tunnel at approximately 2.8km from the intake.

The work adit will be utilized as an inspection passage after the completion of construction work by providing a steel-made door at the junction of the headrace. In addition, it is used as a facility to discharge spring water that occurs at the time of dewatering tunnel and as a flushing facility.

Around the flushing facility, a sand and rock trap is installed to store the sediments, boulders, etc. temporarily which flow into the tunnel.

4.2.5 Head Tank

(1) Location

Head tank which connect the headrace tunnel and penstock is located on the flat area at the edge of the left bank ridge of the Xe Katam River.

(2) Basic Design of the Head tank

(a) Geology at Head tank Site

According to the results of a test pit of 5 m in depth (HTP1) carried out in the vicinity of the head tank, the site is covered with surface soil layer of 2.5m, a gravel layer of 0.5m and hardly weathered sandstone layer. Furthermore, according to the drilling work in the center of head tank (HB-1), hard sandstone can be observed in the depth of 7.0 m and below.

Therefore it is confirmed that there is no troubles with the foundation of head tank. Since the foundation slab of the head tank is located about 20 m below the ground surface, it is expected to be contacted with a sound bedrock.

At the back of the head tank, there will be a cutting slope having a height of around 20 m. Although the surface layer soil around the head tank is composed of soft sediments, the landslide is not to be occurred because of the flatness of the geological structure.

(b) Head tank Surface Area

If the water surface area of the head tank is too small in relation to the power discharge, the water level of the head tank changes rapidly and gaps between actual water level and regulated level for the turbine becomes larger. It causes hunting affect which leads troubles with the operation of the powerhouse. According to the guideline of New Energy Foundation (NEF) in Japan, necessary water surface area to prevent it is calculated by Figure 4.2-8.

The result of calculation of the required water area is shown below.

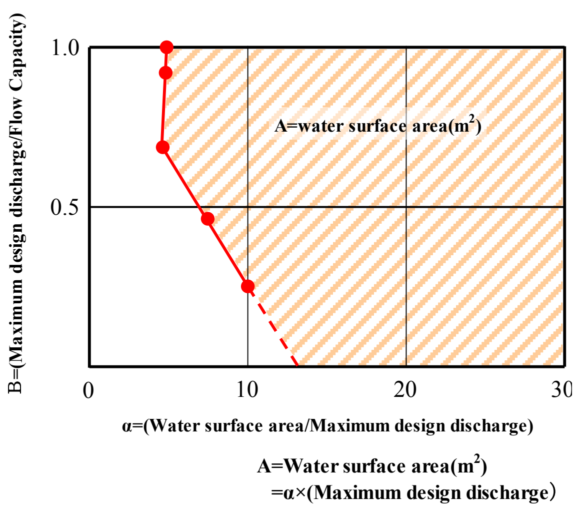


Figure 4.2-8 Required Area for the Head Tank

Maximum design discharge = 20.0 m^3/s
Flow capacity =20.643 m^3/s

B= 0.97 and α=5.0 are obtained from above diagram and the required area is derived at 100.0 m^2. Considering the margin and head tank capacity mentioned below, diameter of the head tank is determined at 13 m.

(c) Capacity of the Head tank

Required height between the water level of the head tank and the top of the penstock pipe is generally twice of the penstock diameter or more for the purpose of preventing air intake into the penstock and the occurrence of vortexes in the head tank. In this design, there is a difference in altitude of 5.0 m or more between the water level of the head tank and the top of the penstock, which is more than twice the penstock pipe diameter of 2.2m.

When the supply of water to the head tank stops and an abnormal decrease in water level in the head tank occurs, equipment in the powerhouse is closed in response to the water level change. Capacity of the head tank is designed to supply the water for the prevention of air mixing into the penstock during the turbine closing.

Emergency stop capacity = Ve = 1/2 * T * Qm = 110 m^3

Where, T is 11 seconds as the closing time, and Qm is 20.0 m^3/s as the maximum power discharge. The decrease in water level corresponding to this capacity is 0.95 m. It is generally assumed that emergency stop of the generator start in response to a decrease in water level of the head tank when the water level decreases around 1.0 m. By adding to a camber of around 0.3 m as the water level adjustment operation, the decrease in water level at the time of emergency stop is planned to be h= 0.95 m + 1.0 m + 0.3 m = 2.25 m.

Since the difference in height between the water level of the head tank (EL.762.797 m) and the top of the penstock pipe at the starting point (EL.757.282 m) is 5.515 m, the height becomes h' = 3.265 m, and thus the required head tank capacity can be secured. Lowering of the water level at the head tank is shown in Figure 4.2-9.

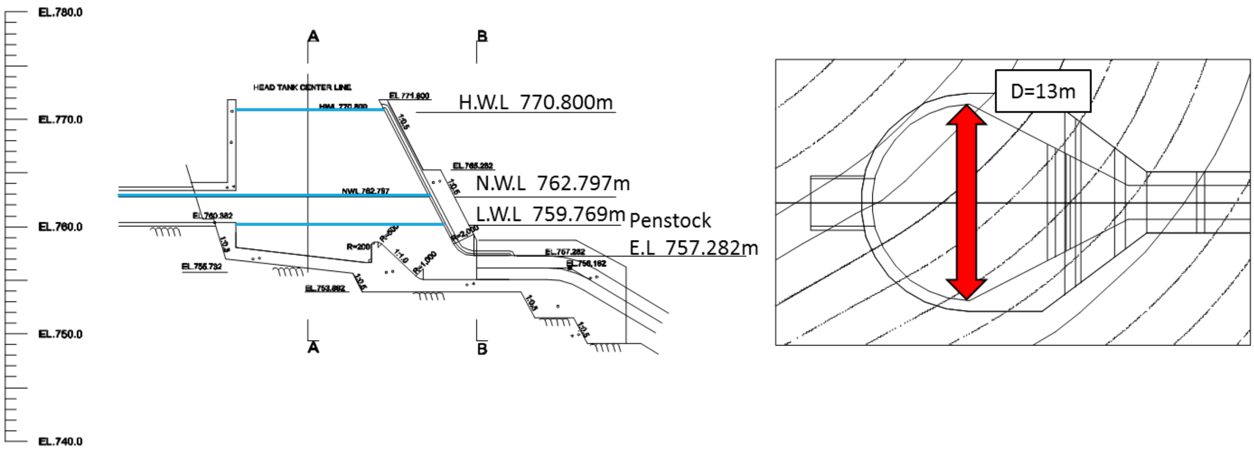


Figure 4.2-9 Lowering of the Water Level at the Head Tank

(3) Appurtenant Facility

Screens are not installed in the head tank, because they are installed in the intake weirs and settling basin. In addition, the entire headrace is a tunnel and extraneous materials are not supposed to be mixed. A submerged weir is installed to prevent the abrasion of penstock by the sand. Accumulated sand is discharged to the outside through the flushing pipe and gate.

4.2.6 Penstock

(1) Alignment of Penstock

Penstock is aligned on the steep bank from head tank to powerhouse. The elevation of the water turbine center line is EL.286.1 m.
Generally it is desirable to align the penstock route in the shortest distance. However, there exist some areas with thick layer of talus deposits and terrace deposits along the slopes. The alignment, particularly in the steep slope section, is set to traverse these areas in the shortest distance.

(2) Basic Design of the Penstock

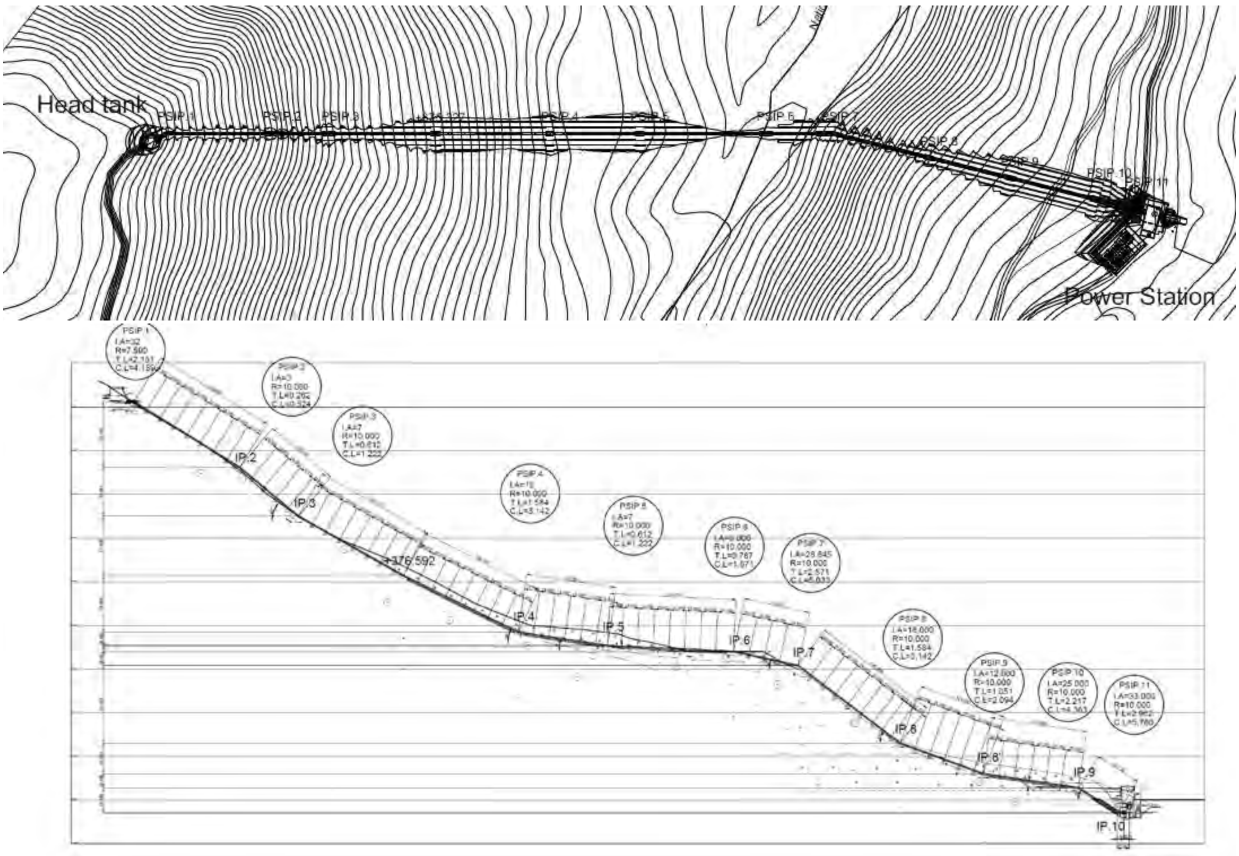


Figure 4.2-10 Layout Plan and Longitudinal Section of the Penstock

(a) Pipe Diameter of the Penstock

Penstock diameter has effect on the head loss due to the flow velocity and construction cost of penstock. Therefore, penstock diameter is determined comparing the construction cost and annual power generation by changing the diameter at 0.1m interval in case of 20.0m^3/s. As a result, 2.2m is selected for the optimum diameter of penstock. Result of the optimization for penstock diameter is shown in Figure 4.2-11.

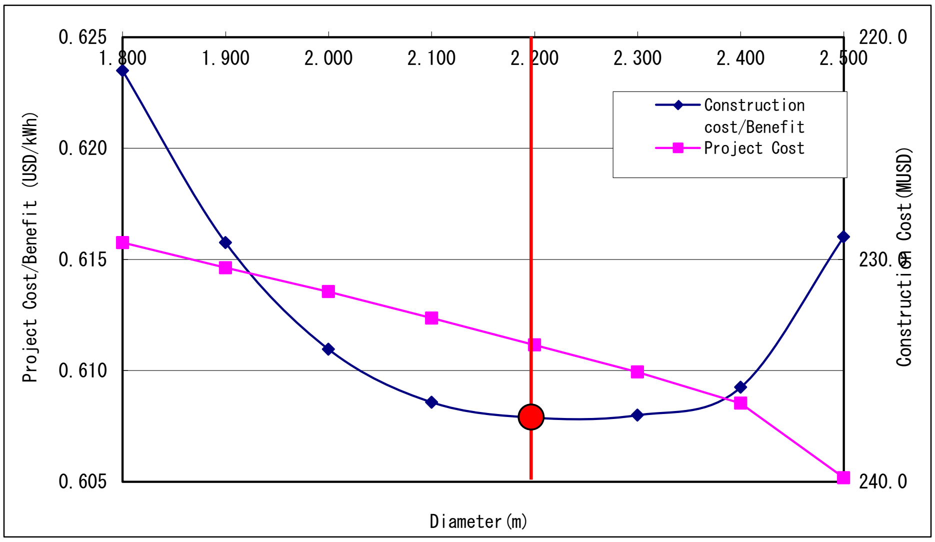


Figure 4.2-11 Result of Optimization for the Penstock Diameter

(b) Maximum Design Water Pressure

The thickness of the penstock pipe is determined by the water pressure acting on the penstock pipe, namely the static pressure and the water hammer. The water hammer is calculated by two methods, Allievi's equation and 10% of the static pressure and the bigger one is selected. Design water pressure is sum of the static pressure and water hammer.

By adding a camber of 20% to the water hammer calculated by assuming that the closing time is 13 seconds, the water hammer hm=66.4 m is obtained. Meanwhile, the static pressure obtained from the difference between the water level of the head tank and the turbine center is 477.40 m. 10% of this value is hm"=47.7 m. Since hm > hm", 66.4m is selected as the water hammer.

As a result, the maximum design head is obtained as shown below.

H = 66.4 + 477.4 m = 543.8m

(c) Weight of Penstock

The materials used for the penstock shall be rolled steels for welded structure or rolled atmospheric corrosion resisting steels for welded structure (SM).

The thickness of the penstock pipe becomes bigger gradually by the altitude lower due to increase of the design water pressure. In order to reduce this thickness as much as possible, it is determined to use the materials by the arrangement of SM400 to SM570.

Plate thickness of the penstock pipe having an allowance that exceeds the maximum design pressure for each inflection section as calculated from the maximum design head is determined, and the penstock weight that is calculated from the said plate thickness is shown in Table 4.2-4.

Table 4.2-4 Penstock Material and Weight

Section	Material	Length (m)	Thickness (mm)	Weight (t)
Start of penstock–IP-2	SM400	153	8.0	40.2
IP-2–IP-3	SM490	87	13	110.37
IP-3–End of penstock	SM570	1,033.	13 - 30	1,355.40
Total		1263		1,505.97

(3) Type of Foundation

(a) Anchor Block

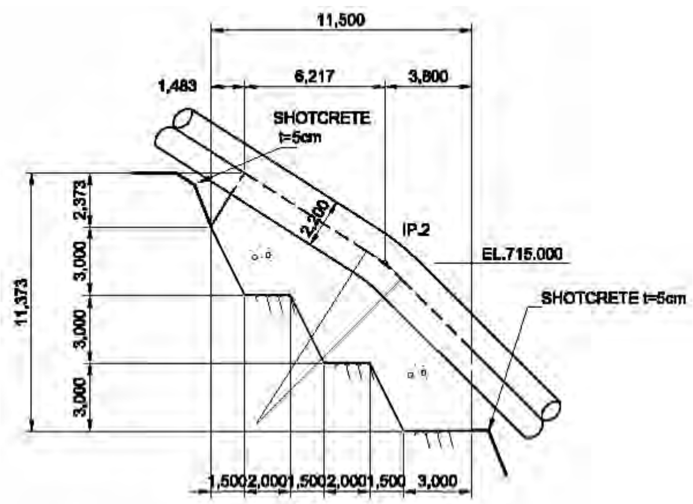


Figure 4.2-12 Anchor Block Foundation of the Penstock (IP2)

Anchor blocks shall be placed on the foundation rock of which line is estimated based on the results of the seismic prospecting.

Displacements occur in the penstock as caused by the force in the pipe axis direction and temperature changes. These displacements shall be absorbed by the expansion joint to be installed just downstream of the anchor blocks.

The interval of anchor blocks shall be set to a certain length that makes these displacements within the allowance range of the expansion joints. In general, the interval of anchor blocks is set to be around 150 m.

In the section extending to the length of approximately 240 m at EL. 470 m to 520 m, talus is deposited. It was determined in the past study on the type of foundation in the talus section that concrete piles should be driven by means of large-diameter casing on-site. It is likely, however, that the penetration of the casing would be difficult because of large stones scattered in the talus layer. Since the result of standard penetration test of boring P-1, N = 30 at the depth of deeper than 5 m was obtained and the existence of bedrock of class D was confirmed, it is assumed that installation of anchor blocks will be possible. The type of foundation shall be, therefore changed from piled foundation to direct foundation. Prior to detailed design, investigation shall be performed and as required, separate measures such as installation of mechanical joint, etc. shall be taken.

Along the penstock alignment, the gentle slope between EL.480 m and EL.430 m is intersected by National Road 16A. A box culvert is installed to the place where the penstock crosses the national road and vehicles lanes are placed above this box.

(b) Saddle Support

The saddle support shall be placed on the foundation rock, like the anchor blocks, which is estimated based on the results of the seismic prospecting except the section traversing the talus deposits. The interval of saddle supports is planned to be 18 m or less based on practices.

A continuous concrete slab foundation shall be applied in the section traversing the talus deposits.

To absorb the deformation by uneven displacement in horizontal and vertical directions, continuous foundation with mechanical joints is applied for the saddle support of this section. In mechanical joint, penstock and continuous slab foundation is placed on the ground which is regarded as the spring function by the coefficient of subgrade reaction. Uneven displacement and deformation toward the penstock direction are absorbed by hinge joints.

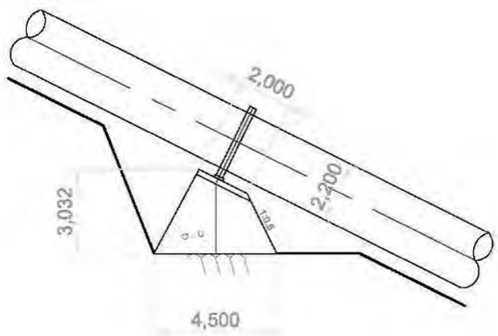


Figure 4.2-13 Saddle Support of the Penstock

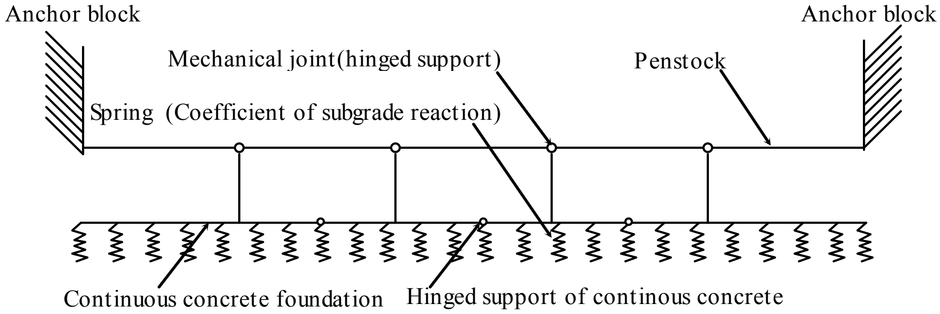


Figure 4.2-14 Outline of the Mechanical Joint

4.2.7 Powerhouse, Tailrace and Substation

(1) Selection of the Powerhouse

Figure 4.2-15 River Situation near the Powerhouse Site (January of 2009)

There are steep gradient riverbeds during the section of 200m near the powerhouse site and additional head of approximately 3.4m can be obtained up to the powerhouse location. In this study, comparison of the powerhouse location is studied as shown in Figure 4.2-16.

As a result, (2) Center which was applied in TR2009 is rejected due to the land slide observed in the site reconnaissance. Concerning (1) Upstream and (3) Downstream, there is no significant difference in the economic evaluation. However, (3) Downstream is located at the steep bank and slope of the mountain side is supposed to be large and required to be protected against the land slide. As a conclusion, (1) Upstream is selected for the powerhouse location.

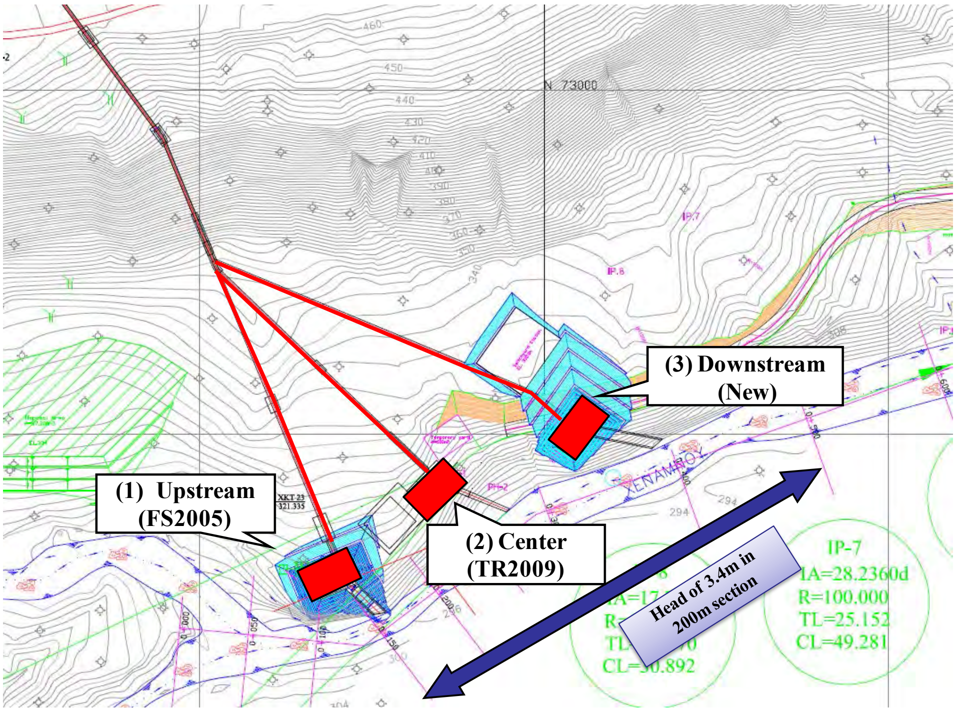


Figure 4.2-16 Selection of the Powerhouse Location

(2) Determination of the Tail Water Level

Although 70% of the basin at powerhouse site belongs to the Xe Namnoy River basin area, there are no hydrological observation records of the Xe Namnoy River. Therefore results of hydrological analysis at Xe Katam basin shown in Chapter 3 are also used for the determination of the tail water level and high water level of powerhouse.

Non-uniform flow analysis is implemented during sections of 1,000m near the powerhouse site using results of the cross sectional survey and flood analysis.

As a result, EL. 293.6m (Q=83.2m^3/s) is determined as the tail water level. Q=83.2m^3/s at the powerhouse site (C.A=1,093km^2) is equivalent to the Q=20.0m^3/s at the intake (C.A 263km^2) calculated by the basin ratio conversion.

Design high water level in Q=2,630m^3/s (1,000-yr probable flood) is estimated at H.W.L 300.0m and turbine center level is determined as EL. 286.1m.

Table 4.2-5 Results of Non-uniform Flow Analysis at the Powerhouse

Return period	Q (m^3/s)	Water Level (EL. m)	Remarks
T.W.L	83.2	293.6	Q=83.2m^3/s at the powerhouse site (C.A=1,093km^2) is equivalent to the Q=20.0m^3/s at the intake (C.A 263km^2) calculated by the basin ratio conversion.
2	770	296.4	
100	1,890	298.8	
200	2,100	299.2	
1000	2,630	300.0	Design Flood of this study

(3) Basic Design of the Powerhouse

The ground level at the powerhouse site is around EL.308 m. According to the geological survey, the area around the site is covered with terrace deposits. Furthermore, a drilling (BP-4) is conducted at the powerhouse site at FS stage and it is confirmed that the site is covered with terrace deposits to the depth of around 6 m. However, in the depth of around 6 m and below, hard sandstone or mudstone is confirmed.

Dimension of the powerhouse building is estimated at L=21.5 m, W=29.0 m and H=39.5 m according to the installed capacity of 81 MW. Layout of the powerhouse is determined by the equipment layout of turbine and generator. Elevation of the ground floor is EL. 301.5 m which is 1.5 m higher than HWL.

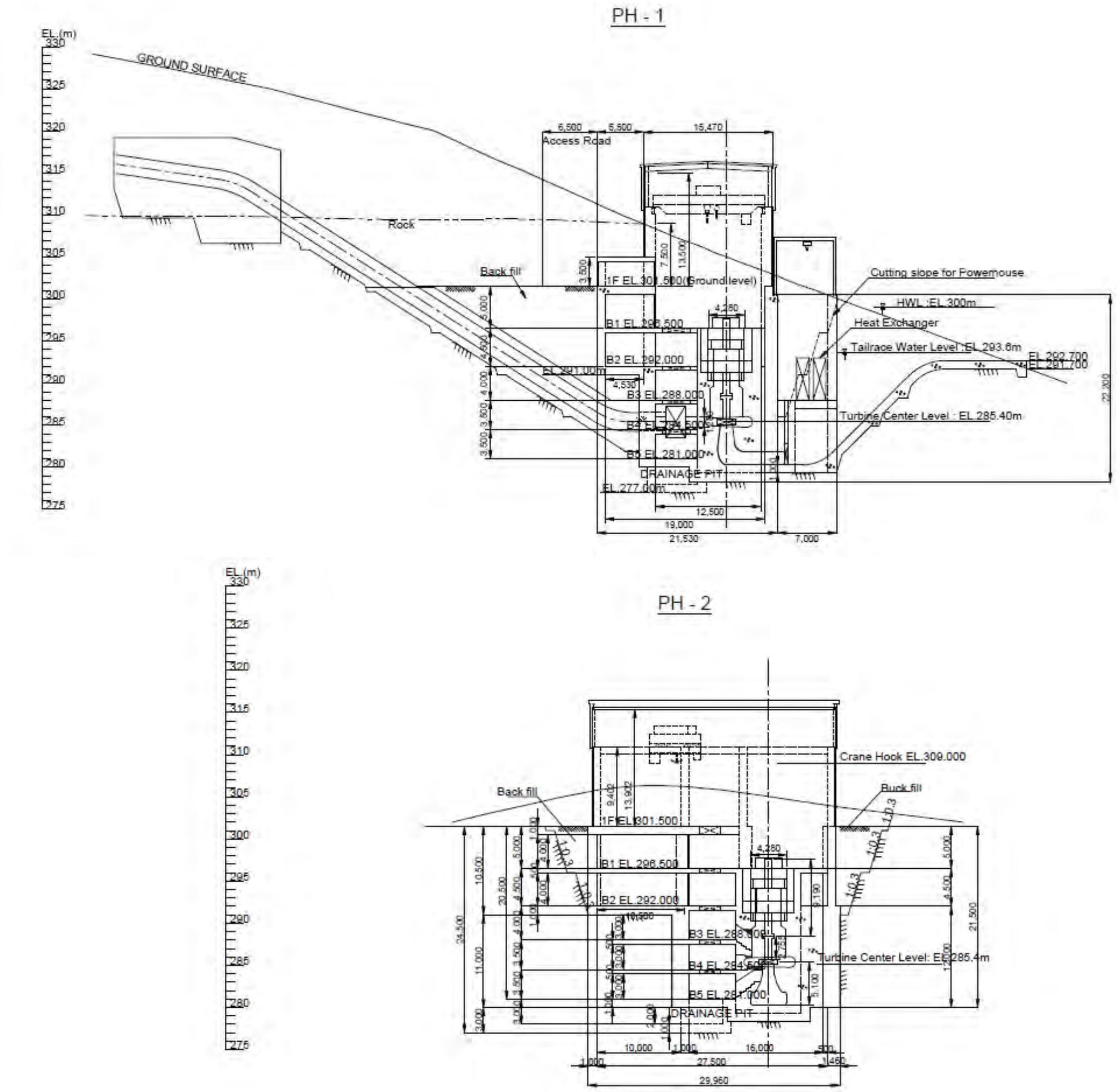


Figure 4.2-17 Cross Section of the Powerhouse

(4) Tailrace

The tailrace is planned to face the river course to prevent discharge from being affected by river flow.

At the boundary between the powerhouse and the tailrace, a draft gate shall be provided for dewatering inside the draft, and a slot shall be provided to insert a stop log for maintenance. The overall length and wide of the tailrace is 30 m 6.5 m respectively. Sill level at the outlet is EL. 293 m which is almost same as the riverbed.

4.3 Design for Electro-Mechanical Facilities

4.3.1 Preliminary Design for Hydraulic Facilities

(1) Maximum discharge and effective head

The maximum discharge and effective head of the hydraulic turbine are specified as follows, in accordance with Section 4.1.4:

• Maximum discharge : 20 m^3/s
• Effective head : 457m

(2) Basic specifications of the hydraulic turbine

Based on the turbine type selection chart that is shown in Figure 4.3-1, the vertical-shaft Pelton type and vertical-shaft Francis type are applicable in consideration of the maximum discharge and the effective head. We selected the vertical-shaft Francis type in accordance with the result of study of Section 4.1.3, (3). The basic specifications of the hydraulic turbine are shown in Table 4.3-1.

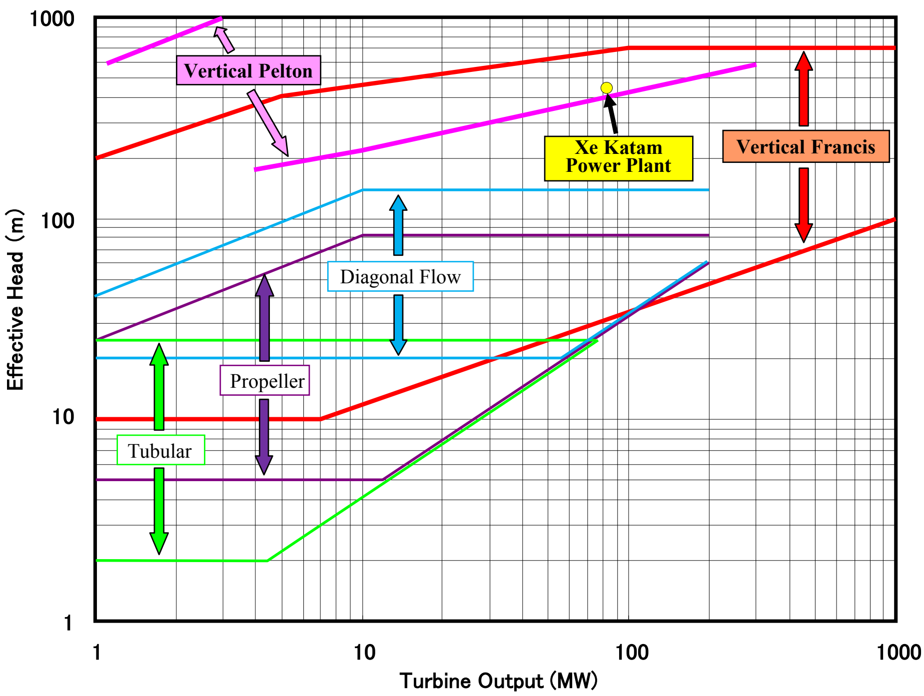


Figure 4.3-1 Turbine Type Selection Chart

Table 4.3-1 Basic Specifications of Hydraulic Turbine

Maximum turbine discharge	20 m^3/s
Effective head	457m
Type	Vertical shaft, single runner, single discharge, spiral Francis turbine
Rated output	83,100 kW
Rated rotational speed	600 min^{-1}
Quantity	One (1) unit

(3) Basic specifications of generator

The power factor of the generator is determined on the condition of 0.85 lagging that Laos adopts as a standard power factor in accordance with the Lao Grid Code. A suspended type generator is selected as an optimum type of bearing arrangement for generator in consideration of the generator capacity and the rated rotational speed of generator. The rated voltage for the generator shall be 11 kV in consideration of the generator capacity. The basic specifications of the generator are shown in Table 4.3-2.

Table 4.3-2 Basic Specifications of Generator

Type	Vertical shaft, suspended type, three phase synchronous generator
Rated capacity	95,000 kVA (80.75 MW)
Rated power factor	0.85 (lagging)
Rated voltage	11 kV
Rated frequency	50 Hz
Rated rotational speed	600 min^{-1}
Quantity	One (1) unit

The efficiency curve for turbine and generator is shown in Figure 4.3-2.

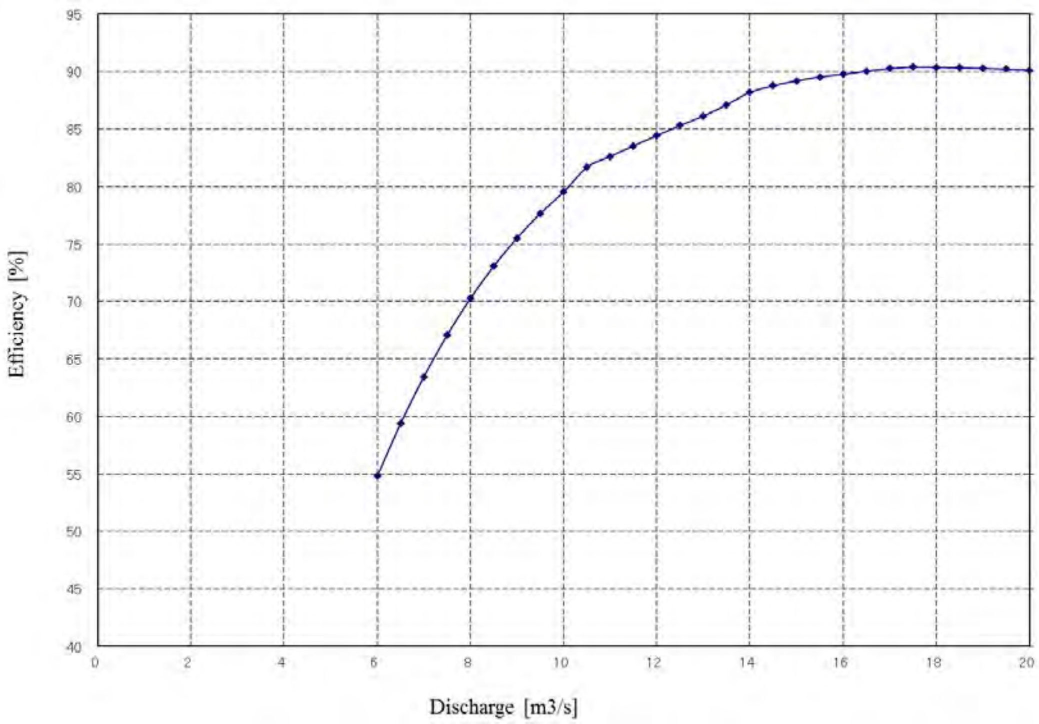


Figure 4.3-2 Total Efficiency of Hydraulic Turbine and Generator

(4) Design of other equipment related to the hydraulic turbine and generator

(a) Inlet Valve

From the viewpoint of high effective head (more than 400m), the inlet valve is installed so as to decrease leakage water and to prevent harmful abrasion for guide vanes under stopping. The type of inlet valve is a rotary valve in consideration of the maximum discharge ant the effective head.

(b) Pressure oil supply system

The pressure oil supply system shall be used for operating both the inlet valve and governor in consideration of economy.

(c) Cooling water supply system

The closed circulation system with water to water heat exchanger installed in tailrace shall be installed for the purpose of stable supply of cooling water. The circulation pumps shall consist of a regular-use pump and a stand-by pump.

(d) Water drainage system

A drainage pit shall be installed at the lowest level of the powerhouse to collect water that is drained and leaked from the powerhouse and electrical and mechanical equipment. The oil separation tank shall be installed in drainage pit to prevent the oil from flowing out of electro-mechanical equipment into the river directly. Drainage pumps shall consist of a regular-use pump, a stand-by pump and an emergency pump. A jet pump shall be adopted for the emergency pump in consideration of the sufficient effective head for the operation.

4.3.2 Preliminary Design of Electro-Mechanical Facilities

(1) Power plant equipment

(a) Configuration of 115 kV main circuit

In order to make transmission voltage equivalent to voltage class of the substation to be connected with the transmission line from Xe Katam power plant, generator voltage of 11 kV is stepped up to transmission voltage of 115 kV by the main transformer in the switchyard located adjacent to the powerhouse. Number of transmission line shall be two (2), taking reliability into account. Single bus bar type shall be adopted from economical viewpoint. Main circuit single line diagram for the Xe Katam power plant is shown in Figure 4.3-3. The reason for selection of the substation to be connected with the transmission line from Xe Katam power plant is shown in Section 4.4.

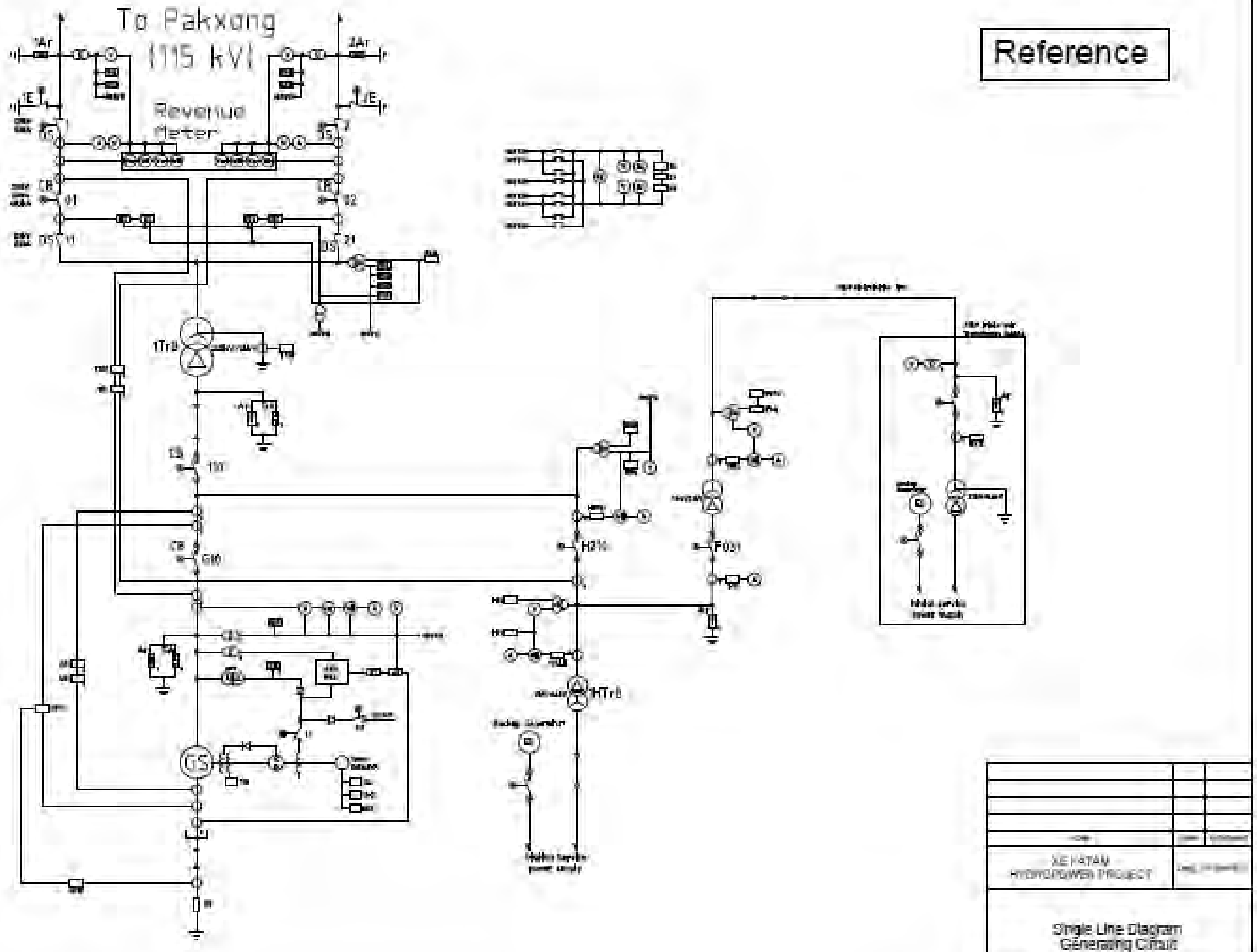


Figure 4.3-3 Main Circuit Single Line Diagram for Xe Katam Power Plant

(b) Main transformer

The rated capacity of main transformer shall be of 95,000 kVA which is the same as the generator capacity. The main transformer shall be three-phase transformer that can be expected to provide a smaller installation space and a lower cost than a single-phase transformer. A cooling method for the main transformer shall be an oil directed air forced (ODAF) type in consideration of rated capacity and cooling efficiency. The basic specification of the main transformer is shown in Table 4.3-3.

Table 4.3-3 Basic Specification of Main Transformer

Type	Outdoor use, ODAF, three-phase transformer
Rated Capacity	95,000 kVA
Rated Voltage	11 kV/115 kV
Connection method	△-Y connection
Neutral grounding method	Direct earthing
Quantity	One (1) unit

(c) 115 kV main circuit equipment

The basic specification of main equipment for the 115 kV main circuit of the switchyard is shown in Table 4.3-4.

Table 4.3-4 115 kV Main Circuit Equipment (Switchyard)

Item	Quantity	Specification
Circuit Breaker	Two (2) sets	Rated voltage: 123 kV Rated current: 1,600 A Rated short-circuit breaking current: 40 kA
Disconnector (with earthing switch)	Two (2) sets	Rated voltage: 123 kV Rated current: 1,600 A
Disconnector (without earthing switch)	Two (2) sets	Rated voltage: 123 kV Rated current: 1,600 A

(2) Pakxong substation

Preliminary design of Pakxong substation, which will be connected with the transmission line from Xe Katam power plant, is shown below.

(a) Configuration of 115 kV main circuit

Since Pakxong substation has service conductors for 115 kV transmission line for Xeset 2 power plant and Jiangxai substation, the configuration of service conductor for transmission line for Xe Katam power plant is so designed as to fit for the arrangement of the existing equipment. The existing facility of bus bar is extended. Main circuit single line diagram of the Pakxong substation is shown Figure 4.3-4.

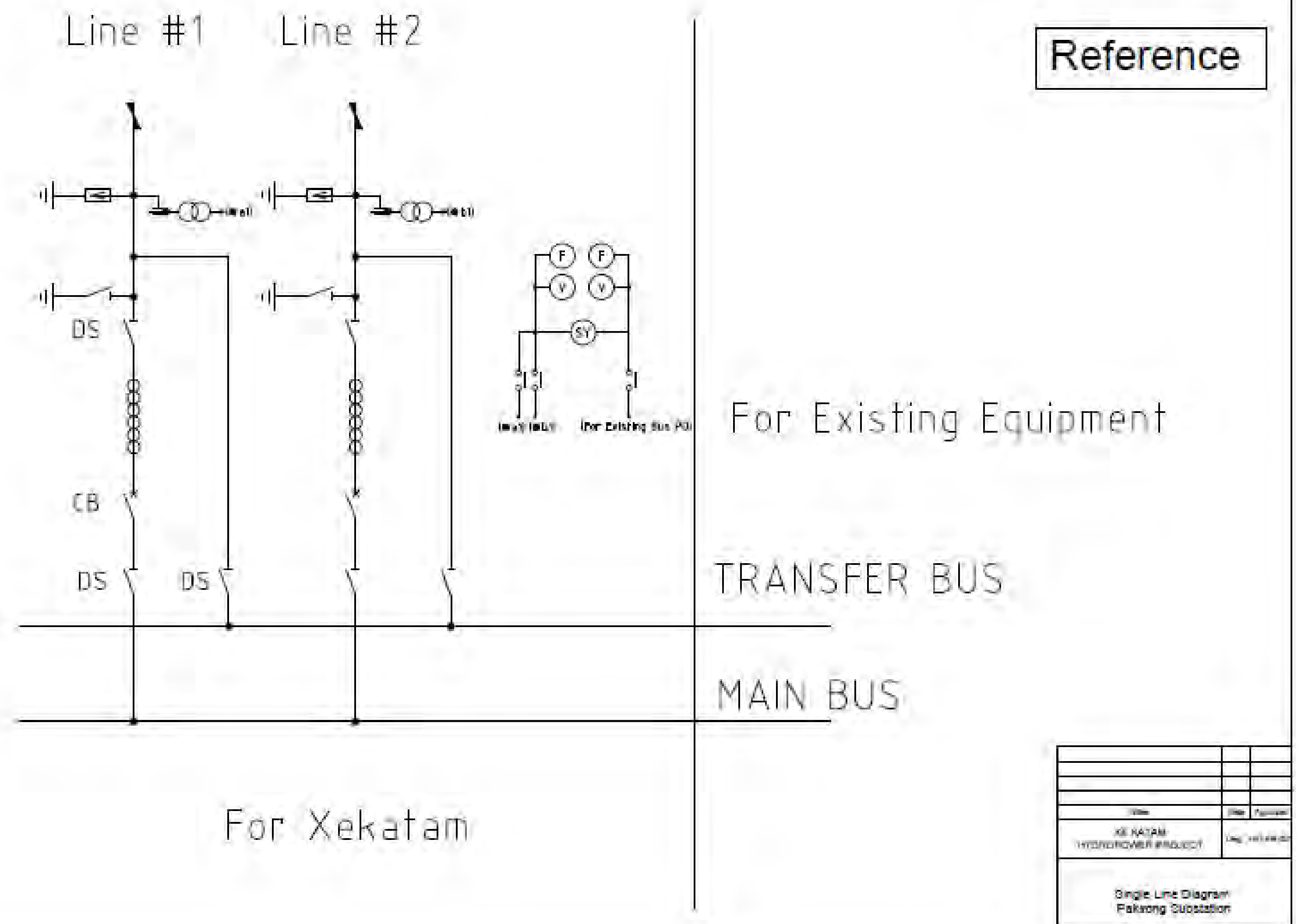


Figure 4.3-4 Main Circuit Single Line Diagram for Pakxong Substation

(b) 115 kV main circuit equipment

The basic specification of main equipment for the 115 kV main circuit of the Pakxong substation is shown in Table 4.3-5.

Table 4.3-5 115 kV Main Circuit Equipment (Pakxong Substation)

Item	Quantity	Specification
Circuit Breaker	Two (2) sets	Rated voltage: 123 kV Rated current: 1,600 A Rated short-circuit breaking current: 40 kA
Disconnector (with earthing switch)	Two (2) sets	Rated voltage: 123 kV Rated current: 1,600 A
Disconnector (without earthing switch)	Four (4) sets	Rated voltage: 123 kV Rated current: 1,600 A

4.3.3 Equipment Layout

Considering that turbine is of vertical type and the turbine center level and the ground level around the powerhouse are EL. 285.4 m and EL. 300.0 m, respectively, the Xe Katam power plant shall be semi-basement type, consisting of one (1) floor above the ground and five (5) floors under the ground.

(1) Equipment layout in the powerhouse and switchyard

The equipment layout in the powerhouse and switchyard is shown in Figure 4.3-5 and Figure 4.3-6 respectively.

(2) Equipment layout in Pakxong substation

The equipment layout in the Pakxong substation is shown in Figure 4.3-7.

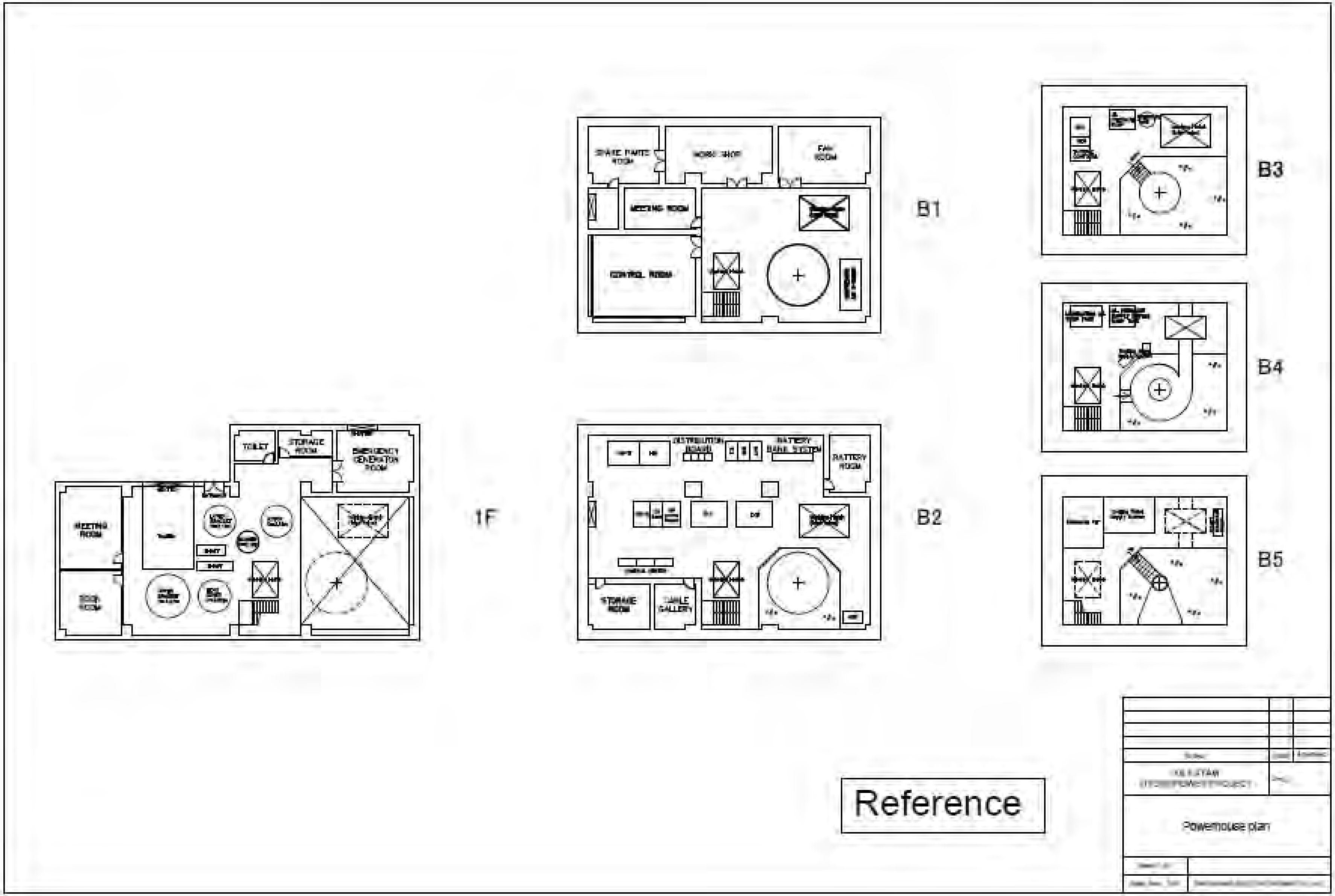


Figure 4.3-5 Powerhouse Plan

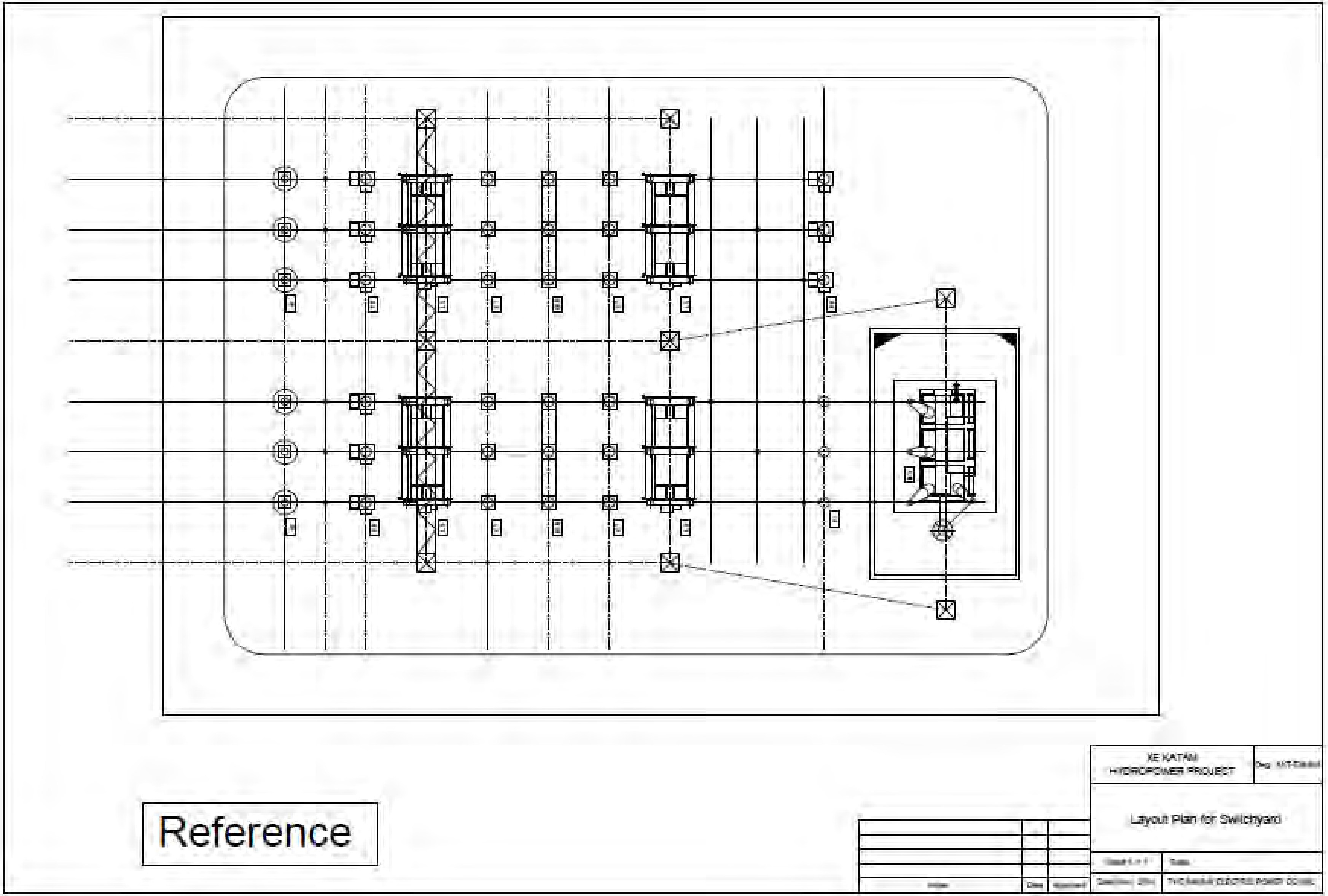


Figure 4.3-6 Switchyard Plan

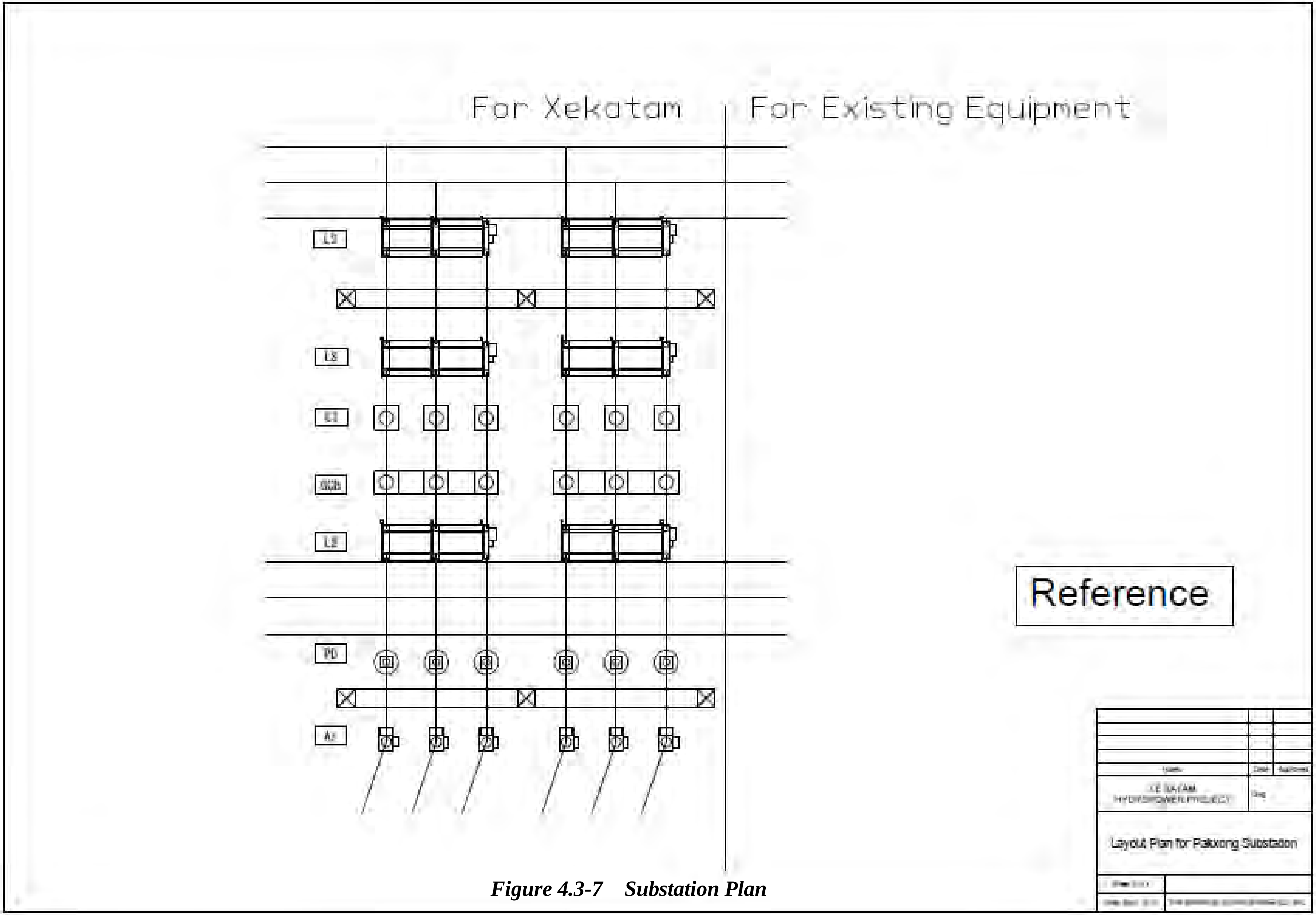


Figure 4.3-7 Substation Plan

4.4 Power Planning

4.4.1 Selection of the Interconnection Point

Xe Katam Hydropower plant will sell power to EDL. Therefore, it will be connected to the power systems that supply power to Laos. Also, considering necessary space to construct two bays and the distance from Xe Katam Hydropower plant, Xe Katam Hydropower plant is to be connected to the EDL power system at Pakxong substation. Figure 4.4-1 shows a current and future power system around Xe Katam Hydropower plant as of May, 2013.

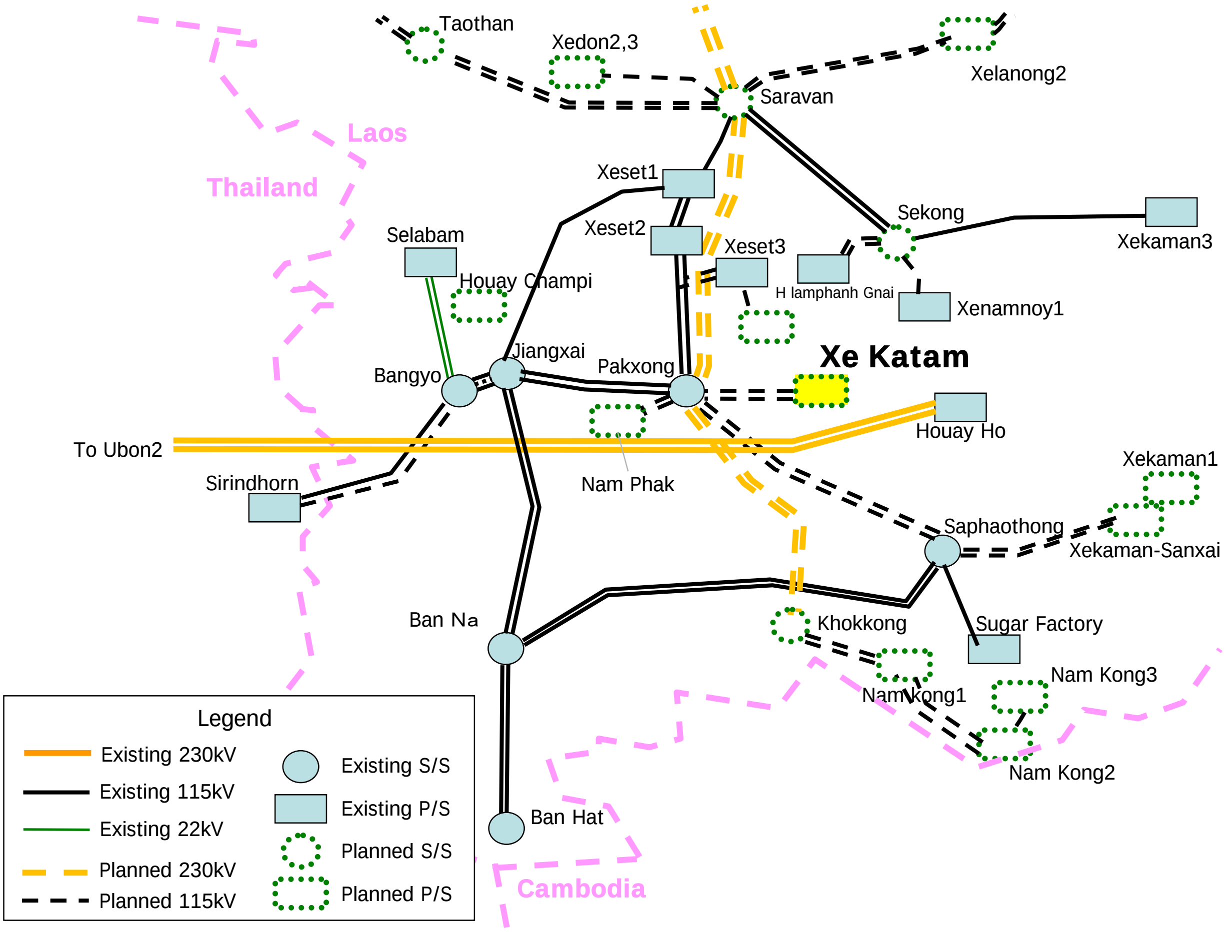


Figure 4.4-1 Current and Future Power System around Xe Katam Hydropower Plant

4.4.2 Power System Stability Study Result

After several discussions among EDL, NEWJEC and KANSAI, power system stability study was entrusted to EDL considering past performance. The study was conducted using the power system as of 2018 including future development plan as shown in Figure 4.4-1.

According to the study conducted by EDL, Xe Katam Hydropower plant seems to be possible to supply power stably to Laos via Pakxong substation. Outline of the study is as followings.

(1) Load Flow Calculations;

It was concluded that the power system would be operated without overloading transmission lines or transformers, stay within acceptable voltage limits at all buses and maintain generator reactive power outputs between acceptable limits in either high demand and light demand case before and after the connection of Xe Katam hydropower plant.

(2) Short Circuit Calculations;

It was concluded that short circuit capacity would be within acceptable range in both high demand and light demand case before and after the connection of Xe Katam hydropower plant.

(3) Stability Analysis;

It was concluded that the power system would be stable after clearance of faults on transmission lines in both high demand and low demand case before and after the connection of Xe Katam hydropower plant.

4.5 Design of Transmission Line

4.5.1 Route Selection

In this Project, installation of 115 kV double-circuit transmission line from Xe Katam SW/S to Pakxong S/S is planned. The transmission line route is selected along the flowchart in Figure 4.5-1.

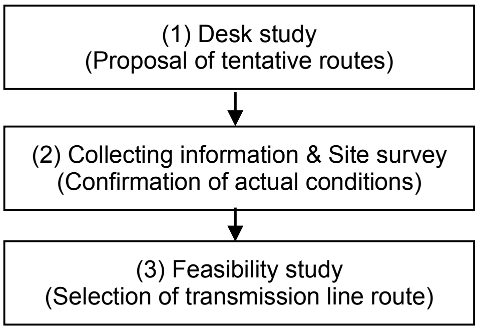


Figure 4.5-1 Flowchart for Route Selection

(1) Desk study

For the selection of transmission line route from Xe Katam SW/S to Pakxong S/S, desk study by topographic map and satellite photo around the concerning area was conducted.

Factors considered for desk study are as follows.

- To apply the straight line route as much as possible
- To avoid residential areas as much as possible
- To avoid flood area
- To avoid the tower site in the valley
- To select the route along the existing roads as much as possible

The investigation of existing transmission lines around project area based on the Power Development Plan (PDP) in Lao PDR was also conducted. These results are shown in Table 4.5-1.

From the desk study above, two (2) tentative routes shown in Figure 4.5-2 were proposed.

Table 4.5-1 Existing Transmission Lines around Project Area

Name	Nominal voltage	Nos. of circuit	Conductor size	Total length	Section
Houay Ho	230kV	2	ACSR/GA 1272 MCM	161km	(From) Houay Ho HPP (To) Udon 2 S/S (Thailand)
Xeset 2	115kV	2	ACSR 240sq	42km	(From) Xeset 2 HPP (To) Pakxong S/S

NOTE) MCM=1,000CM, CM=Circular Mils, 1MCM=0.50671 mm²

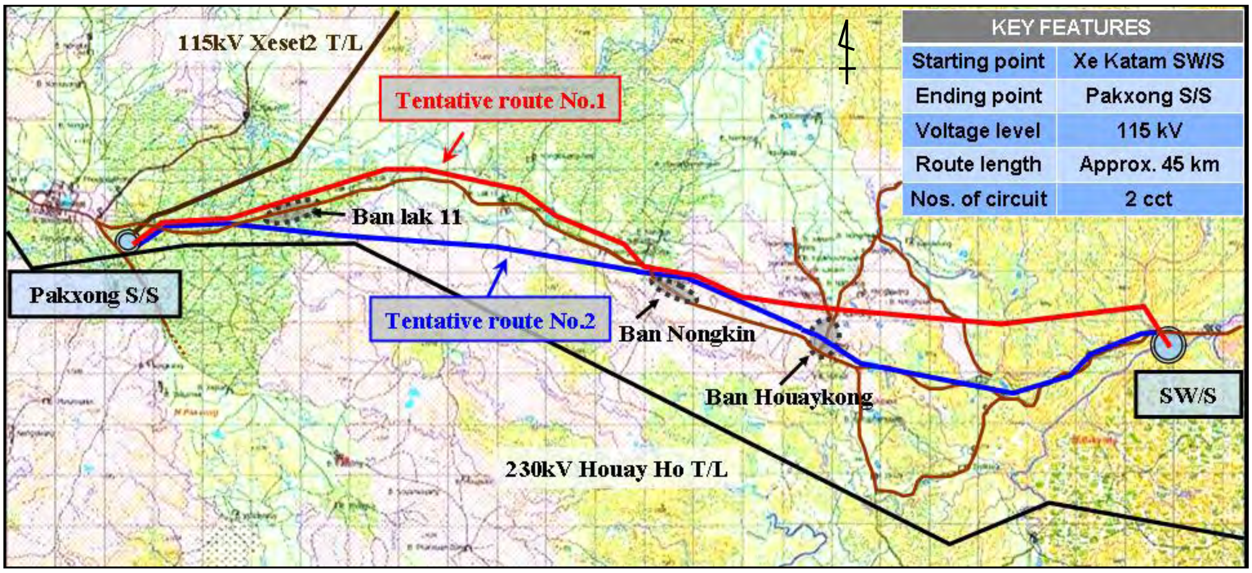


Figure 4.5-2 Location Map of Transmission Line Route

The topographical features of the two (2) tentative routes are as follows.

(a) Tentative route No. 1

Tentative route No.1, starting from Xe Katam SW/S at the elevation of about 360 m, passes through the mountainous area in the northern side of the main road. In the mountainous area, access to the route seems easy during construction and maintenance because the route passes along the headrace. The highest point of the route in the mountainous area locates at the elevation of about 860 m. After crossing the Xe Katam River, the route passes the plateau area to Pakxong S/S at the elevation of about 1,300 m. In this area, the route passes the northern side of the main road apart from residential area.

(b) Tentative route No. 2

Tentative route No.2, starting from Xe Katam SW/S at elevation of about 360 m, passes almost through the plateau area toward west along the main road. In eastern area from Ban Nongkin village at elevation of about 1,000m, access to the route seems easy during construction and maintenance because the route passes along the main road. In western area from Ban Nongkin, the route passes in the southern side of the main road apart from residential area. In this area, the route passes apart from the main road, but the line length to Pakxong S/S is shorter.

(2) Collecting information and site survey

Collecting information from concerned parties and site survey were conducted.

(a) Collecting information

The information about land usage collected from the concerned parties is as follows.

(i) PDEM (Provincial Department of Energy and Mine)

- There are two (2) mining concession areas of Cinoma and YUQIDA.
- There are many plantations along the existing main road.

(ii) PONRE (Provincial department Of Natural Resource and Environment)

-Most of plantations are coffee plantations owned by companies.

The mining concession areas are shown below (Figure 4.5-3).

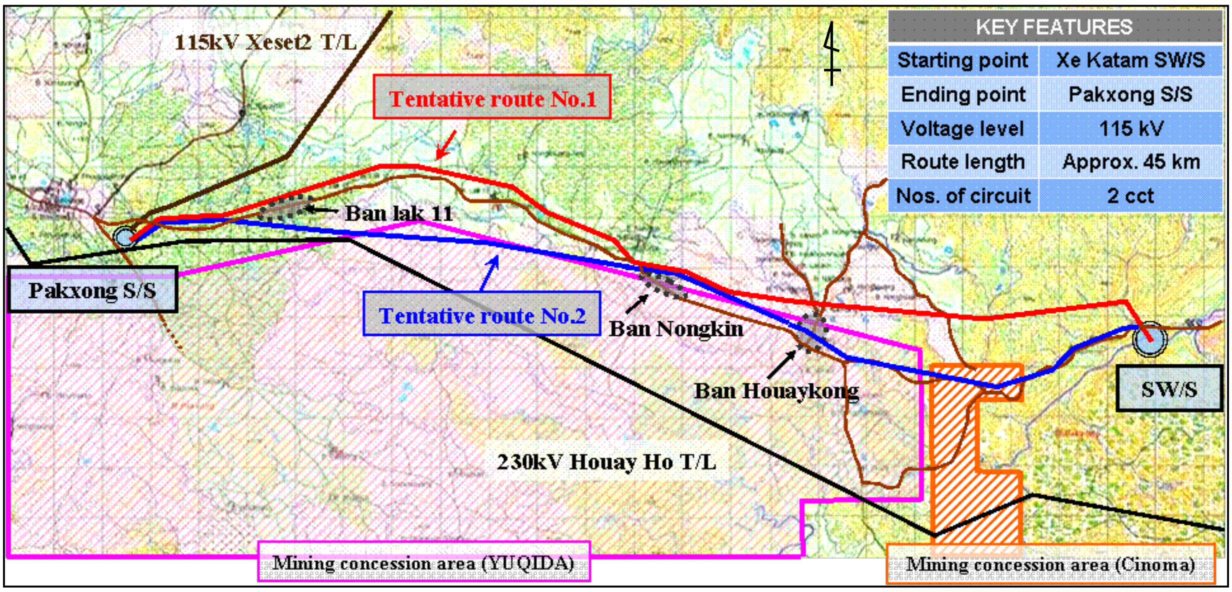


Figure 4.5-3 Location Map of Transmission Line and Mining Concession Area

(b) Site survey

The site survey of two (2) tentative routes was conducted to confirm actual conditions in the vicinity of the routes. Main findings by the site survey are as follows.

(i) Around Xe Katam SW/S

The actual condition around Xe Katam SW/S is shown below (Figure 4.5-4). Tentative route No.2, running along the main road toward west, passes Cinoma mining concession area. The development including land clearing had widely implemented around the mining concession area. The development possibly causes serious impact on tentative route No.2. On the other hand, tentative route No.1, running through the mountainous area in the northern side of the main road, are preferred because there were no evidence indicating the development in the vicinity of the route. The picture from the main road to the direction of tentative route No. 1 is shown below (Figure 4.5-5).

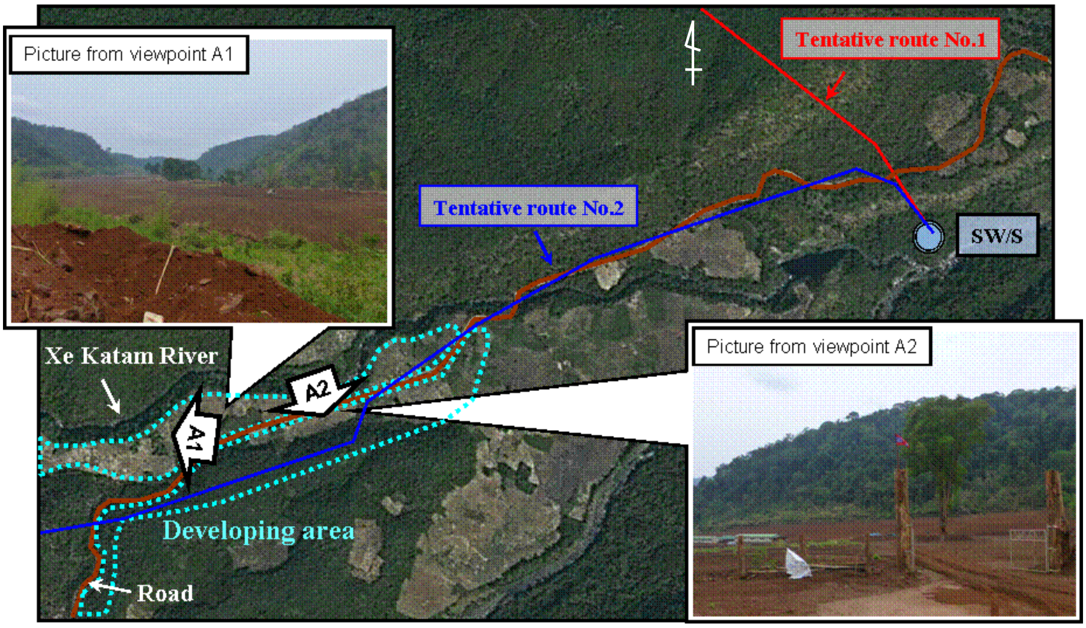


Figure 4.5-4 Actual Condition around Xe Katam SW/S (Tentative Route No.2)

Figure 4.5-5 Picture from the Main Road to the Route Direction (Tentative Route No. 1)

(ii) Around Ban Houaykong

The actual condition around Ban Houaykong is shown below (Figure 4.5-6). The residential areas of Ban Houaykong had expanded continuously along the road (refer to the picture from viewpoint B in Figure 4.5-6) and we confirmed that both of tentative route No. 1 and No. 2 passes the residential area.

To avoid the resettlement of houses, it is necessary to adjust a part of tentative routes to the north edge of Ban Houaykong (refer to the desirable tentative route in Figure 4.5-6).

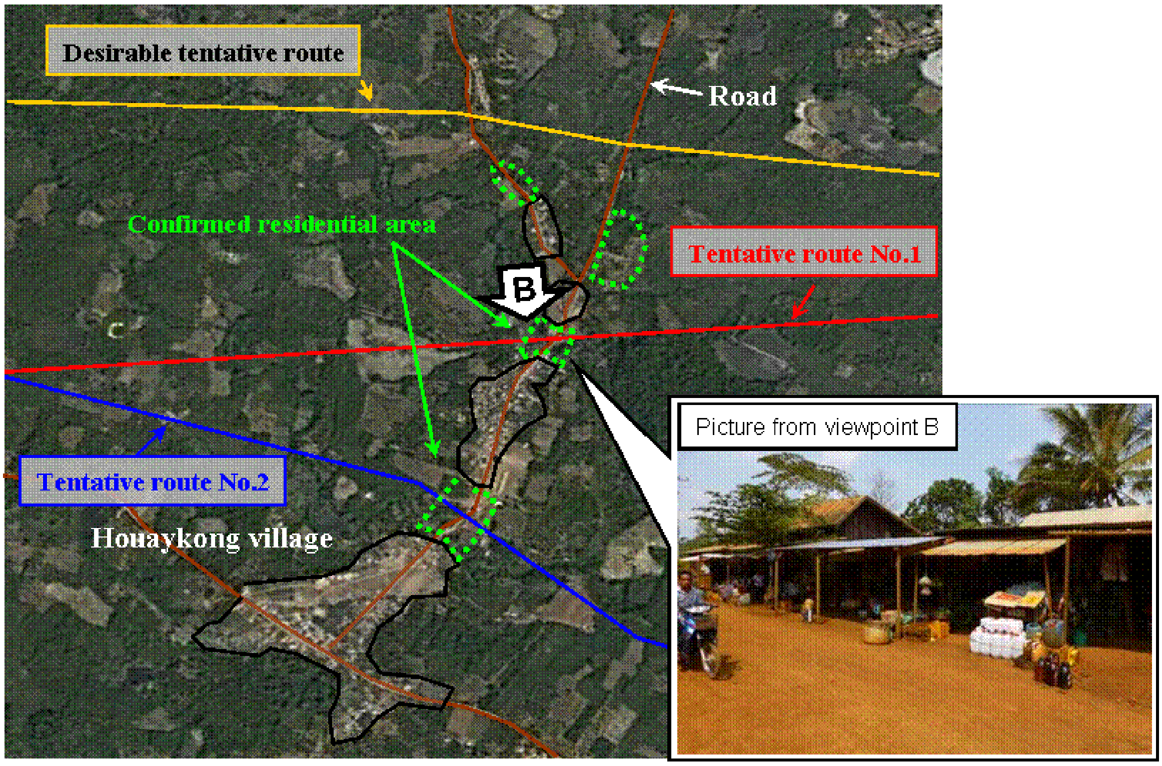


Figure 4.5-6 Actual Condition around Ban Houaykong

(iii) Around Ban Lak 11

The actual condition around Ban Lak 11 is shown below (Figure 4.5-7). Although Ban Lak 11 has a small residential area, it has large coffee plantations in the southern side of the main road.

There are many plantations not only in the area around Ban Lak 11 but also in other areas in the vicinity of tentative route No. 1 and No. 2. But it is difficult to avoid all plantations. So the route was selected so as to avoid large plantation area. Thus, the tentative route No. 1 is preferred.

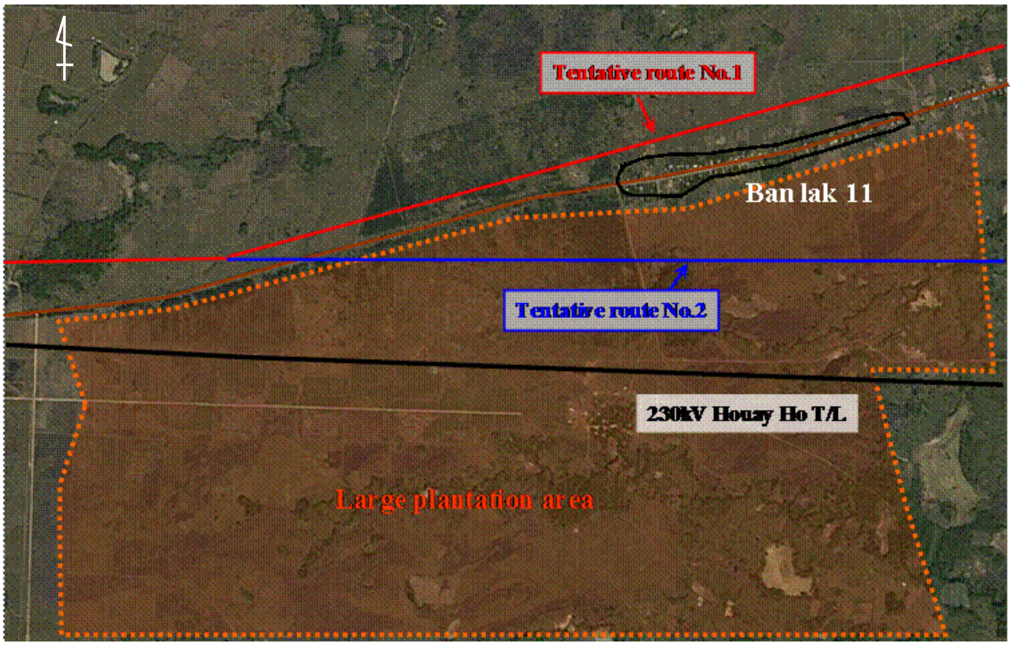


Figure 4.5-7 Actual Condition around Ban Lak 11

(iv) Around Pakxong S/S

The actual condition around Pakxong S/S is shown below (Figure 4.5-8). Around Pakxong S/S, tentative route No. 1 and No. 2 are the same, and the tentative routes runs parallel to the two (2) existing transmission lines described in Table 4.5-1. There is enough distance from these transmission lines to keep required insulation clearance. Thus, both of the tentative route No. 1 and No. 2 are appropriate.

Next, the layout of Pakxong S/S is shown below (Figure 4.5-9). There is enough space at the southeast corner of Pakxong S/S to install a new bay for Xe Katam line and the tentative routes can be connected to the bay.

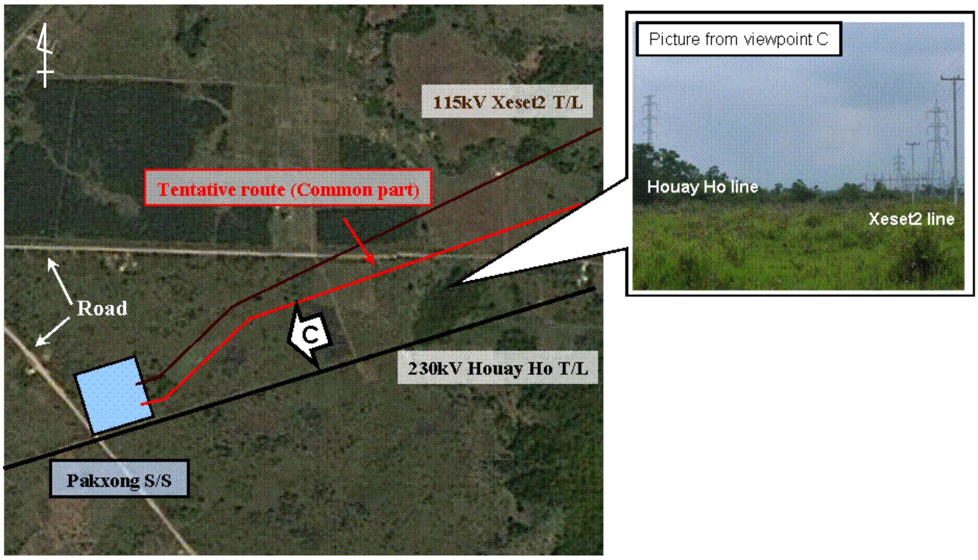


Figure 4.5-8 Actual Condition around Pakxong S/S

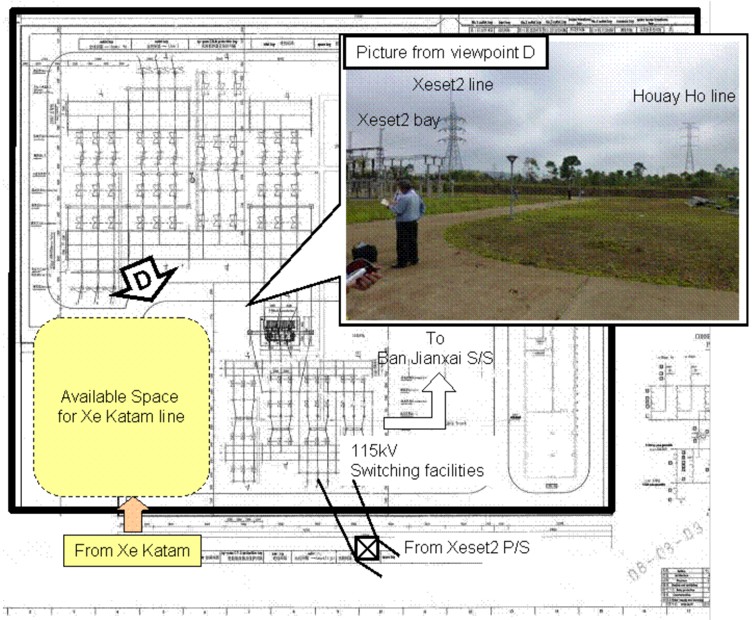


Figure 4.5-9 Layout of Pakxong S/S

(3) Feasibility study

We selected a desirable tentative route taking into account above conditions. The site survey described above found that tentative route No.1 is preferred, if the route is adjusted suitably around Houaykong village. The selected route properly avoids the developing area, mining concession area, large plantations, and residential area. So, the project will have little social impact.

In mountainous area of the selected route from Xe Katam SW/S to the Xe Katam River, the access road for headrace is expected to be available during construction and maintenance of transmission line. In the plateau area from the Xe Katam River to Pakxong S/S, the selected route runs apart from the main road, but the construction of the access road to the route is not difficult.

In conclusion, the selected route is feasible from the viewpoint of easy access and little social impact. In addition, we conducted the route survey entirely by foot, and confirmed that the selected route has no major problem. The environmental impacts are now evaluated.

4.5.2 Basic Design for Transmission Line Equipment

(1) Basic information

Section	:	Xe Katam SW/S - Pakxong S/S
Line length	:	approx. 45 km
Nominal voltage	:	115 kV
Electrical system	:	A.C. Three-phase three-wire system
Nos. of circuit	:	2
Nos. of conductor	:	single bundle for each phase
Nos. of ground wire	:	single string of optical ground wire (OPGW)
Frequency	:	50 Hz

(2) Conductor

As the transmission line route is far from sea coast and there are no factories, which generates corrosive gases, in the vicinity of the route, the possibility for conductor corrosion is little. Therefore, it is desirable to adopt aluminum conductor steel reinforced (hereinafter referred to as "ACSR"), and single ACSR 477MCM (Hawk) would be applied. The properties of the conductor are described in Table 4.5-2.

Table 4.5-2 Properties of ACSR 477 MCM (Hawk)

Stranding/ Wire diameter [-/mm]	Diameter [mm]	Unit weight [kg/m]	DC resistance at 20 ºC [ohm/km]	Ultimate Breaking Strength [kN]	Temperature coefficient of resistance [/ºC]
AL:16/3.439 ST: 7/2.675	21.78	0.9765	0.1196	86.7	0.004

NOTE) MCM=1,000CM, CM=Circular Mils, 1MCM=0.50671 mm²

Transmission capacity should be larger than sending-end output from Xe Katam SW/S. Considering the efficiency of transformer (99.3%) and station service power (0.65 MW), calculated value of sending-end output is 79.8 MW. Current-carrying capacity of the conductor can be calculated according to "CIGRE WG 22.12; The Thermal Behavior of Overhead Conductors (1992)". The temperature of conductor is assumed to be 80 ºC. The results are shown below.

- Current carrying capacity per 1 phase: 480 [A]
- Transmission capacity per 1 cct: 81.2 [MW] (power factor = 0.85) > 79.8 [MW]

From the study above, the selected conductor has enough transmission capacity (81.2 MW) larger than the maximum output from Xe Katam SW/S (79.8 MW).

(3) Ground wire

The transmission line of this project is an isolated system connecting Xe Katam SW/S and Pakxong S/S. So, it is desirable to adopt single ground wire and 30 degree as shielding angle in order to reduce line fault caused by lightning. On the other hand, Optical Ground Wire (hereinafter referred to as "OPGW") will be adopted as the ground wire in order to build SCADA system. OPGW 70 mm2 with 12 optical-fiber cores, which is widely used for an isolated power system in Lao PDR, is desirable to be adopted. The properties of the OPGW are described in Table 4.5-3.

Table 4.5-3 Properties of OPGW 70 mm²

Stranding/ Wire diameter [-/mm]	Diameter [mm]	Unit weight [kg/m]	DC resistance at 20 ºC [ohm/km]	Ultimate Breaking Strength [kN]
AC: 8/3.2 OP unit: 1/5.0	11.4	0.4701	0.834	80.2

(4) Number of insulator units and insulator strings

120 kN 250 mm Ball and Socket type insulator unit in compliance with IEC 60383 will be used. The number of insulator units for one string will be 10 based on the pollution design according to IEC (Table 4.5-4). Insulator strings are selected according to Table 4.5-5. However, it is necessary to determine the type of insulator string in consideration of detailed design, such as the maximum working tension.

Furthermore, it is desirable to apply arching horns to all insulator strings in order to protect insulator units from the overvoltage by lightning.

Table 4.5-4 Number of Insulator

Nominal voltage [kV]		115
Highest voltage [kV]		123
250mm insulator	Creepage distance of a disc [mm]	292
	Pollution level according to IEC 60815	Medium
	Specific creepage distance (Phase to Phase) [mm/kV]	20
	Required creepage distance [mm]	2,460
	Required number of insulators for a string	9
Additional insulator for maintenance		1
Total number of insulators		10

Table 4.5-5 Type of Insulator String

Type	Description	installation
Single suspension string	120kN, 10 units, single string	Normal suspension tower
Double suspension string	120kN, 10 units, double string	Suspension tower at the span crossing over main roads
Single tension string	120kN, 10 units, single string	Normal tension tower
Double tension string	120kN, 10 units, double string	Tension tower at the span crossing over main roads

(5) Insulation clearance

Insulation clearances are determined as shown in Table 4.5-6 based on standards and guidelines in Lao PDR and Japan.

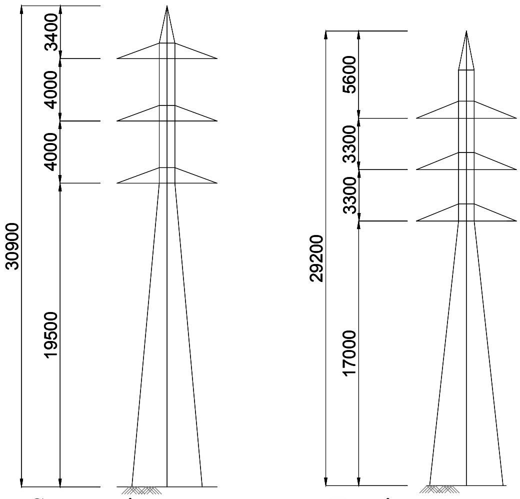
Table 4.5-6 Insulation Clearances

Name	Clearance [mm]
Minimum insulation clearance	950
Horn gap	1,100
Standard insulation clearance	1,250
Abnormal insulation clearance	310
Minimum phase to phase insulation gap	1,350
Abnormal state phase to phase insulation gap	530

(6) Tower configuration

Tower configuration is determined in consideration of the insulation clearance and shielding angle.

Basic tower configurations of the suspension and tension towers are shown in Figure 4.5-10.



Suspension tower Tension tower

Figure 4.5-10 Basic Tower Configuration

(7) Foundation

It is necessary to select the optimum type of foundation taking into account soil conditions and bearing capacity obtained from subsoil investigation. The following two (2) types of foundation are considered depending on the soil conditions.

- Pad and Chimney foundation
- Pile foundation

The target value of grounding resistance for 115 kV transmission line is recommended to be below 10 ohm in Lao PDR, and the countermeasures to reduce grounding resistance are necessary if the grounding resistance exceed 10 ohm.

CHAPTER 5

CONSTRUCTION PLANNING

CHAPTER 5 CONSTRUCTION PLANNING

5.1 Construction Planning

According to the civil and electro-mechanical facilities designed above, selection and arrangement of construction facilities and construction methods are studied considering climate, topographic, geologic and transportation route conditions at the project site.

Items and components of construction planning are summarized below.

Table 5.1-1 Items and Components of Construction Planning

Item	Issues to be confirmed or studied	Components
Basic Conditions		
Topographic and Geological conditions	Confirmation of the topographic and geological conditions which affect construction works	Calculation of the construction efficiency per hour
Meteorological and Hydrological Conditions	Confirmation of rainfall, river discharge and water level during dry and rainy seasons	Estimation of nominal working days
Construction Road and Transportation Route		
Topographic and Geological Conditions	Confirmation of topographic and geological situations	Selection of access route and study of construction workability
Transportation Routes for Materials and Equipment	Surveys for access routes inside and outside the site	Study on possibility of transportation of heavy machine and equipment Study on reasonableness of transportation route inside the construction site
Arrangement of the Construction Facilities	Selection of transportation routes for construction materials	Transportation plan for embankment materials of the main and saddle dams Scale of concrete structures and transportation distance
Procurement Plan of Construction Materials		
Procurement of materials at quarry sites and borrow pits	Procurement plan of main construction materials	Procurement of main construction materials and location of stockyards
Determination of construction methods for each work	Procurement plan of main construction materials and construction machines	Procurement of main construction materials and location of stockyards Availability of construction machines in Lao or abroad
Temporary Facilities Plan and Construction Method		
Topographic and Geographic Conditions	Suitable construction methods at the site	Selection of the construction machines Compatibility with the arrangement plan of construction facilities
Procurement of materials at quarry sites and borrow pits	Available volume of concrete aggregates and dam embankment materials	Selection of production facilities for concrete aggregates Production methods of dam embankment materials
Arrangement of Construction Facilities	Layout of concrete mixing plant, production facilities for concrete aggregates, and stockpiles	Estimation of concrete placement efficiency Arrangement of temporary facilities
Electricity for Construction Works	Maximum electricity demand for construction works	Electricity demand for each facility during the construction period Procurement of electric source for construction
Construction Schedule Plan		
Meteorological and Hydrological Conditions	Confirmation of rainfall and river discharge during dry and rainy seasons Diversion plan Programme of reservoir filling	Period of diversion Proper construction season and schedule
Procurement of materials at quarry sites and borrow pits	Procurement plan of construction materials	Detailed planning of the construction schedule

5.1.1 Estimation of Working Days for Construction Works

Based on the rainfall data collected in Chapter 3 (2004 – 2012) and the Lao PDR calendar, working days for construction works are estimated as shown in Table 5.1-2.

Table 5.1-2 Working Days for each Construction Item

Item	1	2	3	4	5	6	7	8	9	10	11	12	Total	Average
Concrete	23.8	23.6	24.2	14.3	17.3	15.5	15.4	15.3	18.5	22.4	25.6	22.8	238.6	19.9
Earth	24.0	23.9	25.6	18.8	23.3	22.3	20.1	20.9	20.4	25.1	25.9	22.8	273.0	22.7
Tunnel	24.0	24.0	26.0	20.0	25.4	24.5	24.6	25.0	23.6	26.3	26.0	22.9	292.3	24.4

Working Day/Month

Working days shall be estimated considering following items.

- Except tunnel works, construction works planed planned in daytime due to the difficulty of night lightning.
- If no working days exceeds 10 days in a month due to rainfall during the rainy season (May to October), Sunday is counted as working days.

5.1.2 Overall Schedule

This project is planned to commission in 29 months from the commencement of construction works. As climate around the project side is clearly divided into rainy season (May – October) and dry season (November – April), river works should be planned to be implemented in dry season.

It is necessary to install two permanent bridges for the access road and to plan construction of these works in dry season when heavy machineries can cross the river.

5.2 Moving Earth Plan

5.2.1 Moving Earth Plan

Although it is important for the preparation of the moving earth plan to utilize excavated soils and rocks in each work and to reduce the construction cost, transportation of these materials should be considered in Xe Katam site conditions which facilities are widely located along the Xe Katam River, approximately 8km. Xe Katam site can be divided into two construction divisions, Upstream area (Intake weirs area) and Downstream area (Powerhouse area). Moving earth plan for Xe Katam project is shown in Figure 5.2-1.

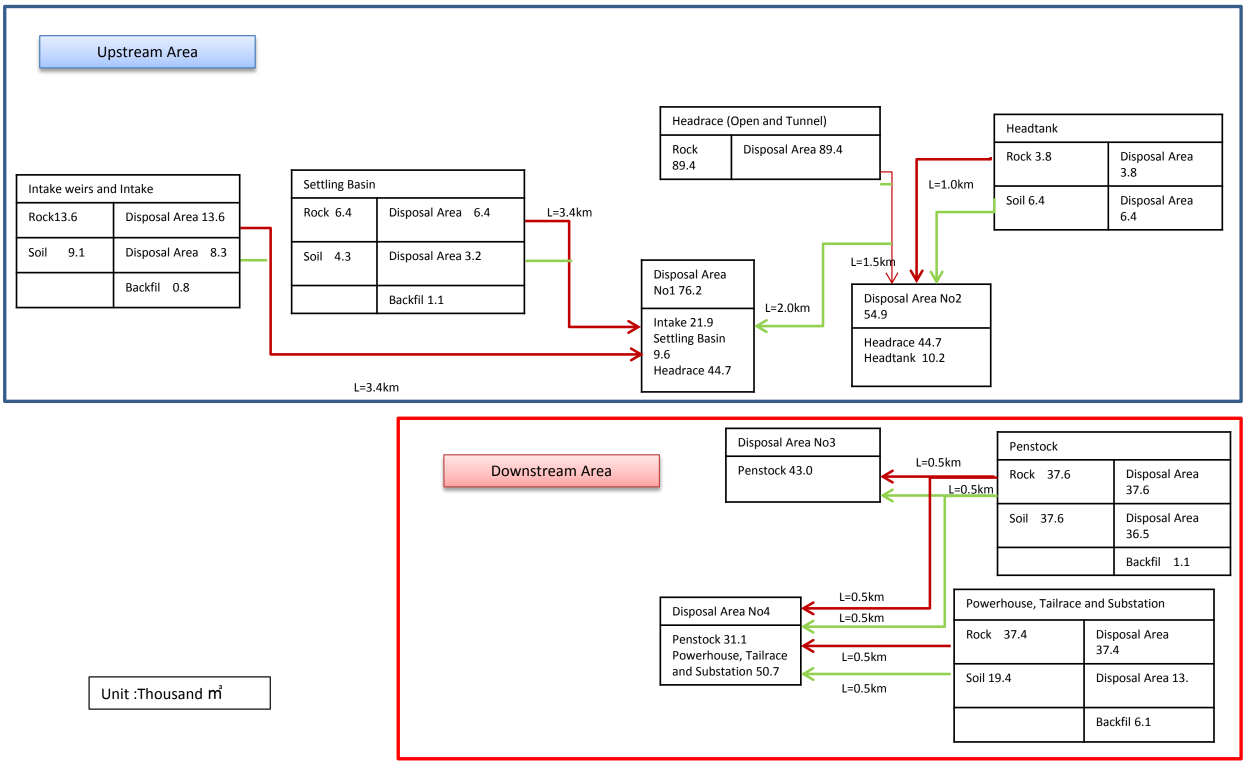


Figure 5.2-1 Earth Moving Plan

5.2.2 Procurement Plan of Aggregates

Concrete aggregates of 92,401.6t (concrete: 59,740.6t (31,442.4m^3) and shotcrete: 32,661.1t (18,547m^3)) are required for Xe Katam project. JICA Study Team had surveyed the availability of aggregates around Xe Katam site and clarified that it is difficult to obtain applicable materials such as river gravels. Therefore it is necessary to purchase aggregates from neighboring plants or to product them on site.

Table 5.2-1 Quantity of Aggregates for Concrete and Shotocrete

Item		Concrete (m^3)	Shotcrete		
			Thickness (mm)	Area (m^2)	Volume (m^3)
Intake Weirs		7,467.3	50	1,698.0	118.9
Intake		666.2			
Settling Basin		1,109.8			
Headrace	Tunnel	6,158.3	50	80,616.5	10,480.1
			100	16,591.8	3,982.0
			150	1,249.3	449.7
			200	421.8	202.5
	Open	107.7	50	0.0	0.0
Upper Adit	Tunnel	153.0	100	2,142.0	428.4
	Open	131.3	50	94.5	6.6
Lower Adit	Tunnel	193.2	100	2,584.1	516.8
	Open	131.3	50	31.5	2.2
Head Tank		1,540.9	50	1,838.4	128.7
Penstock		8,546.0	50	22,670.0	1,586.9
Powerhouse		4,135.0	50	9,213.1	644.9
Tailrace		743.3			
Substation		359.1			
Total		31,442.4			18,547
Required Volume (t)					
Concrete		59,740.6	Shotocrete	32,661.1	

*Table 5.2-2 Calculation of the Volume for each Aggregate Size**

t/m^3

Item	Fine	Coarse				Total (t)	Remarks
	5~0mm	150~80mm	80~40mm	40~20mm	20~5mm		
Concrete	0.75			0.575	0.575	1.9	Pomp Mixture Hase Dam
Mortar	1.353					1.353	Takizawa Dam
Shotcrete	1.086				0.675	1.761	

*) The aggregate size based on construction experiences in Japan

5.3 Construction Plan of Each Facility

5.3.1 Preparatory Works

(1) Access Road

Bridge works are the critical path in access road works.

Two options of bridge are expected to be applicable for Xe Katam site, temporary ones such as KD bridge and permanent ones with steel girders and concrete plates. Considering the cost reduction and maintenances after the construction, permanent ones are applied.

To construct bridges within during season, it is necessary to implement bridge works immediately and to complete designs and production of steel girders as soon as possible after the commencement.

Heavy machineries can cross rivers in Xe Katam site during dry season. Temporary submerged bridges will be installed at Nam Touad and Xe Katam (downstream of intake weirs) to make the path for construction vehicles and to commence the bridge and road works as soon as possible. Construction period of each bridge is assumed as total 3.5 month, 3 month for bridge formation and 0.5 month for curing of concrete. Road pavement speed is estimated at 1 - 2 km/month.

Table 5.3-1 Construction Road

No	Section			Extension (km)			Remark
				Renovation	New	Total	
1	Nam Touad	~	Intersection (1)	3.3	0.0	3.3	New Bridge × 1 (Nam Touad River)
2	Intersection (1)	~	Intake Weirs	0.0	1.8	1.8	New Bridge × 1 (Xe Katam River)
3	Intake Weirs	~	Head Tank	0.0	8.0	8.0	
4	Adit Tunnel			0.0	1.0	1.0	
5	Penstock			0.0	0.7	0.7	
6	National Road	~	Powerhouse	0.0	1.5	1.5	
	Total			**3.3**	**13.0**	**16.3**	

(2) Temporary Plant

Main components of construction works for Xe Katam project are intake weirs, headrace tunnel, penstock and powerhouse. Although total concrete volume of approximately 50,000m^3 including shotcrete is relatively small, single concrete plants shall be installed at intake weirs and powerhouse at each site due to the wide construction area and high difference of elevation. Until the completion of plants, concrete shall be procured from manufacturers at Pakse.

5.3.2 Intake Weirs, Intake and Settling Basin

(1) Outline

There are two rivers namely Xe Katam and Dakproun and twin weirs are required. A weir at the Dakproun River with the intake is defined as No.1 weir and one at the Xe Katam River is as No.2. Construction of weirs shall be implemented sequentially by diversion of each river stream to avoid complex processes of works and to reduce the cost.

(2) Diversion Method

A Corrugated steel pipe with ϕ 2 m will be buried by excavating the small hill between rivers. Access road is installed above the buried pipe.

For the construction of No. 1 weir, river stream of Dakproun will be closed by the cofferdam and diverted to Xe Katam through the corrugated pipe. Probable maximum flood of 30 years is applied for this closure because part of works will be continued until rainy season.

For the construction of No. 2 weir, river stream of Xe Katam will be closed and diverted to Dakproun through the corrugated pipe in the same way. Water will flow through the gate of No.1 weir. Cofferdam will be embanked to close the Xe Katam River and install the access road on the bank considering the overflow elevation and freeboard. This work will be completed safely within dry season.

(3) Access Road for Construction Works

Two routes for construction works are required. One is connected to the intake (left bank of Dakproun) and another one is to the small hill between Xe Katam and Dakproun which routes are attached from the bridge.

(4) Construction

Concrete is placed by pump tracks. Actual placement capacity of pump trucks is estimated at approximately 30m^3/h which is 35% of the rated capacity. Maximum placement volume is approximately 290m^3 per time and placement duration is around 10 hour.

(a) No.1 Weir

No.1 weir is divided into four (4) blocks with average 20m length including the intake part. Number of lifts for the intake part is ten (10) lifts and for the weir body is (6) lifts. Working days for concrete works are 22 days/month and construction period is estimated at 6.0 month.

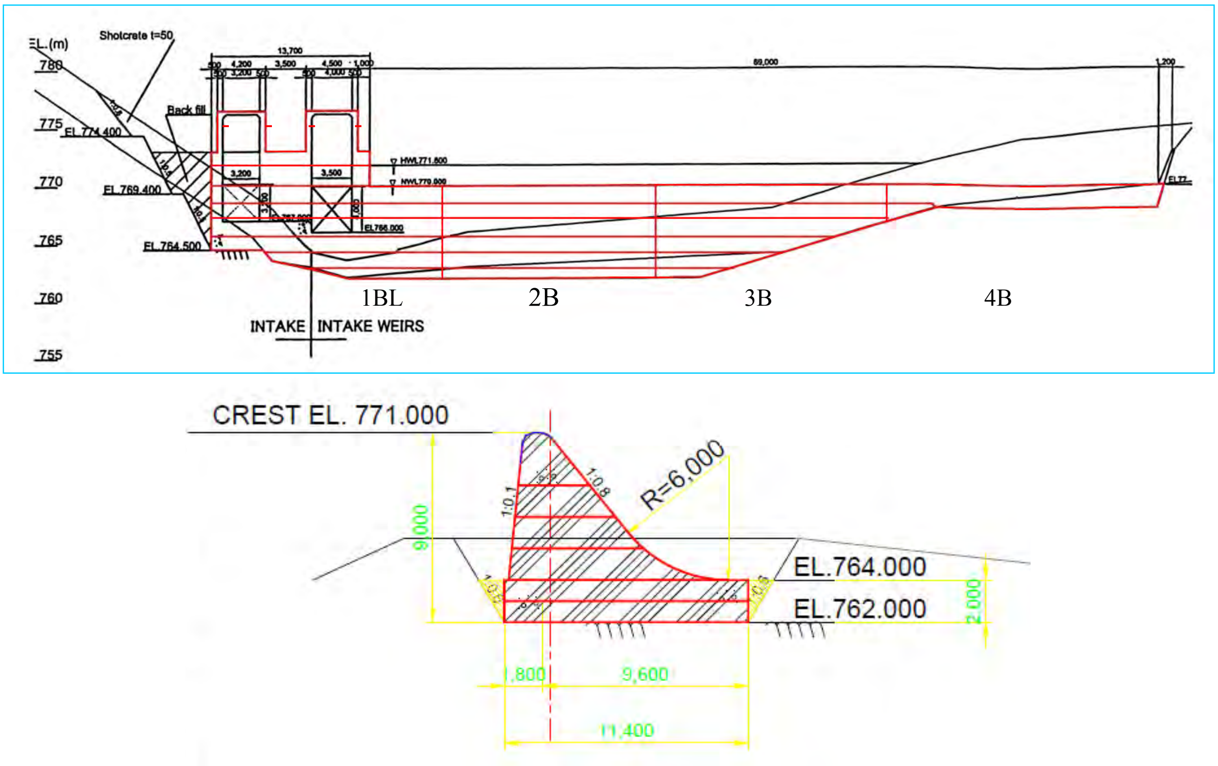


Figure 5.3-1 Establishment of No.1 Weir

(b) No.2 Weir

No.2 weir is divided into six (6) blocks and number of lifts is (7) lifts for the main weir body and two (2) for the additional placement. Construction period is estimated at 4.9 month and it can be completed within dry season.

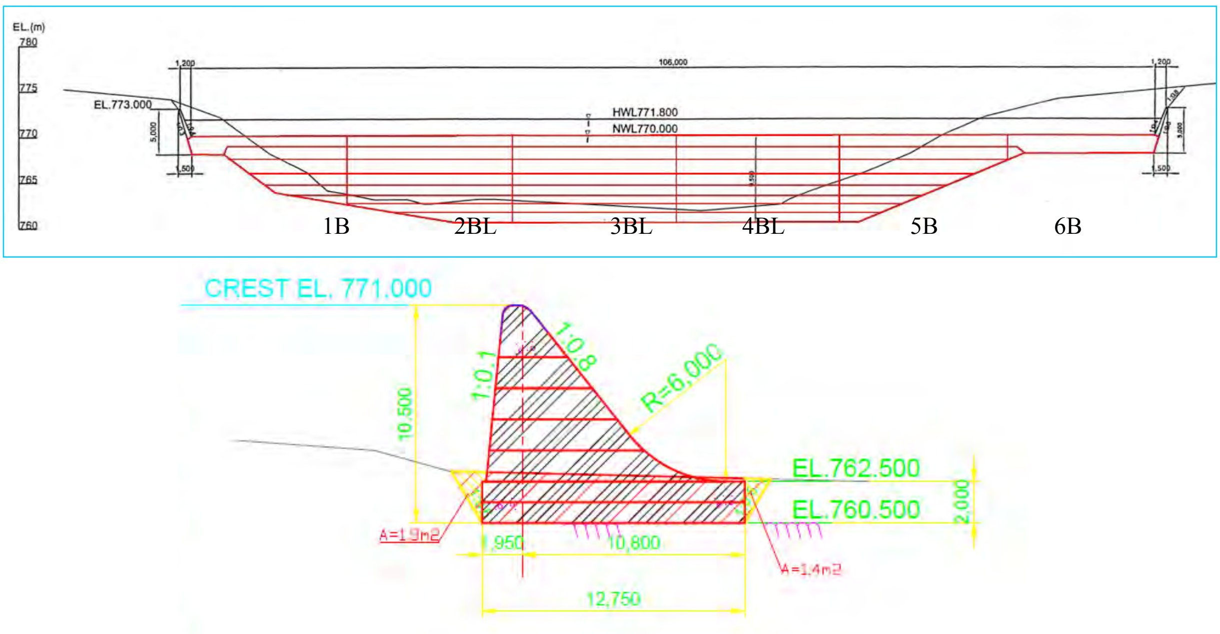


Figure 5.3-2 Establishment of No.2 Weir

(c) Settling Basin

Excavation for the settling basin is continuously implemented from the intake works. Although excavation volume is small, cutting works should be implemented carefully due to the slope height over 20m. Settling basin is divided into two blocks with four (4) lifts and construction period is approximately 3.4 month.

5.3.3 Headrace Tunnel

(1) Headrace Tunnel

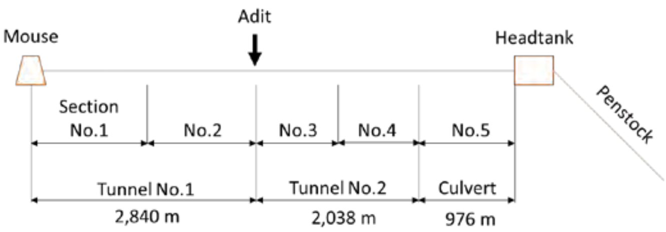


Figure 5.3-3 Section of Headrace Tunnel

Headrace is composed of approximately 4.9 km tunnel, 1.0 km culvert and 17m of open channel which connects the settling basin and tunnel. As tunnel extension length is long, it is divided into five (5) sections and constructed partially with one adit.

Considering the size of tunnel section, NATM is applied for the excavation and rail method is applied for the debris transportation.

Tunnel support patterns and proportion is shown below and they are applied to the all section. Culvert box of open channel will be constructed after the tunnel completion.

Table 5.3-2 Tunnel Support Patterns and Proportion

Support Pattern	Support	Proportion (%)
A	Shotcrete 5 cm	41.8
B	Shotcrete 5 cm＋Rock Bolts 3 pieces	41.8
C	Shotcrete 10 cm＋Rock Bolts 5 pieces	4.1
C-1	Shotcrete 10 cm＋Rock Bolts 5 pieces＋Steel Support	4.1
D	Shotcrete 10 cm＋Rock Bolts 5 pieces＋Steel Support＋Concrete lining	8.2

(2) Construction

(a) Excavation Works

Monthly average excavation length of each support pattern and excavation period of each section is shown below.

Table 5.3-3 Monthly Average Excavation Length of each Support Pattern

Item	Unit	A	B	C	C-1	D	Remark
Length per day	m	5.76	4.55	3.46	3.42	2.93	Two shift
Length per month	m	138	109	83	82	70	24 day/month
Proportion of patterns		41.8	41.8	4.1	4.1	8.2	(%)
Monthly average excavation length	m	109					

Table 5.3-4 Construction Period of each Section

Section	Extension Length (m)	Monthly average excavation length (109m) Period (month)
1	1,600	14.7
2	1,240	11.4
3	1,019	9.4
4	1,019	9.4
5	975	8.9
Total	**5,634**	**53.8 month**

(b) Concrete Lining Works

Concrete lining is only applied to the Type D shown in Table 4.2-3 (8.2% of tunnel extension). Invert concrete is placed at all sections.

Table 5.3-5 Breakdown of Concrete Works

Section	Extension (m)	Lining			Invert		
		Extension (m)	Concrete (m^3)	Period (month)	Extension (m)	Concrete (m^3)	Period (month)
1	1,600	131	413	3.0	1,600	967	2.3
2	1,240	101	320	2.4	1,240	750	1.7
3	1.019	84	263	1.8	1,019	616	1.3
4	1,019	84	263	1.8	1,019	616	1.3
Total	4,878	400	1,260	Total 10.9	5,634	2,949	Total 8.0

(c) Temporary Facilities

1) Batcher Plant

Although batcher plants are generally installed at each tunnel mouth, shotcrete and concrete is produced at No.1 batcher plant at the downstream of intake weirs and transported by mixer trucks. No.1 batcher plant has production capacity of $55m^3/h$ which is adequate to supply concrete to all sections and other facilities in parallel.

2) Debris Pit

Tunnel excavation debris are transported by muck cars (side opening door type with $4.8m^3$) and placed at outside debris pits temporarily. Debris pits shall be designed to have the capacity of minimum one day amount from two tunnel mouth. This debris is transported to disposal areas by dump trucks in the daytime.

5.3.4 Head Tank

(1) Outline

Head tank is a circular structure with long span of 22.425m and short span of 14.5m. Considering the characteristics of the structure, it is preferable to construct it as one block.

Because progress of head tank is also the critical path of penstock construction which is relatively tight schedule, it is necessary to finish excavation works as soon as possible. After the access road is connected to the head tank and headrace tunnel mouth, installation of tunnel debris pits, excavation and establishment works is implemented one by one.

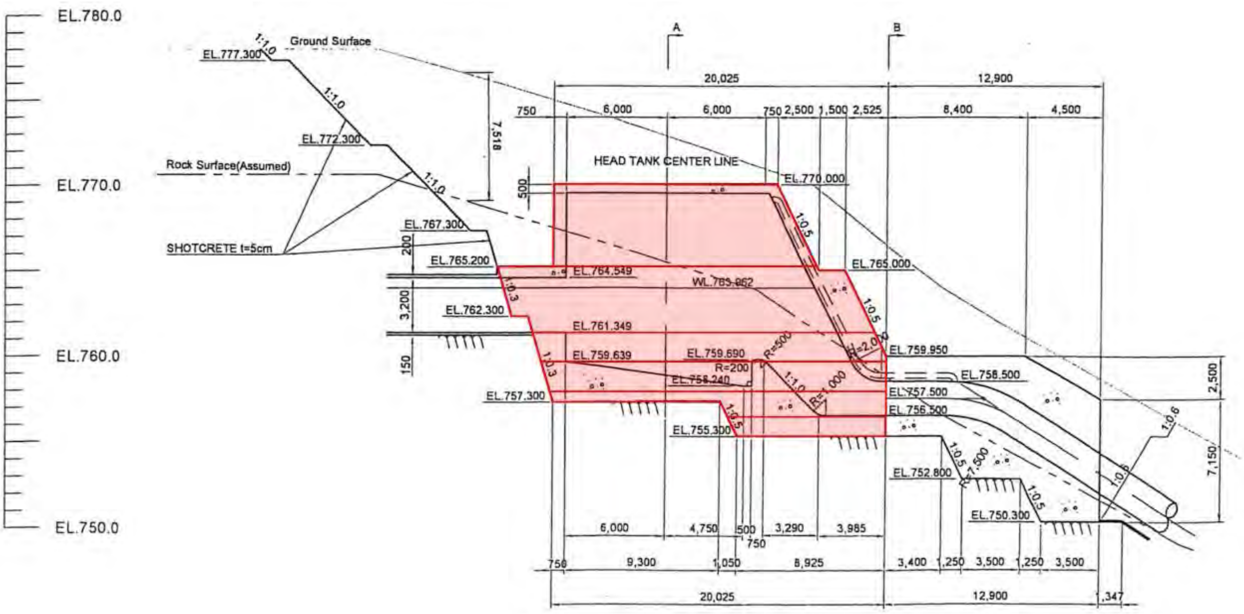


Figure 5.3-4 Establishment of the Head Tank

(2) Construction

(a) Excavation

Excavation works with a backhoe of 0.7m^3 class of the head tank and the beginning part of penstock will be continuously implemented. Debris is transported to the disposal area if possible.

(b) Establishment

Head tank has complicated shapes to establish. Therefore concrete placement shall be less than 300m^3 per time and six (6) lifts as shown in Figure 5.3-4. Concrete is placed by the pump truck. Construction period is estimated at approximately 4.5 month including the excavation.

5.3.5 Penstock

(1) Outline

Penstock dimensions are horizontal length of 1,137.7m, vertical difference of 472.0m and pipeline length of 1263m. Topography of the penstock route is steep and excavation of soil and rock are totally over 70,000m^3. Welding of steel are 241 points. Construction works are divided into three (3) sections and implemented in parallel.

Table 5.3-6 Section of Penstock Works

Section	Elevation (m)	Horizontal (m)	Real Length (m)	Remarks
1	757.4 ~ 523	357.5	432.8	Access road for heavy machineries is constructed and a cable way which has the capacity of 6 ton is installed for materials transportation. EL.757.5 ~ 752: Excavation works shall be implemented at the same time with head tank.
2	523 ~ 432	434.7	446	Access road for vehicles is constructed with switchbacks at the corner (maximum slope is 14%)
3	432 ~ 285.4	343.3	394.8	EL.432 ~ 342: Access road for heavy machineries is constructed and a cable way which has the capacity of 6 ton is installed for materials transportation. EL.342 ~ 326: Access road for vehicles is constructed which is attached from the route to powerhouse. EL.326 ~ 297: Excavation works shall be included in powerhouse works. Travelling cranes are installed for the materials transportation.

(2) Construction Plan

(a) Excavation

Excavation method and construction plan are studied as shown below according to the topography of penstock route.

- Steep Slope: EL.757.4 ~ 615.0m、EL.432 ~ 342m

  Soil Excavation capacity per day is 268 m^3 by a backhoe of 0.7m^3 (working efficiency of 0.5). Excavated soil for backfill is placed temporarily and other portion is thrown lower.

  Rock Excavation capacity per day is 140m^3 by a crawler drill. Excavated rock is thrown lower.

- Mild Slope: EL.615 ~ 523m

  Soil Same as steep sections (Excavation capacity per day is 268 m^3 by a backhoe of 0.7m^3)

  Rock Excavation by explosion using a crawler drill. Giant breaker of 0.7m^3 is also applied for the supplementary. Excavation capacity per day is 192 m^3 (working efficiency of 0.3).

- Flat Area: EL.523 ~ 432m, EL.342 ~ 313m

  Soil Excavation capacity per day is 376 m^3 by a backhoe of 0.7m^3 (working efficiency of 0.7).

  Rock Same as steep sections (Excavation capacity per day is 192 m^3)

Construction period is total 8.9 month due to Section 2.

Table 5.3-7 Excavation Schedule

	Section	Horizontal Distance (m)	Excavation Volume (m^3)		Excavation Capacity (m^3/day)	Period (day)
Section 1	EL.757.4 ~ 615	171.5	Soil Rock	5,400 5,400	268 140	20.1 38.6
	*EL.615 ~ 523	186.0	Soil Rock	2,270 2,270	268 192	8.5 11.8
	Sub total					79 day
	79day ÷22 day/month					3.6 month
Section 2	EL.523 ~ 432	434.7	Soil Rock	16,190 16,190	376 192	43.1 84.3
	EL.462	Cross section of National Road Box culverts are installed and temporary route of the road is aligned along the mountain side. After installation of boxes, road route is replaced to the original one. 22 day × 2 blocks + 10 day (Replace)				50
	Sub total					177.4
	177.4day÷22day/month					8.1 month
Section 3	EL.432~342	87.3	Soil Rock	3,590 3,590	268 140	13.4 25.6
	EL.342~313	256	Soil Rock	9,740 9,740	376 192	25.9 50.7
	Sub total					115.6
	115.6 day÷22 day/month					5.3 month

* As for EL615~523m, although it is included in Section 1, excavation works shall be implemented by crawler drills sequentially from the Section 2.

(b) Anchor Blocks

Following to the excavation works, concrete placement of anchor blocks will be implemented. Concrete placement will be implemented by boom type pump trucks within two months after the completion of excavation works.

(c) Installation of Penstock

Unit length of penstock shall be basically 6m. Considering the weight and cable capacity, it shall be 4m between EL.432 – 342. Period of penstock installation works is according to the welding processes (2 days per point). There are 90 welding points in Section 1 which is critical among all sections and total period for the installation works is approximately 9 month including the inspection and painting. Installation works shall be started after the 40% completion of concrete

Table 5.3-8 Installation of Penstock at Each Section

Section	Elevation (m)	Penstock Length (m)	Welding Point
No.1	EL 757.5 ~ 523	432.8	90
No.2	EL 523 ~ 432	446	75
No.3	EL 432 ~ 313	394.8	76

placement works for anchor blocks.

(3) Permanent Facilities

Cable ways for penstock and materials transportation are installed at steep slope sections where is hard to construct access road. Considering the penstock weight per unit, rated hoisting capacity shall be 6 ton (actual load is 5 ton). Cable ways are installed at two points as shown below.

1)	EL.757.5 ~ 523m	Span 400m	Post 30m
2)	EL. 432 ~ 342m	Span 140m	Post 25m

A fabricating factory for penstock is built along the National Road. Other factories such as steel bar assembling are shared with powerhouse facilities.

5.3.6 Powerhouse

(1) Access Road

Access road of 1,400m from the National Road to the powerhouse is constructed. Elevation of the approach point to powerhouse area is GL. 301.8m. Elevation Difference between the National Road and powerhouse point is approximately 56m and average gradient is approximately 3.7%. This road is used for the permanent access road to powerhouse after the commissioning and width of 6.5m is secured.

As elevation of the excavation bottom is EL 279.250m, route for the excavation debris transportation blanched from the above road is constructed at the river side.

(2) Excavation

Excavation of the penstock route (EL.313.05 ~ 285.44m) and tailrace route will be implemented simultaneously. Excavation volume is shown below.

Soil	19,130 m^3
Rock	36,980 m^3

Excavation method is by explosion using a crawler drill. A giant breaker of $0.7m^3$ is also applied for the supplementary. Backhoe of $1.2m^3$ class is used for the debris loading. Excavation capacity is shown below.

Soil	564.2 m^3/day
Rock	352.8 m^3/day

As height of the excavated slope is maximum 37.5m, berm is installed by 5m and slope protection by mortar is implemented.

(3) Steel Dock

After the completion of excavation works, steel dock is established for the equipment installation and building construction. Structural standard of this dock shall be applied for the 50 ton crawler crane. Because switchyard station is planned to be located at the upper side of powerhouse, this crane should equip the function to intersect up and downstream. Total length and width of this dock is 40m and 8m respectively. However, in the case of tower crane application, steel dock is unnecessary.

(4) Building Construction

Bottom slabs including the equipment foundation are placed at first. Lift up of the building shall be implemented sequentially in correspond to the equipment installation process. Gantries are used for the putting of construction materials and concrete placement.

(5) Installation and Adjustment of Equipment

Water turbine generators and auxiliary equipment, medium and low-voltage switchgear and control system shall be installed. The construction work shall be executed one after another from the bottom to the top in coordination with placement of concrete. Upon completion of installation of equipment, pre-commissioning test and commissioning test shall be performed.

(6) Tailrace

Tailrace works shall be implemented simultaneously with powerhouse. As tailrace outlet is required to close, construction works shall be implemented in dry season.

5.4 Temporary Facilities Plan

5.4.1 Temporary Facilities Plan

(1) Batcher Plant

Xe Katam site can be divided into two construction divisions, upstream area (Intake weirs area) and Downstream area (Powerhouse area) and two batcher plants are installed at each area. These plants equip the precipitation pond for the turbid water treatment which is also utilized to process turbid water from other construction works. In addition, Power generators, water supply and drainage equipment and repair factories are also installed near the batcher plant.

Location and specifications of batcher plants are shown in Figure 5.4-1 and Table 5.4-1.

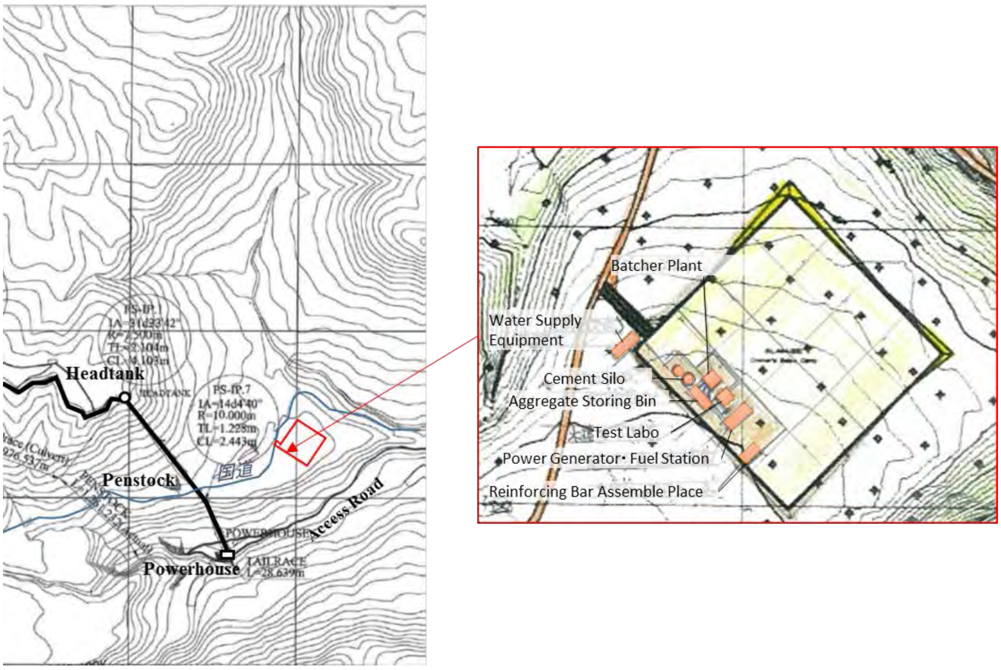


Figure 5.4-1 Layout of Batcher Plant No.2 (Downstream area)

Table 5.4-1 Specification of Batcher Plants

Plant	No. 1	No.2
Location and Area	Downstream of Settling Basin (approx. 1,000m^2)	Powerhouse Area (approx. 1,000 m^2)
Type and Capacity	Double shaft pugmil mixer 1.5 m^2× 1, 83kW, 55 m^3/h	Double shaft pugmil mixer 1.5 m^2× 1, 83kW, 55 m^3/h
Facilities	Intake weirs – Headrace tunnel	Head tank – Powerhouse
Operation Period	18 month (20 month in installation)	12 month (20 month in installation)
Average Monthly Production	1,750 m^3	1,550 m^3
Aggregate Facilities	Aggregate bins (Concrete partition type) Open ground storage yard, Tractor shovel Storage capacity 1,000t	Aggregate bins (Concrete partition type) Open ground storage yard, Tractor shovel Storage capacity 1,000t
Cement Silo	100t × 2 unit	100t × 2 unit
Turbid Water Treatment	Sedimentation Basin (300 m^3)	Sedimentation Basin (300 m^3)
Power Generation	Generator 100kVA	Generator 100kVA

(2) Other Facilities

Other major temporary facilities are shown in below table.

Table 5.4-2 Major Temporary Facilities and Required Area

Location	Name	Features	Area (m^2)	Remark
Downstream of Settling Basin	Batcher Plant	$1.5m^3\times$ 1 unit, 55 m^3/h	3,000	Including aggregates bin and cement silos
	Power Generator	100kVA×1 unit	200	
	Fuel Station			
	Water Supply Equipment			
	Repair Factory			
	Turbid Water Treatment	Sedimentation sand	300	
	Test Labo		80	Concrete
	Magazine		50	
	Reinforcing Bar Assemble Place		1,500	
	Miscellaneous		200	
Each Mouth of Headrace Tunnel	Debris Pit		300	
	Air Supply Unit	50kVA×1 unit		
	Water Supply and Drainage Equipment		300	
	Miscellaneous		200	
Penstock	Railway Equipment	2 unit		
	Reinforcing Bar Assemble Place		1,000	Cranes
Powerhouse	Batcher Plant	$1.5m^3\times$ 1unit, 55 m^3/h	3,000	Including aggregates bin and cement silos
	Power Generator	100kVA×1unit	200	
	Fuel Station			
	Water Supply Equipment			
	Repair Factory			
	Turbid Water Treatment	Sedimentation sand	300	
	Test Labo		80	Concrete
	Magazine		50	
	Reinforcing Bar Assemble Place		1,500	
	Concrete Form Place		500	
	Miscellaneous		200	

5.4.2 Mobilization Plan of Heavy Machineries

Maximum required number of heavy machineries is shown in below except tunnel machines.

Table 5.4-3 Maximum Required Number of Heavy Machineries

Machines	Type	Number	Main Objective Works
Bull Dozer	32t	1	Excavation and earth works
	21t	1	Excavation and earth works
	10t	3	Excavation and earth works
Backhoe	1.2 m^3	3	Excavation and loading
	0.7 m^3(with breaker)	4	Excavation and loading
	0.4 m^3	2	Excavation and supplementary of loading
Crawler Drill	150 kg	4	Rock excavation
Dump Truck	10t	16	Transportation of tunnel debris and disposal soil
Truck Mixer	4.5 m^3	4	Concrete and mortar transportation
Vibration Roller	3t	2	Road and disposal area
Pump Truck with Boom	90 m^3/h	2	Concrete placement
Grazer		1	Road maintenance
Sprinkler Truck	10 t	2	Access road
Traction Vehicle for Machineries	20 t	1	Towing of machines
Crane	Crawler Type :50 t	1	Establishment and installation works
	Truck Type :20 t	1	Establishment and installation works
Truck with Cranes	10 t	4	Tunnel materials transportation
Tractor Shovel	1.5 m^3	2	Aggregates supply for batcher plants

Construction Works		Year	X-yr						X+1-yr												X+2-yr												X+3-yr				Remark
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
		Month	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	
Preparatory Works																																					
Access Road	Bull dozer	10 t		2	2	2	2	2	2	2	2	2	2	2																							
	Back hoe	0.7 m^3		2	2	2	2	2	2	2	2	2	2	2																							
	Cradler	10 t		1	1	1	1	1	1	1	1	1	1	1																							
	Vibration roller	3 t		1	1	1	1	1	1	1	1	1	1	1																							
	Crane	20 t			1	1	1	1	1																												
	Crane	50 t				1	1																														
	Dump truck	10 t		2	3	3	3	3	3	3	2	2	2	2																							
Plant	Bull dozer	10 t				1	1	1	1	1	1	1	1																								
	Back hoe	0.4				1	1	1	1	1	1	1	1																								
	Crane	20 t									2	2	2																								
	Dump truck	10 t				1	1	1	1	1																											
	Dozer shovel	3.2 m^3						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										
Intake Weirs / Intake / Settling Basin	Bull dozer	10 t														1	1	1																			
	Back hoe	1.2 m^3														1	1	1										1	1								
	Back hoe	0.7 m^3														1	1	1		1								1	1		1						
	Crawler drill	150 kg															1	1										1	1								
	Dump truck	10 t														7	7	7										9	9								
	Crane	20 t																1	1	1										1	1						
Headrace (Open Channel)	Back hoe	0.7 m^3								1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3												Except Tunnel Machines
	Bull dozer	10 t								1	1		2	2	2	2	2	2	2	2	2	2	2	2	2												
	Crawler drill	150 kg								1	1		1	1																							
	Crawler drill	20 t									1			1	1										1												
	Dump truck	10 t								2	3	4	6	8	8	8	13	13	13	13	13	13	13	10	10												
Headtank	Bull dozer	10 t											1	1	1																						
	Back hoe	1.2 m^3												1	1																						
	Back hoe	0.7 m^3											1	1	1																						
	Crawler drill	150 kg											1	1	1																						
	Dump truck	10 t											2	3	3																						
	Crane	20 t														1	1	1																			
Penstock	Back hoe	1.2 m^3												4	4	4	4	4	4	4	4	4	4	2													
	Back hoe	0.7 m^3												4	4	4	4	4	4	4	4	4	4	2													
	Bull dozer	10 t												1	1	1	1	1	1	1	1																
	Dump truck	10 t												2	2	2	2	2	2	2	2																
	Crane	20 t												1	1	1	1	1																			
Powerhouse	Bull dozer	10 t											1	1	1	1																					
	Back hoe	1.2 m^3											1	1	1	1																					
	Back hoe	0.7 m^3											1	1	1	1																					
	Crawler drill	150												1	1	1																					
	Dump truck	10 t											5	5	5	5																					
	Crane	20 t														1	1	1	1	1																	
Common Work	Pump Truck					1	1	1	1	1	1	1	1	1	2	2	3	3	3	3	2	1	1	1	1	1		1	2	2	1						
	Crawler crane	50 t									1	1	1	1	1	1	1																				
	Crane	20 t				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
	Unic Car	10 t				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
	Cradler										1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
	Bull dozer	10 t									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
	Sprinkler car					1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1					
	Traction vehicle for machineries										1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
Disposal Area	Bull dozer	20 t							1	1	1	1	1	1	1	1																					
	Bull dozer	10 t							1	1	1	1	1	1	1	1	1	1	1	1	1																
	Back hoe	0.7 m^3							1	1	1	1	1	1	1	1	1	1	1	1	1																
	Vibration roller	3 t								1	1	1	1	1	1	1	1																				

Figure 5.4-2 Heavy Machine Mobilization Schedule

5.4.3 Construction Schedule

Construction schedule of Xe Katam project is planned as shown below.

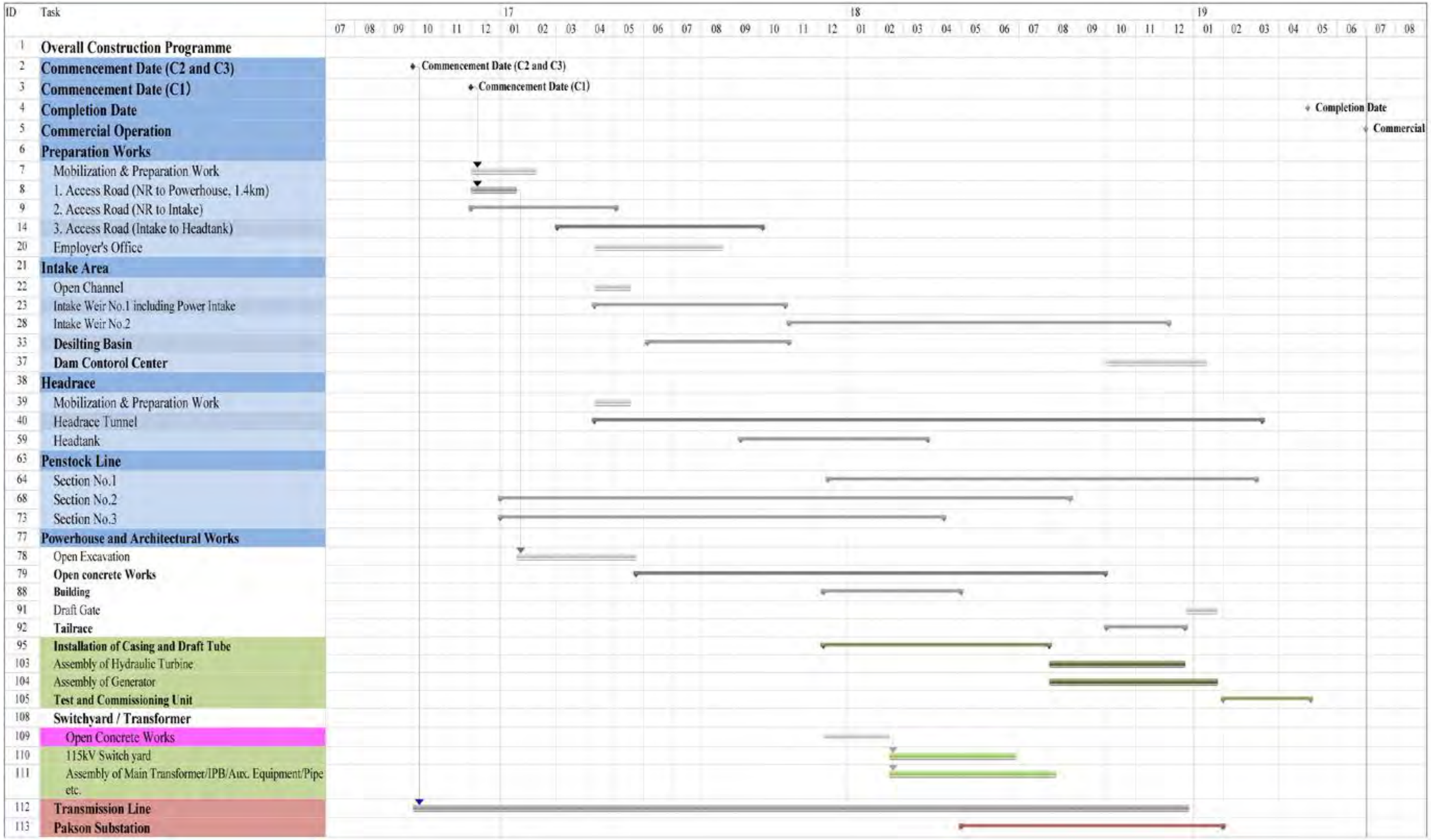


Figure 5.4-3 Construction Schedule

CHAPTER 6

ENVIRONMENTAL AND SOCIAL CONSIDERATION

CHAPTER 6 ENVIRONMENTAL AND SOCIAL CONSIDERATION

During this Preparatory Survey, an environmental and social consideration survey was conducted in accordance with the JICA Guidelines for Environmental and Social Consideration (April 2010, hereinafter called JICA Guideline). The survey result was submitted as an Environmental and Social Impact Assessment (ESIA) to the Ministry of Natural Resource and Environment (MONRE).

ESIA had been prepared and submitted based on the reservoir type design with a dam at the initial stage of the Preparatory Study. As the design of the Project was revised from reservoir type to run-of-river type, a revised ESIA for the run-of-river type without dam was resubmitted to MONRE. In this Chapter, the description is based on the ESIA for the run-of-river-type (the intake weir, however has an impoundment capacity enough to regulate incoming water daily).

6.1 Overview of the Project Component that causes Environmental and Social Impacts

Xe Katam Hydropower Plant Project (Project) had been planned as the reservoir type with 81.3 MW capacity to assist development in southern Laos PDR, located on the Bolaven Plateau in southern Laos. As a result of this Preparatory Survey, the design has revised to the run-of-river type with 81MW capacity. The location of the Project is shown in Figure 6.1-1.

Figure 6.1-1 Project Location

6.1.1 Project Scope

The layout and features of main facilities are shown in Figure 6.1-2 and Table 6.1-1 respectively. Electric power is generated by diverted water at intake weirs in the Xe Katam River.

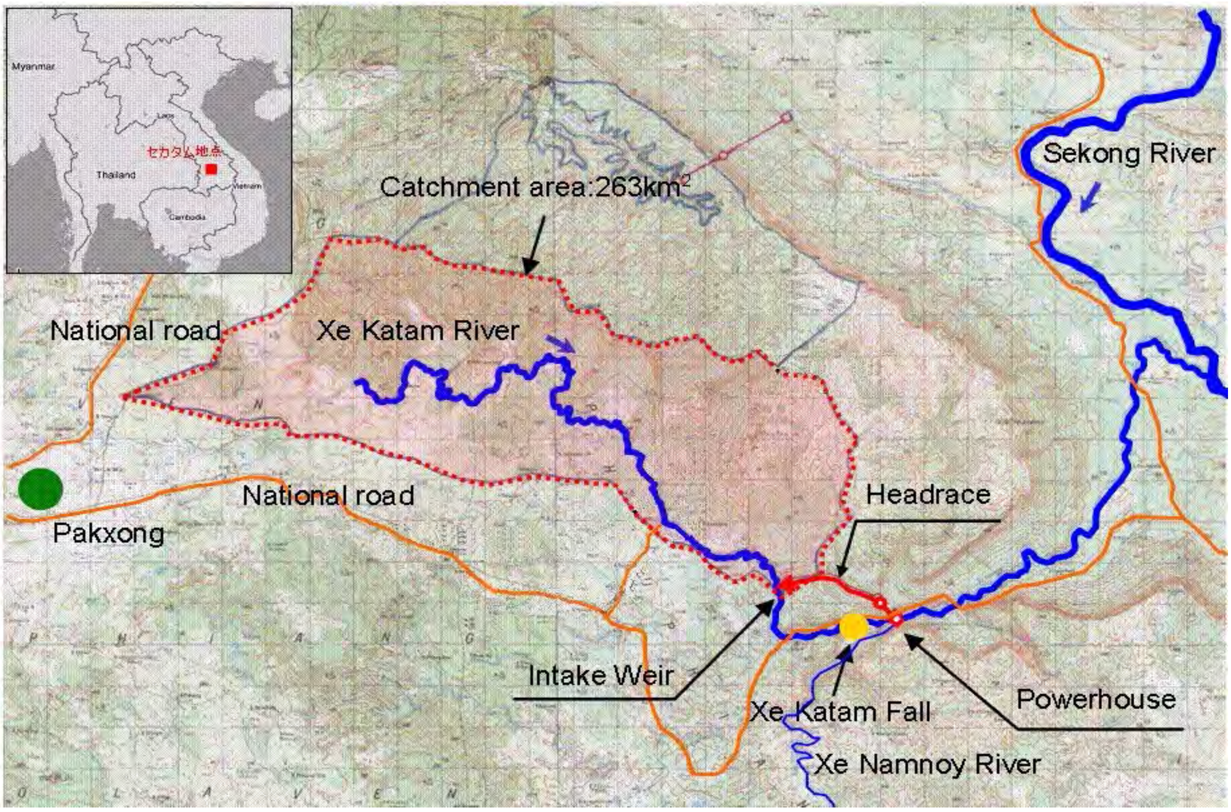


Figure 6.1-2 Xe Katam Catchment and Layout of Project Components

Table 6.1-1 Main Facilities of the Project

Structure		Revised Design
Intake Weirs	Catchment Area Annual Average Inflow Dam Type Crest Length (Main River) Crest Height (Main River) Crest Length (Branch) Crest Height (branch)	263 km^2 12.1 m^3/s Gravity 106.0 m 9.8 m 73.0 m 8.5 m
Headrace Tunnel	Design Flow Rate Length of Tunnel Diameter Length of Culvert Width Height	20.0 m^3/s 4.9 km (non-pressure during operation) 3.9 m (Hood-shape) 1.0 km (non-pressure during operation) 3.2 m 3.0 m
Penstock	Type Length Diameter	Exposed 1,263 m 2.2 m
Powerhouse	Type Gross Head Effective Head Turbine Type Rated Output Annual Energy Generation	Semi-underground 475.40 m 457 m Francis 81 MW 299 GWh
Transmission Line	Capacity Length Connecting Point	115 kV 45 km Pakxong S/S

6.1.2 Access Road

Existing roads are renovated for 3.3 km and new roads are constructed for 13.0 km. The total length of access road is 16.3 km.

Table 6.1-2 Access Road Plan

No	Section	Extension (km)			Remark
		Renovation	New	Total	
1	Nam Touad - Intersection	3.3	0	3.3	New Bridge × 1 (Nam Touad River)
2	Intersection - Intake Weirs	0	1.8	1.8	New Bridge × 1 (Xe Katam River)
3	Intake Weirs - Head Tank	0	8.0	8.0	
4	Adit tunnel	0	1.0	1.0	
5	Penstock	0	0.7	0.7	
6	National Road - Powerhouse	0	1.5	1.5	
	Total	**3.3**	**13.0**	**16.3**	

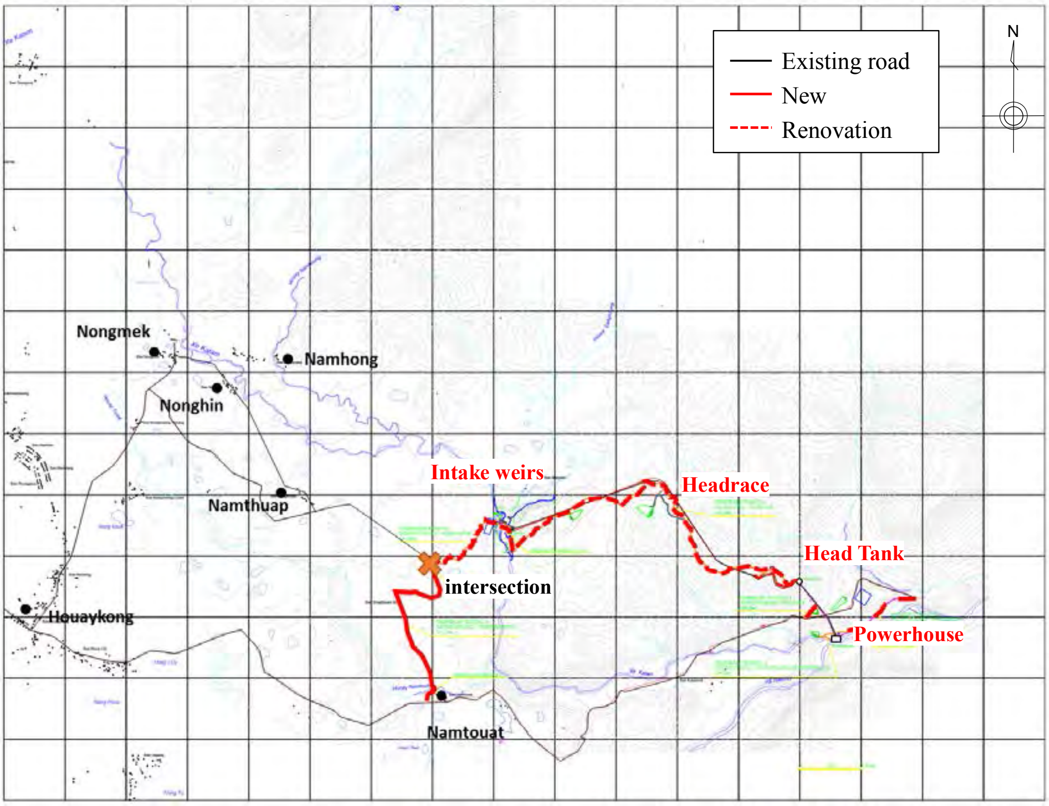


Figure 6.1-3 Access Road Planning Route

6.1.3 Transmission Line

Generated power is evacuated by an overhead transmission line of 115 kV with 45 km-length from the powerhouse to the Pakxong Substation (see Figure 6.1-4). 131 transmission towers with 12m × 12m in foundation area and 40m in height are erected.

Figure 6.1-4 Transmission Line Route

6.1.4 Work Plan

Construction period is anticipated approximately 29 months based on a basic design (Figure 5.4-3).

6.1.5 Operation Plan

As described in Section 4.1.2, the intake weirs regulate inflow with utilizing its impounding capacity and maintain the maximum output for about 6 hours following the power demand. Environmental flow for mitigating the impact on water use and aquatic biota, and additional flow for preserving visual value of the Xe Katam Fall is released from the intake weir to downstream (collectively, “river maintenance flow”). The river maintenance flow is 0.52 m^3/s throughout the day as environmental flow and 0.67 m^3/s during the daytime (approximately 8 hours) in consideration with landscape (see Section 6.10.2 for the river maintenance flow). The operation plan of Project is described as follows;

a. During normal operation (inflow is low to medium), 0.52 m^3/s and 0.67 m^3/s is released from the intake weir during night time and day time, respectively. Rest of inflow is diverted to headrace tunnel for generation.

b. Following the increase of inflow, diverted flow increase. In case inflow reaches more than 20 m^3/s, generation hours extend.

c. In case inflow reaches to the amount equivalent to 24 hours maximum output operation, remaining inflow that cannot be utilized for power generation is released to downstream.

6.2 Environmental and Social Baseline

6.2.1 Natural Environment

(1) Climate/ Meteorology

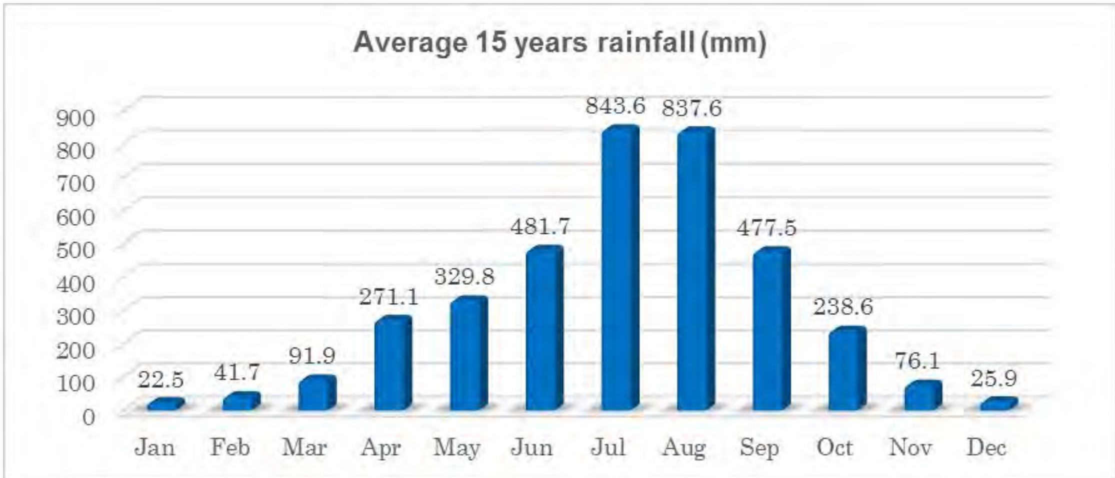
The Project is located in the South East Asia monsoon climate region. This area is located in a tropical climate zone and has rainy and dry season. The rainy season begins from May and extends until October, while the dry season runs from November to April.

During the winter, the regional climate is under the influence of a cold continental high pressure region over the China. The winds move in a clockwise direction around the high pressure region and are from the northeast. This system is known as the Northeast Monsoon and is characterized by cold dry air and infrequent and light rain, which occurs from November until April. In some years night temperatures as low as 0° degrees Celsius have been recorded.

In the period from May to October, radiation heats the landmass beneath to form an extensive low pressure region called the Inter-tropical Convergence Zone (ITCZ) or the Monsoon Trough. This causes warm winds from the southwest to carry moisture from the Andaman Sea and the Gulf of Thailand to the part of the trough in the Lao PDR region, where orographic lift causes rain, often with heavy rainfall during the height of the monsoon when the local temperatures and humidity is high.

In addition to the monsoons, the Project area occasionally experiences tropical cyclones, typhoons, and weak tropical depressions.

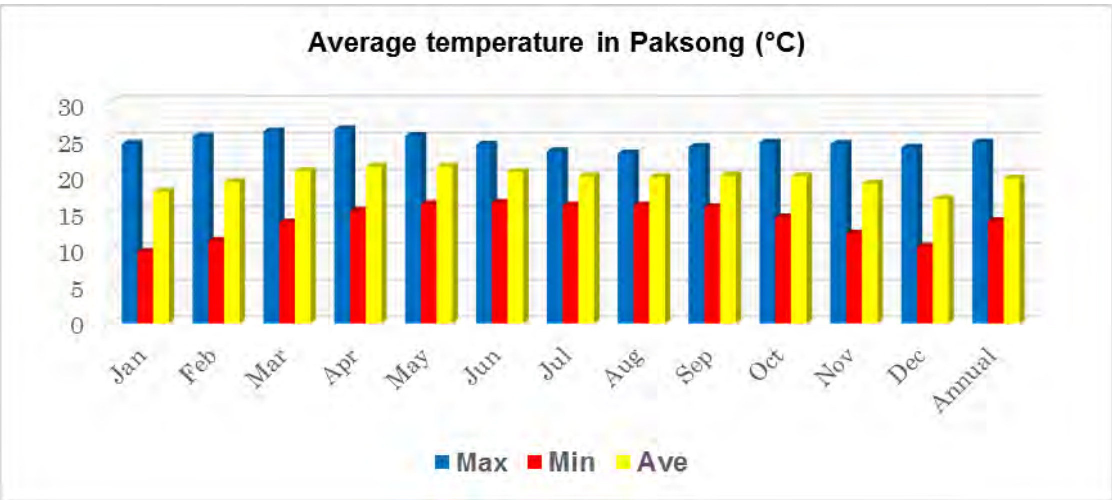
The Project is located on the Bolaven Plateau where it experiences very good weather conditions in comparison to the rest of the Lao PDR. The Government Meteorology Station at Pakxong at an altitude of 1,280m amsl has provided records collected since 1999[1]. The patterns of monthly rainfall and temperatures are given in Figure 6.2-1 and Figure 6.2-2 below:



Source: Meteorology of Pakxong Station (1999-2013)
Total Average Annual Rainfall : 3706.2 mm

Figure 6.2-1 Rainfall

1 Department of Meteorology and Hydrology Statistics 2013



Source: Meteorology of Pakxong Station (1999-2013)
Max Ave : 24.6 °C
Min Ave : 13.9 °C
Middle Ave : 19.7 °C

Figure 6.2-2 Temperature

(2) Evaporation

Evaporation in Pakxong District, as well as in the Project area, is high in comparison to other parts of Champasak Province. The highest levels of evaporation occur during the dry season from October to April with an average of about 102 mm to 132 mm, while in the rainy season evaporation levels range from 80 mm to 93 mm. Annual evaporation is estimated about 800 mm / year.

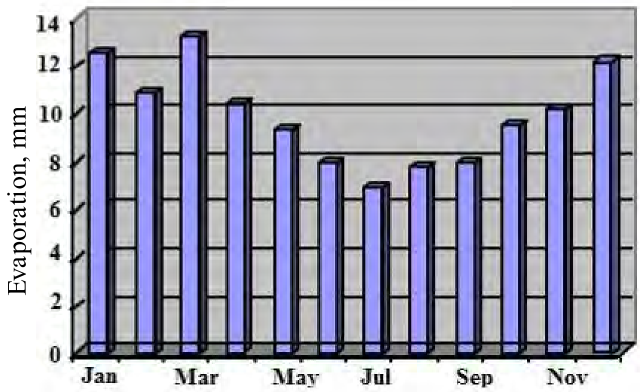


Figure 6.2-3 Evaporation in Pakxong District

(3) Topography

The regional topography of the Project area is illustrated on Figure 6.2-4 showing the position of the Project area on the Bolaven Plateau.

The northern half of the catchment consists of the steep southern slopes of a mountain ridge between 900 and 1300 meters amsl dissected by about 5 significantly sized streams, each one flowing directly into the Xe Katam River running in a southwest to north east direction to join the Xe Namnoy River. The southern half of the catchment is undulating terrain about 900 meters amsl that has been extensively cleared for agricultural production. The eastern boundary of the catchment is defined by the steep escarpment of the Bolaven Plateau.

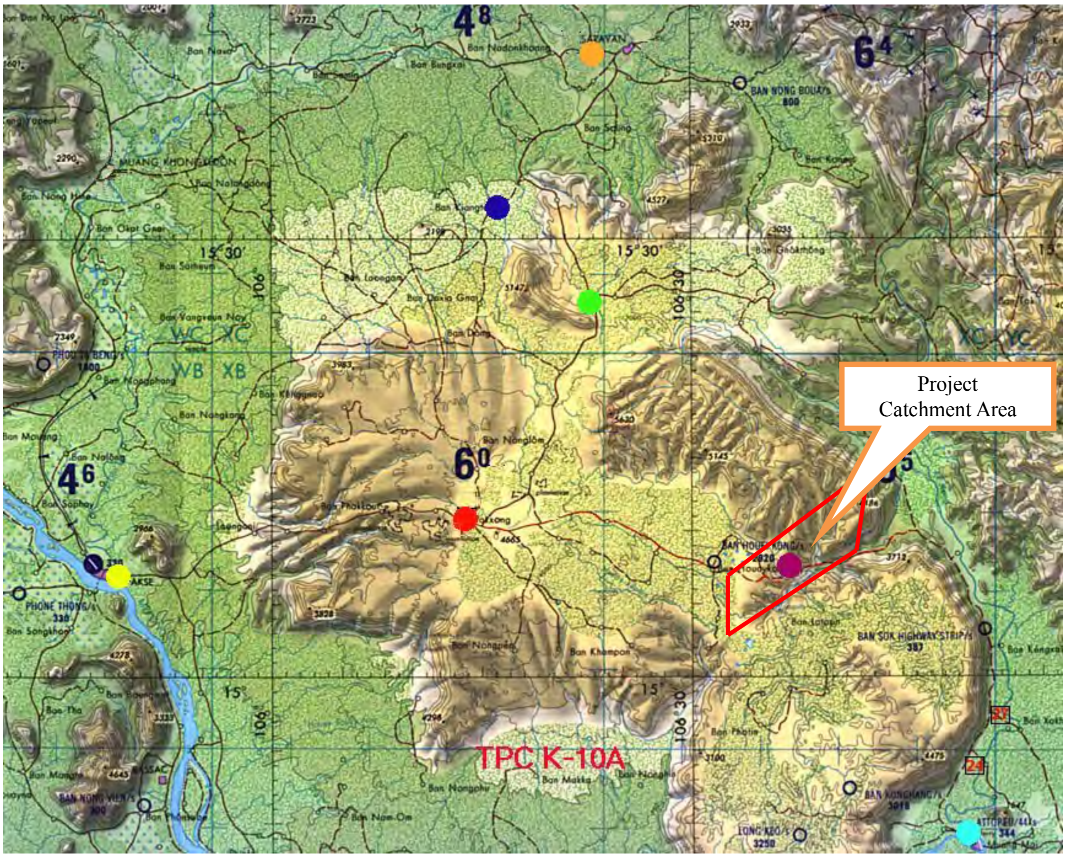


Figure 6.2-4 Location Map of the Project Area on Bolaven Plateau

(4) Geology

The Xe Katam basin with 263 km^2 catchment area is situated in the north – eastern sector of the Bolaven Plateau, and occupies mostly the south-side slopes of a mountain range formed along an east –west axis. The highest peak among the watersheds is the Mt. Maihia, 1,548 m. The Xe Katam River joins to the Xe Namnoy River at the immediate upstream of the powerhouse location of the Project. The Xe Namnoy River then takes its course to the east before entering the Xe Kong River.

The geology of the Bolaven Plateau is comprised of basement rocks that consist of red-colored conglomerate, sandstone and mudstone belonging to the Cretaceous Period Champa Formation, which is covered with layers of basaltic volcanic rocks erupted in the Tertiary Period. The mountains surrounding the plateau are also Cretaceous sandstones and mudstones.

Table 6.2-1 Geological Formations of the Bolaven Plateau

Age		Formation	Geological Faces
Cainozoic	Quaternary Alluvium	Alluvial sediments	Alluvial sediments and talus deposits composed of clay, sand and gravel
	Tertiary	Basaltic volcanic rocks	Basalt lava, volcanic laterites
Mesozoic	Cretaceous	Champa Formation	Red conglomerate, sandstone and mudstone
	Triassic to Jurassic	Tholam Formation	Red conglomerate, sandstone, mudstone and calcareous shale

(5) Natural Disaster/ Earthquake

In the Project area, flooding due to heavy rain has the possibility to arise a natural disaster. On the other hand, the storm such as a cyclone seldom occurs.

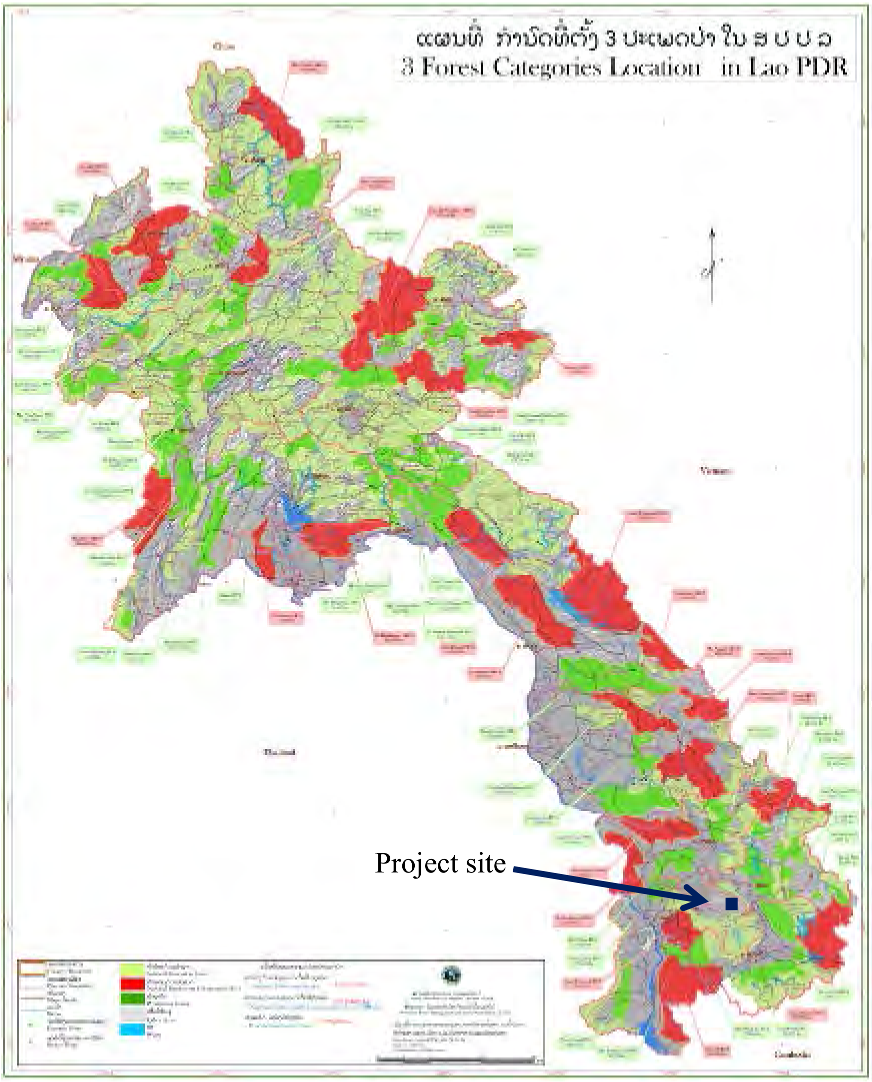
The bedrocks of the Champa Formations have a nearly horizontal structure, indicating the region is in a structurally stable area with very few fault lines present. As a result, the area in seismology terms is very low risk and earthquakes are unlikely to occur.

(6) Protected Area

The Project area is not included in a national park or national protected area. However, it is located approximately 10km from Phou Piang Bolaven National Protected Forest. Dong Houa Sao National Biodiversity Conservation Area is in the west of the Project area.

(7) Ecology

The Project area has the vegetation types of the dry evergreen forest, the mixed deciduous forest, semi-dry mixed dipterocarp, grass land and follow forest. Semi-dry mixed dipterocarp and dry evergreen species forest types are dominant vegetation types in the Project area. In the past, these region was so richly endowed with nature that larger mammals such as Asian Elephant and Tiger, and rare birds such as Masked finfoot and Crested fireback inhabited. But most of the forest was logged in the 1970’s, 80’s and 90’s. At present, many of the land has been used as coffee garden.



Source: DFR, MONRE

Figure 6.2-5 Location Map of National Protected Areas in Lao P.D.R

6.2.2 Social Environment

(1) Administrative Area

The Project area is located in Pakxong District, Champasak Province, which is in the south of Laos. Pakxong District is in charge of local administration.

(a) Champasak Province

Champasak Province has 15,415 m^2 area and 660,000 population. Pakse District (16-01) is central of Champasak Province which has 10 districts (see Figure 6.2-6).

The main industry is agriculture, the production of coffee, tea and rattan etc.

Figure 6.2-6 Administrative Division of Champasak Province

(b) Pakxong District

Pakxong District (16-04), which is the largest district in Champasak Province, has 88 villages and 73,000 population. The main industry is agriculture. Coffee has been extensively produced due to the location where is in the Bolaven Plateau with fertile soil and cool climate.

(2) Land Use

Land use in the Project area is mainly extensively exploited forest cover and shifting cultivation with the recent development of large and small scale coffee plantations also occurring.

6.3 System and Organization related to Environmental and Social Consideration in Laos

6.3.1 Legal Framework related to Environmental and Social Consideration

Basic law on environmental protection in Lao P.D.R. is Environmental Protection Law, which was enacted in April 1999. Following the section 8 of the EPL, Government of Lao (GOL) introduced procedure of environmental assessment in 2000 and promulgated Regulation on Implementing the Environmental Assessment for Electricity Projects in Lao PDR (Ministry of Industry and Handicraft) in 2001.

This regulation stipulates standard contents and procedure of Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA). Environmental Impact Assessment for Electricity Projects (Ministry of Industry and Handicraft, Department of Electricity, October 2001) and Environmental Management Standard for Electricity Projects (Ministry of Industry and Handicraft, Department of Electricity, January 2003) regulate details of EIA and Social Impact Assessment (SIA).

Those regulations were integrated and upgraded in 2010 by Decree of Environmental Impact Assessment (Degree 112/Prime Minister's Office) which stipulates public involvement, environmental management plan and monitoring plan, implementing organization, allocated budget and grievance redress mechanism together with revised procedure of EIA for avoiding or minimizing negative impacts caused by the projects. Ministry of Natural Resource and Environment (MONRE), which is a responsible ministry at present, promulgated Environmental Impact Assessment Guideline in November 2011.

MONRE revised process of EIA by Ministerial Instruction on the Process of Environmental and Social Impact Assessment of the Investment Projects and Activities (No 8030/MONRE) in December 2013. The ministerial instruction stipulates MONRE's involvement from the planning stage of projects, new procedure for complicated projects that involve large scale resettlement, reports of EIA to be written in Lao etc.

Besides those laws and regulations for regulating procedures of EIA, hydropower development is regulated by relevant laws and regulations, such as Environmental Management Standards, Water and Water Resource Law, Forestry Law, Law on Aquatic Animal and Wildlife, Electricity Law, Law on Public Roads, Decree on Compensation and Resettlement in terms of natural and social environment. The major laws and regulations are introduced in Table 6.3-1.

Table 6.3-1 Regulations relating to Environmental and Social Considerations in Lao PDR

Category	Regulations
EIA	Law on Environmental Protection, 1999, (Amendment 2013)
	Regulation on Environmental Assessment in Lao PDR, 2000
	Regulation on Implementing the Environmental Assessment for Electricity Project in Lao PDR, 2001
	Environmental Management Documents for the Department of Electricity, 2001
	Decree on Environmental Impact Assessment, 2010 (Decree No. 112/PM)
	Environmental Impact Assessment Guideline, 2011
	Ministerial Instruction on the Process of Environmental and Social Impact Assessment of the Investment Projects and Activities, No 8030 / MONRE, 17-Dec, 2013
Environmental Standard	Environmental Management Standard, Environmental Impact Assessment for Electricity Projects, 2003
	Agreement on the National Environmental Standards, No2734 /PMO. WREA, 7 Dec 2009
Resettlement, Compensation	Decree on the Compensation and Resettlement of the Development Project, 2005 (Decree No. 192/PM)
	Regulation for Implementing Decree 192/PM on Compensation and Resettlement of People Affected by Development Projects, 2005
	Technical Guidelines on Compensation and Resettlement in Developing Projects, 2010
Waste	Environmental Guidelines for Biomass Removal from Hydropower Reservoirs in Lao PDR, 2010
	Step by Step Environmental Guidelines for Biomass Removal from Hydropower Reservoir in Lao PDR, 2010
Electricity	Electricity Law, 2008, (Amendment 2012)
Land	Land Law, 2003
	Decree on State Land Lease or Concession, 2009 (Decree No. 135/PM)
Water Resource	Water and Water Resource Law, 1996
Forest	Forestry Law, 2007
	Decree on Protection Forest, 2010 (Decree No. 333/PM)
Road	Law on Public Roads, 1999
Landscape Heritage	Law on National Heritage, 2005
	Decree on the Preservation on the Cultural and Natural Heritage (1997)
Tourism	Tourism Law, 2005
Wildlife	Law on Aquatic Animal and Wildlife, 2007
Health	Law on Hygiene, Disease, Prevention and Health Promotion, 2001
Labor	Labor Law, 2006
Agriculture	Law on Agriculture, 1998
Fishery	Fishery Law, 2009
Construction	Construction Law, 2009

6.3.2 Legislative System for EIA

Development projects are categorized by the magnitude of the environmental impact stipulated in the Decree on Environmental Impact Assessment (Decree No.112/PM).

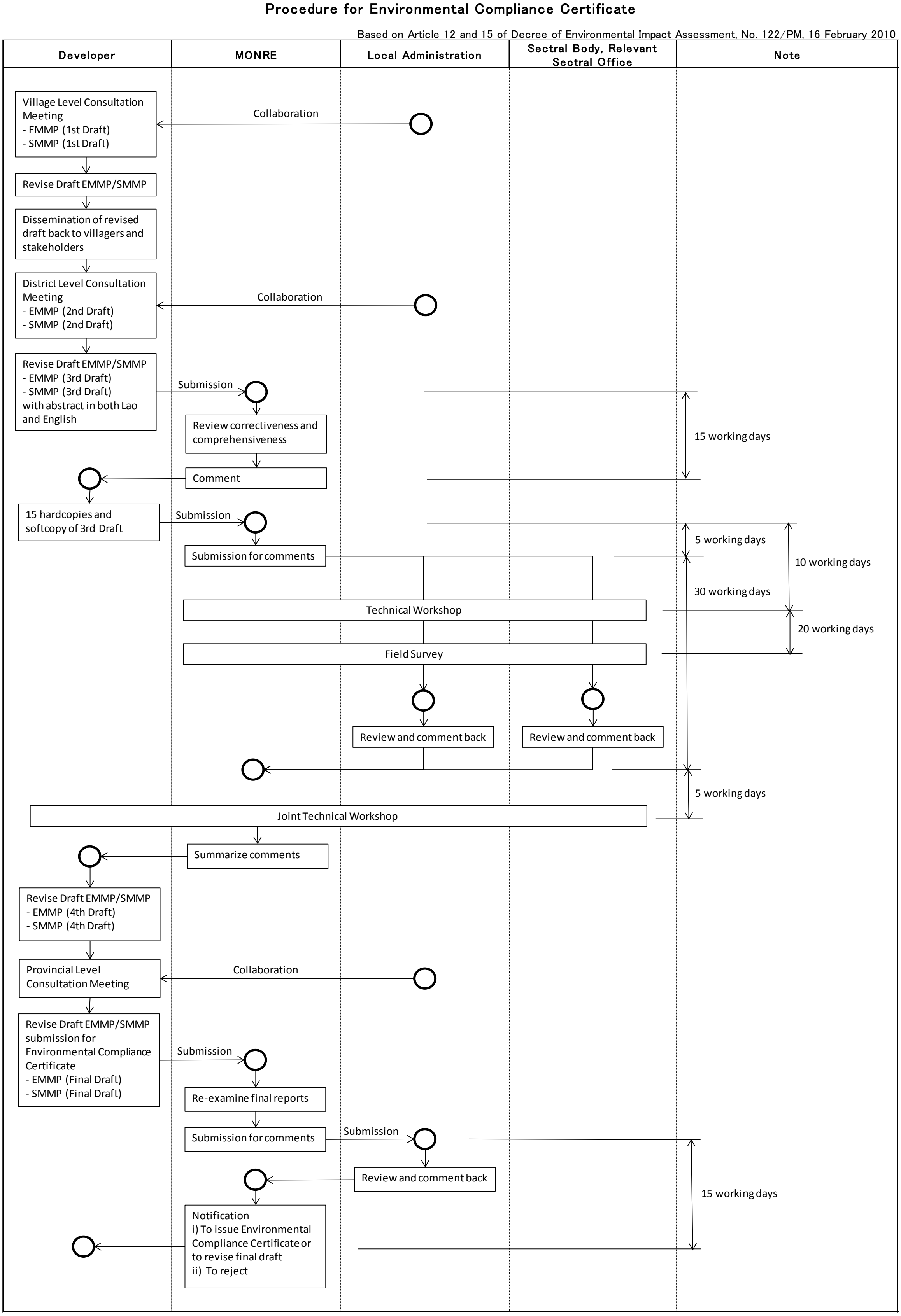
Small scale development which has a less environmental impact is categorized in Category I while large scale project is categorized in Category II. The development projects which require EIA is defined in the List of Projects Development shall be doing Initial Environmental Examination and Environment Impact Assessment (No. 679/PM-WREA, March 2012).

The development of Xe Katam Hydropower Project (a hydropower project more than 15MW) is categorized in Category II while 115kV transmission line and access road is categorized in Category I which needs IEE.

(Note: This regulation was revised in case power plant construction projects with transmission line/access road by Ministerial Instruction on the Process of Environmental and Social Impact Assessment of the Investment Projects and Activities (No 8030/MONRE) in December 2013. See the last paragraph in this Section)

Figure 6.3-1 shows EIA application procedure for Category II projects. The project developer has an obligation to hold a stakeholder consultation meeting (SCM) to villages on which proposed project may impact at the beginning of the environmental and social survey for EIA and also hold SCMs at village level, district level and provincial level when the draft EIA has been completed.

The project developer shall revise the EIA report taking result of the village level and district level SCM into account and submit the final draft EIA report (including Environmental Management and Monitoring Plan (EMMP) and Social Management and Monitoring Plan (SMMP)) to MONRE. MONRE, after the receipt of the application, shall review and hold a Technical Workshop with relevant central governmental agencies and local government agencies and conduct field survey. A Joint Technical Workshop shall also be held with project developer.



(Source: revised Decree No.112 by JICA Study Team)

Figure 6.3-1 Procedure of EIA

For transmission line and access road classified in Category I, IEE is required. Approval procedure of IEE is slightly simpler than EIA. The difference between EIA and IEE is summarized in Table 6.3-2.

Table 6.3-2 Procedure of EIA and IEE

	EIA	IEE
Disclosure of the development plan (before commencement of the survey)	✓	✓
Field survey to assess the impact on natural environment and social environment	✓	✓
Stakeholder meeting of EIA (draft) at village level	✓	✓
Stakeholder meeting of EIA (draft) at district level	✓	✓
Preparation of EMMP and SMMP	✓	1)
Joint review meeting with relevant government agencies and local authorities on EIA (draft) (Technical Workshop)	✓	✓
Field confirmation by relevant government agencies and local authorities	✓	If necessary
Joint review meeting with the developer in addition to relevant government agencies and local authorities (Joint Technical Workshop)	✓	
Stakeholder meeting of EIA (draft) at provincial level	✓	2)
Approval	MONRE	MONRE

Notes; 1) In IEE, Environmental Management Plan and Monitoring Plan should be described in the text of IEE instead of EMMP and SMMP.
2) In IEE, the stakeholder meeting at provincial level is not required. However, provincial authorities usually attend the stakeholder meeting at district level in order to reflect provincial opinions.

(Source: JICA Study Team from Decree No.112)

In accrdance with the Decree 122/PM, consturction of transmission line and access road is categorized in the Category I, which require IEE. However, Ministerial Instruction on the Process of Environmental and Social Impact Assessment of the Investment Projects and Activities (No. 8030 / MONRE 17-Dec 2013) stipulate that the transmission line and access road developed for newly built power generation facility is considered as a part of the power plant hence they need EIA. This new regulation is applied to Xe Katam Hydropower Project through consultation with MONRE.

6.3.3 Approvals related to Environmental Matters other than EIA

Approval procedure to construct permanent buildings in national and provincial protected areas is described in Decree 333/PM July 2010. Some structures are planned to construct in Xe Katam Provincial Protected Forest. It is approximately 45,000 ha and is setup by the Provincial Governor Decision 173/PG December 1995. The general procedure of construction permit acquisition is shown below;

- ✓ Developer submits the application with all information related to the development to MONRE in order to alter land use in provincial protected area. This procedure is required to alter forest land use for permanent buildings and civil structures.
- ✓ MONRE demands recommendations to Ministry of Agriculture and Forestry and related land management agencies and adds any conditions should be held in alteration of land use.
- ✓ MONRE submits the application from developer with the recommendations to National Assembly.

- ✓ After approval of National Assembly, developer submits applications including the construction plan with the copy of the authorization of the National Assembly to local authorities of the province. Related approvals and/or licenses are; application to log commercial trees (Department of Agriculture and Forestry, DAF), application to log non-commercial trees by Developer (DAF), land legislation of permanent buildings (Department of Land Office), permit to newly construct or renovate roads and bridges.

6.3.4 Organization in charge of Environmental and Social Consideration

(1) Major Governmental Organization

Major governmental organizations that relate to the approval of EIA are listed below:

Table 6.3-3 Major Governmental Organizations related to EIA

Ministry	Department
Ministry of Natural Resources and Environment (MONRE)	Department of Environment and Social Impact Assessment (DESIA)
	Department of Forest Resource Management (DFRM)
	Department of Water Resource Management (DWRM)
Ministry of Public Works and Transport (MPWT)	Department of Roads
Ministry of Agriculture and Forestry (MAF)	Department of Livestock and Fishery (DLF)
Ministry of Energy and Mines (MEM)	Department of Energy Policy and Planning (DEPP)
	Department of Energy Business (DEB)
Ministry of Health (MOH)	Department of Hygiene and Public Health (DHPH)
Lao Front for National Construction	Ethnic Department
Provincial and District Offices representing the above central government administrations	

(2) Organization of MONRE

The Ministry of Natural Resource and Environment (MONRE) is a responsible governmental agency for environment and social consideration. MONRE consists of 17 department including Department of Environmental and Social Impact Assessment (DESIA) which is responsible for EIA application. DESIA has Mining Division, Hydropower Division and Urban Development Division.

Table 6.3-4 Structure of MONRE

No.	Department	No.	Department
1	Secretariat	9	Department of Air Pollution Control
2	Personnel Department	10	Department of Forest Resource Management
3	Audit Department	11	Department of Geology and Mineral
4	Department of Planning and Cooperation	12	Department of Meteorology and Hydrology
5	Department of Land and Development	13	Department of Disaster Management and Climate Change
6	Department of Land Management	14	Department of Environmental and Social Impact Assessment
7	Department of Water Resources	15	Institute of Natural Resource and Environment
8	Department of Environment Promotion	16	Secretariat Mekong River Commission
		17	Natural Resource and Environment Data Center

6.4 Comparative Study of Alternatives

In this Section, five (5) patterns of alternatives are studied.

① Comparison study with zero option
② Comparison study on other electric power generations
③ Comparison study on other hydropower developments
④ Comparison study on power generation types of hydropower
⑤ Comparison study on transmission line route

Comparison in No.1 and 2 are intended the run-of-river type, while comparison in No.3 was conducted based on the reservoir type before the revised design. The run-of-river type is compared with the reservoir type in No.4.

6.4.1 Zero-Option

The development of the Project can contribute domestic and business economy demand for electric power in southern region of Lao PDR. Therefore, the economic and social consequences of not proceeding with the Project to the regional and national Lao PDR economy are significant. However, deforestation caused by the project development may extend due to improved access by access roads construction. Zero-option has no negative impact on natural and social environment because forest and farmland do not decrease.

Table 6.4-1 Comparison with Zero-Option

Items	Impact	Zero-option	Xe Katam Project
Energy Supply	Positive	--	• The Project supplies electric energy to the southern Laos
	Negative	• High cost energy import may be required to support energy demand to southern Laos.	--
Environmental Pollution	Positive	• Environmental pollution dose not arise.	--
	Negative	--	• Water pollution and waste may arise.
Natural Environment	Positive	• There is no impact on natural environment.	--
	Negative	--	• Deforestation is required. There is possibility of impact on fishes.
Social Environment	Positive	• Local residents can continue their present lifestyle.	• Employment opportunities may increase. • Social infrastructure is developed.
	Negative	• Local residents may not receive social infrastructure, opportunities of education and health assist.	• Land acquisition and resettlement are required. • There is possibility of impact on livelihood such as fishery.

6.4.2 Comparison with Other Power Generation System

Conventional fossil fuel based power plants installation to meet southern Laos domestic demand is not realistic for economic and environmental reasons due to increased carbon emissions or air pollutant such as SOx or NOx and the long distance transportation costs of resources from northern Laos or western Thailand. Concerning renewable resources, solar power generation has a high construction cost per generation and the biomass power generation need new development to ensure the biomass resources. For those reasons, hydropower generation is considered as optimal power source.

Small hydropower development (about from 1 to 10 MW) may have less environmental impact by individual plant. However, as the Xe Katam Hydropower Project selected the most effective development layout to obtain large head using the river reach as short as possible on the terrain, sum of affected river length by plural small hydropower plants may be longer than that of the Xe Katam Hydropower Project to obtain equal power supply capability. Therefore, single development of the Xe Katam Hydropower Project is considered to have as relative magnitude of environmental impact as power development by plural small hydropower plants.

At present, there is no other dam construction plan around the Xe Katam River.

A pico-hydropower equipment has 100 to 1,000W output and is effective for individual household power supply such as electric light. However, as its output and voltage are fluctuated, it cannot be operated in case of high river flow in the rainy season, or there is a risk of electric shock rises, the pico-hydropower cannot be a stable power source.

6.4.3 Comparison with Other Hydropower Development Plan

In this section, the reservoir type design of the Project is compared with other hydropower development plans.

In 2000, World Bank assisted GOL to examine potential hydropower development for accommodating future power demand growth considering both project economics and environmental impact. Comparison of each potential development plan was conducted by a consortium of Worley and Lahmeyer with cooperation from Ministry of Industry and Handicraft then being responsible ministry for power development policy. This section presents the result of comparison with three (3) sites including Xe Katam from development priority sites selected by GOL by above mentioned measures.

Generally, economic efficiency of hydropower deeply depends on topography, geology and hydrology. Priority of development is determined by survey of topographical map, site reconnaissance and existing hydrological data and study of necessity of dam, intake and outlet location and annual potential energy generation calculated by those data. Economic efficiency is evaluated by an index of construction cost divided by annual potential energy generation. The smaller the index is, the economic efficiency is higher.

In the GOL's study in 2000, environmental and social consideration was firstly evaluated before the economic efficiency. The projects with lower impacts on environment were firstly selected and then priority development projects were selected from "lower impact projects" taking economic efficiency into account.

Two (2) indexes were selected for evaluating environmental and social impacts.

i) Required relocating persons per annual potential generation (Pers.per GWh/a), and
ii) Reservoir area per annual potential generation (km^2 per GWh/a)

Annual potential generation (GWh/a) represents economic efficiency provided that the construction cost per GW/a is the same. The above indexes are considered as a comparison of environmental and social impact on several development candidates which have equivalent economic value. The first index represents social impacts and the second one represents natural impact including loss of forest, impacts on flora and fauna.

Using above indexes, 40 potential hydropower developments and 2 coal fired power developments were compared. The evaluation was made by ranking method. Rank points were given to a certain range of the indexes and average of each rank point was considered to represent the overall impact that project would cause on natural environment and society. Rank points of each index, comparison table of 42 projects and evaluation result are shown in Table 6.4-2, Table 6.4-3 and Table 6.4-4, respectively.

As the Xe Katam project was then considered with peak output of 100 MW, annual generation of 709 GWh with 0.2 km^2 reservoir area in 2000, indexes are revised by considering dam type design, 61.6 MW, 381 GWh and 7.6 km^2, respectively following the latest design at study time in 2004.

Table 6.4-2 Range of Indexes and Ranking Points

Rank	Relocation : Pers/GWh/a.	Reservoir Area : km^2/GWh/a.
1	0	0
2	0.1-0.5	0.001-0.009
3	0.51-1.0	0.010-0.019
4	1.1-2.0	0.020-0.049
5	2.1-5.0	0.050-0.099
6	> 5.0	> 0.100

Table 6.4-3 Rank Points of Hydropower and Coal Plant Development

Name of Project	Installed capacity	Energy produced	Resettled persons	Reservoir area	Resettlers		Reservoir		Overall Rank
	MW	GWh/a	N	km²	Pers. per GWh/a	Rank 1	km² per GWH/a	Rank 2	
Northern Provinces									
Nam Long	11	53	na	na	-	-	-	-	-
Nam Sim	7	24	0	0.2	0	1	0.008	2	1.5
Nam Beng	54	175	na	12	-	-	0.069	5	-
Hongsa Lignite [1]	720	4,415	1,000	30	0.2	2	0.007	2	2
Moung Houn Lignite	30	184	na	5.1	-	-	0.028	4	-
Nam Ngum Basin									
Nam Ngum 5C	100	430	500	14.6	1.2	4	0.034	4	4
Nam Ngum 5D	120	515	na	na	-		-		-
Nam Ngum 4A	55	250	1,740	14.4	7	6	0.058	5	5.5
Nam Ngum 4B	56	254	0	0.5	0	1	0.002	2	1.5
Nam Ngum 3	444	1,851	300	25.6	0.2	2	0.014	3	2.5
Nam Ngum 3E	580	2,654	500	25.6	0.2	2	0.01	3	2.5
Nam Ngum 2	615	2,109	5,778	86	2.7	5	0.041	4	4.5
Nam Ngum 2A	159	709	200	3.8	0.3	2	0.005	2	2
Nam Ngum 2B	183	830	1,000	7.5	1.2	4	0.009	2	3
Nam Bak 2B	116	536	0	4.8	0	1	0.009	2	1.5
Nam Mang 3	51	141	60	9.5	0.4	2	0.067	5	3.5
Nam Ngiep									
Nam Pot	23	97	0	6.1	0	1	0.063	5	3
Nam Ngiep 1 (FSL 360)	360	1,905	5,200	148.2	2.7	5	0.078	5	5
Nam Ngiep 1 (FSL 320)	240	1,349	1,600	73.9	1.2	4	0.055	5	4.5
Nam Mo	100	581	0	10.8	0	1	0.019	3	2
Nam Sane	62	279	6,190	121.8	22.2	6	0.437	6	6
Nam Theun Basin									
Nam Theun 3	236	772	1,220	126	1.6	4	0.163	6	5
Nam Theun 2	975	5,173	4,500	450	0.9	3	0.087	5	4
Nam Theun 2 S-538	900	4,169	4,000	313	1	3	0.075	5	4
Nam Mawan	137	695	0	120	0	1	0.173	6	3.5
Nam Mouan	84	445	na	120	-		0.27	6	-
Nam Theun 1F	600	2,824	330	44	0.1	2	0.016	3	2.5
Xe Pon	74	301	800	29.5	2.7	5	0.098	5	5
Xe Set									
Xe Set 2	69	252	0	1.5	0	1	0.006	2	1.5
Xe Set 3	16	72	0	1.3	0	1	0.018	3	2
Xe Kong (Upper)									
Xe Kong 5	258	1,183	980	70	0.8	3	0.059	5	4
Xe Kong 4	451	1,746	5,870	160.4	3.4	5	0.092	5	5
Houay Lamphan Gnai	59.72	354	0	3.5	0	1	0.01	3	2
Xe Katam	**62**	**381**	**0**	**7.6**	**0**	**1**	**0.019**	**3**	**2**
Xe Pian-Xe Namnoy	392	1,995	820	43.5	0.4	2	0.022	4	3
Xe Kong (Lower)									
Xe Kaman 3	308	1,348	0	12	0	1	0.009	2	1.5
Xe Kaman 1	469	1,925	800	220	0.4	2	0.114	6	4
Xe Kaman 1B	300	1,433	800	193	0.6	3	0.135	6	4.5
Xe Xou	59	277	500	112.9	1.8	4	0.408	6	5
Nam Kong 3	33.8	156	1,550	36.9	9.9	6	0.237	6	6
Nam Kong 1	238	802	200	12.1	0.2	2	0.015	3	2.5
Mekong									
Thakho (Phapheng Falls)	36	2,067	0	0	0	1	0	1	1

1 mining are instead of reservoir area in the case of lignite fired thermal power plants
na = information not available

Table 6.4-4 Evaluation of Hydropower Ranking Points

Name of Project	Overall Rank	Comments
Thakho (Phapheng Falls)	1	Very low impact. No or very small reservoir (ROR projects). No resettlement.
Nam Sim	1.5	Low impact. No or very little resettlement, small reservoir in relation to output.
Nam Ngum 4B	1.5	
Nam Bak 2	1.5	
Xe Set 2	1.5	
Xe Kaman 3	1.5	
Xe Katam	2	
Hongsa Lignite	2	
Nam Ngum 2A	2	
Nam Mo	2	
Xe Set 3	2	
Houay Lamphan Gnai	2	
Nam Ngum 3	2.5	Medium impact. Some of these projects (e.g. Nam Theun 2) have large reservoirs and comparatively high number of resettled people, but a high installed capacity and a high energy production.
Nam Ngum 3E	2.5	
Nam Theun 1F	2.5	
Nam Kong 1	2.5	
Nam Ngum 2B	3	
Nam Pot	3	
Xe Pian-Xe Namnoy	3	
Nam Mang 3	3.5	
Nam Mawan	3.5	
Nam Ngum 5C	4	
Nam Theun 2	4	
Nam Theun 2 S-538	4	
Xe Kong 5	4	
Xe Kaman 1	4	
Nam Ngum 2	4.5	High impact. Large reservoir, at least in relation to energy produced, and a high number of resettled persons.
Nam Ngiep 1 (FSL 320)	4.5	
Xe Kaman 1B	4.5	
Nam Ngiep 1 (FSL 360)	5	
Nam Theun 3	5	
Xe Pon	5	
Xe Kong 4	5	
Xe Xou	5	
Nam Ngum 4A	5.5	Very high impact. Very large reservoir and very high number of resettled persons in relation to energy output.
Nam Sane	6	
Nam Kong 3	6	
Moung Houn Lignite	-	Projects not ranked due to missing data.
Nam Beng	-	
Nam Long	-	
Nam Ngum 5D	-	
Nam Mouan	-	

In 2004, when the Kansai Electric Power Co., Inc. (KANSAI) attempted to select a potential hydropower project, above GOL's study was taken into account. KANSAI considered factors of economic efficiency, accessibility, easy connection with existing power grid and other developers' activity and selected three (3) candidate projects from project group which has relatively lower impact on environment through information from and discussion with the Ministry of Industry and Handicraft. Those are:

a) Xe Katam
b) Houay Lamphan Gnai
c) Nam Kong 1

Nam Kong 1 and Houay Lamphan Gnai were investigated and studied by Russian private firm and EDL, respectively after 2006 and detailed design and environmental and social survey and assessment were conducted to date. In addition, the survey on environmental and social consideration was conducted in this Preparatory Survey at Xe Katam site. In this report, those three projects are compared utilizing available information at present.

(1) Nam Kong 1 Project

- Reservoir area is covered by 1,700 ha of secondary forests, 390 ha of deciduous forest zone and partially by grass land due to deforestation and slush and burn agriculture. Part of the reservoir area is designated as Provincial Production Forest.
- Steep gorge at the dam site changes to flat depositional plain at 10 km downstream. Flat plain is important for bio-diversity and utilized for agriculture.
- When the project is completed, river discharge will reduce from the dam to 3 km downstream, which may cause negative impact on aquatic biota.

Table 6.4-5 Optimization Result for Nam Kong 1 Project

Item		Specification
Catchment Area		1,250km^2
Dam	Height	85.3m
	Length	379.1m
	Effective Storage	505 mil. m^3
	Area of Reservoir	21.8km^2
Headrace Tunnel	Length	2,955m
Transmission Line	Length	41km
Access Road	Length	31.8km
Output		150MW/75MW
Annual Generation		563GWh/469GWh

Note: Output and Annual Generation will vary based on generation pattern. Those will be determined in the future as an option

- Animals will move to adjacent riverine area after the creation of the reservoir, but the impact is limited because of current cultivation activities.
- Stratification of the reservoir may cause water quality deterioration and temperature decrease of the discharge water.
- Dam will block migratory fish species.
- No resettlement is expected by the reservoir. Social impact is expected at the four (4) villages with 384 households or 1,612 people living between downstream of the dam to confluence of the Sekong River. The access road passes three (3) villages.
- Since major income source of the 4 villages downstream of the dam is fishery, reduction of migratory fish species will cause impact on villagers' livelihood.
- Most of PAPs belong to Lao Teung (Mon-Khmer linguistic group), which is regarded one of ethnic groups.

- There is a cave adjacent to the dam, which is regarded as a sacred place from villagers. Grave yard in the proposed reservoir need to be resettled.

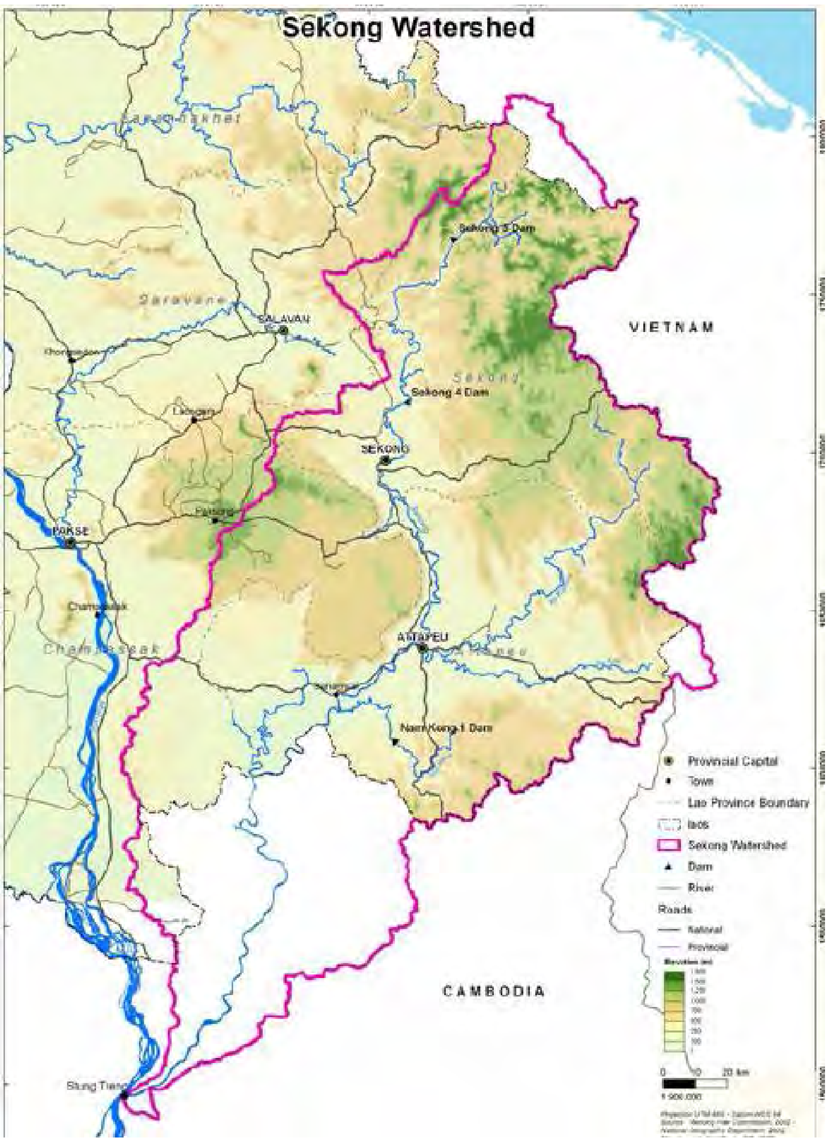


Figure 6.4-1 Location of Nam Kong 1 Project

Figure 6.4-2 Dam and Powerhouse Planed Location of Nam Kong 1 Projecct

(2) Houay Lamphan Gnai

- Though there was no resettlement expected in the 2000 study, two (2) villages with 189 households or 1,292 people were found to be resettled. Other 49 households or 367 people in adjacent 5 villages and part of 1 village near the powerhouse will be impacted by construction of access road.

- PAPs belong to Katu, Arak, Lavi and Laven (Mon-Khmer linguistic group), all of which are regarded as ethnic people, and Lao-Tai linguistic group. 95% of PAPs are Katu, while 2% is Arak.

- It is required to establish Resettlement and Ethnic Minority People Plan in which program of resettlement, livelihood restoration, ethnicity consideration be included. Resettlement area is expected to be near the access road with enough capacity.

Table 6.4-6 Optimization Result of Houay Lamphan Gnai Project

Item		Specification
Catchment Area		237km^2 Main Dam 144km^2 Tributary Weir 93km^2
Main Dam	Height	79m
	Length	630m
	Effective Storage	122 mil. m^3
	Area of Reservoir	6.8km^2
Headrace Tunnel	Length	2,831m
Transmission Line	Length	12km
Access Road	Length	22km
Output		84.8MW
Annual Generation		452GWh

- Reservoir area is covered by evergreen woodland, coffee plantation, rice paddy, cardamom field and the secondary forests. The area has been developed and thus the impact on flora and fauna is limited.

- River discharge is reduced from dam to powerhouse outlet, about 21 km long. Though a tributary joins at the 12.5 km downstream of the dam, aquatic biota may be impacted from dam to confluence by reduced discharge. Environmental flow is necessary to mitigate the impact on fishery.

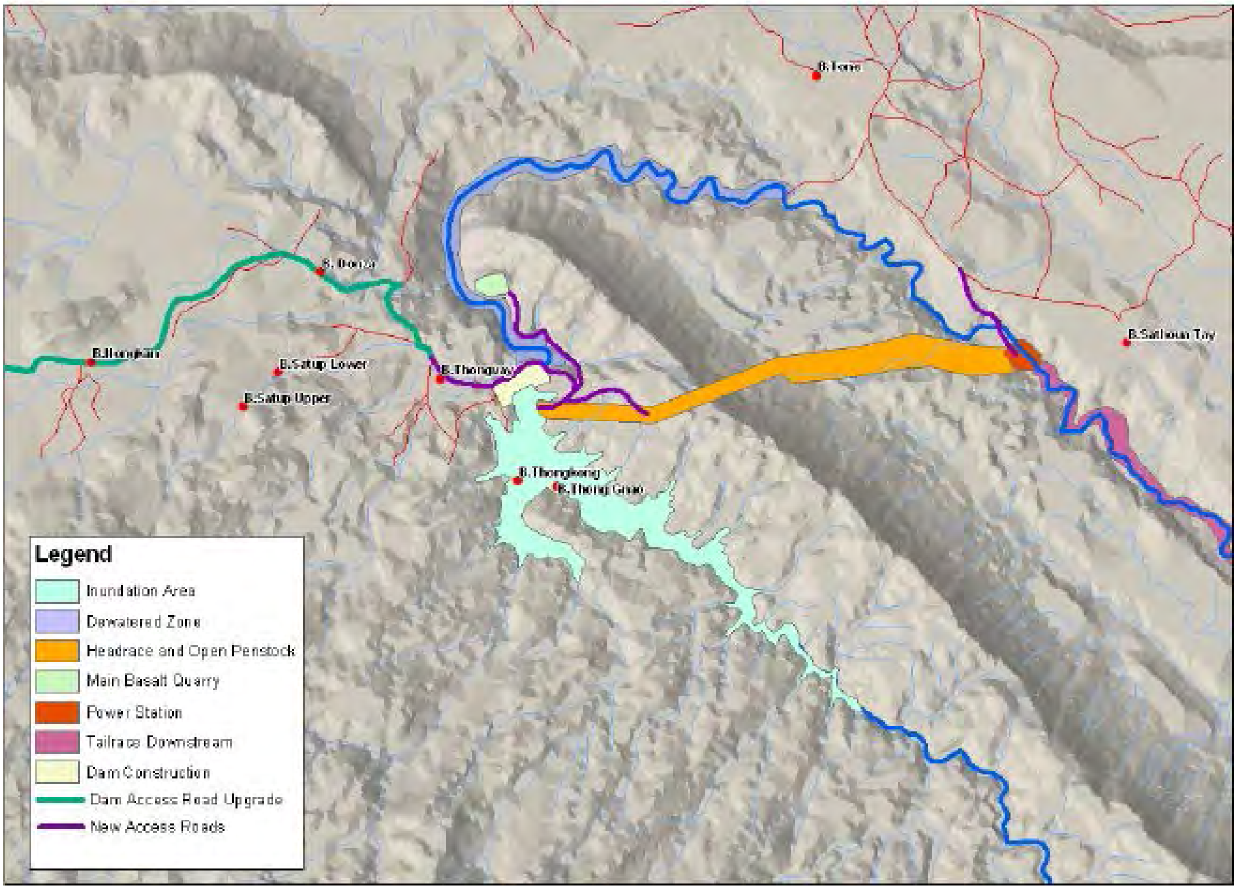


Figure 6.4-3 Location of Houay Lamphan Gnai Project

(3) Xe Katam (Design in 2004)

- The dam is planned to build at the Nam Houng River which was the tributary of the Xe Katam River, and a diversion weir at the Xe Katam River diverts river flow to the dam in order to impound river flow of both of the Xe Katam River and the Nam Houng River. The river flow is regulated through the year for stable power generation.

- The planned reservoir area are about 25 % occupied by coniferous and mixed deciduous forest, others are rice production land, coffee gardens, orchards and secondary forest. Most of the land have been already developed, therefore the impact on fauna and flora will be limited by the Project (the survey result in 2013).

- As there is no permanent residential house in the planned reservoir area, large scale resettlement will not be required. There is one residence within the ROW of the transmission line, which requires resettlement (the survey result in 2013).

- The 348 ha of the planned reservoir area has been used as farmland. The farmland is owned by 300 households and required resettlement. The relocation candidate site is planned at Old Nong Hin near the planned reservoir area (the survey result in 2013).

- The river flow will reduce for the total 14.5 km, about 6 km from the diversion weir to the downstream at the Xe Katam River and about 8.5 km from the intake weir to the powerhouse. The recession area is used for fishery and daily life water, so the mitigation measures of the impact is required.

- The five villages will be affected by construction of the dam and the powerhouse. Affected people are Nyaheun and Yuroo (or Laven) ethnic belonging to Mon-Khmer Linguistic group. 99% of them are Nyaheun.

Table 6.4-7 Optimization Result of Xe Katam Project

Item		Specification
Catchment Area		214 km^2 Diversion Weir 176 km^2 Main Dam 38km^2
Main Dam	Height	41.6m
	Length	449.8m
	Effective Storage	121 mil. m^3
	Area of Reservoir	7.6km^2
Headrace Tunnel	Length	5.6km
Transmission Line	Length	45km
Access Road	Length	New Construction 4 km Renovation 24 km
Output		61.6MW
Annual Generation		381GWh

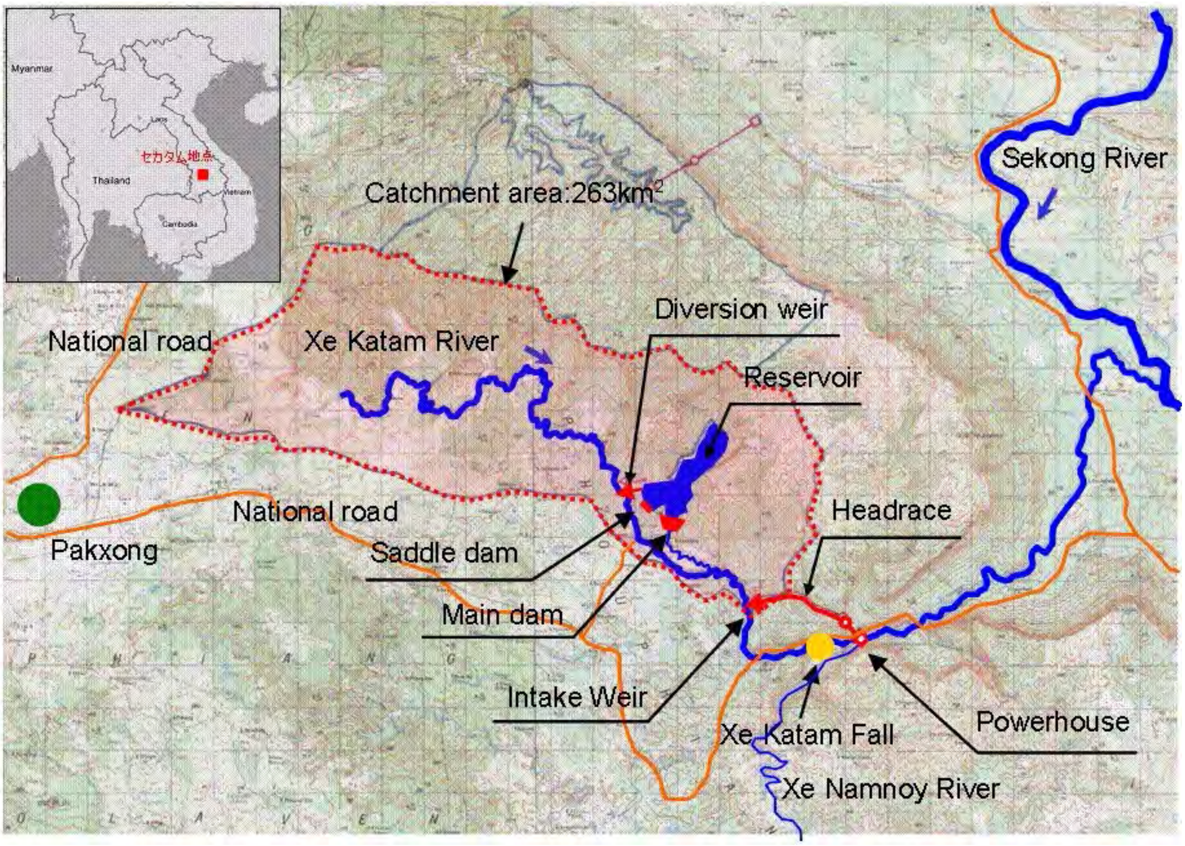


Figure 6.4-4 Location of Xe Katam Project (in 2004)

(4) Comparison of 3 Sites

Table 6.4-8 summarizes the result of the comparison of three project sites.

From the comparison of natural and social impact, Xe Katam project is selected for further study and investigation.

Table 6.4-8 Comparison of Candidate Hydropower Projects

<table>
<tr><th colspan="2">Items</th><th>Xe Katam</th><th>Nam Kong 1</th><th>Houay Lamphan Gnai</th></tr>
<tr><td rowspan="6">Main Characteristics</td><td>Output (MW)</td><td>61</td><td>150/75</td><td>84.8</td></tr>
<tr><td>Annual Generation (GWh)</td><td>381</td><td>563/469</td><td>452</td></tr>
<tr><td>Area of Reservoir (km^2)</td><td>7.6</td><td>21.8</td><td>6.8</td></tr>
<tr><td>Catchment Area (km^2)</td><td>258</td><td>1,250</td><td>237</td></tr>
<tr><td>Transmission Line (km)</td><td>50</td><td>41</td><td>12</td></tr>
<tr><td>Access Road Length (km)</td><td>Rehabilitation 24
New road 4</td><td>31.8</td><td>22</td></tr>
<tr><td rowspan="3">Economics</td><td>Construction Cost (ratio)</td><td>100%</td><td>95%</td><td>47%</td></tr>
<tr><td>Cost per output MW (ratio)</td><td>100%</td><td>38%/77%</td><td>34%</td></tr>
<tr><td>Cost per generation (ratio)</td><td>100%</td><td>64%/76%</td><td>39%</td></tr>
<tr><td>Technical</td><td>Dam etc.</td><td>Proven technology (41m height rockfill dam etc.)</td><td>Proven Technology (85m-height concrete gravity dam etc.)</td><td>Proven Technology (79m-height concrete gravity dam etc.)</td></tr>
<tr><td rowspan="2">Natural</td><td>Modified Area</td><td>Mainly reservoir (7.6 km^2)</td><td>Reservoir and access road (32 km) disturb larger area.</td><td>Mainly reservoir (6.8 km^2)</td></tr>
<tr><td>Impact on Flora and Fauna</td><td>Reservoir area already developed, limited impact. Reduction of river discharge (7km d/s of diversion weir and 9km d/s of intake weir) impacts on aquatic biota.</td><td>Though reservoir is mainly covered by the secondary forests, large area of reservoir may impact on flora and fauna. Reduction of river discharge (3km) impacts on aquatic biota.</td><td>Reservoir area already developed, limited impact. Reduction of river discharge (12.5km) impacts on aquatic biota.</td></tr>
<tr><td rowspan="5">Social</td><td>Land Use</td><td>60% of reservoir area are developed for agriculture</td><td>Reservoir area is forest land with small scale cultivated land.</td><td>75% of reservoir area are developed for agriculture</td></tr>
<tr><td>Landscape</td><td>Reduction of river discharge impacts on Xe Katam Fall.</td><td>-</td><td>-</td></tr>
<tr><td>Resettlement</td><td>No resettlement.</td><td>No resettlement</td><td>2 villages (189 HHs, 1,292 persons) will be resettled.</td></tr>
<tr><td>Impact on Community</td><td>5 villages (288 HHs, 1,652 persons) may be impacted. Cultivated land in the reservoir need to be resettled.</td><td>4 villages (358 HHs, 1,612 persons) near the project area and 3 villages along the access road may be impacted.</td><td>5 villages along the access road and 1 village near the project area (49 HHs, 367 persons) may be impacted. Cultivated land in the reservoir need to be resettled.</td></tr>
<tr><td>Ethnic People</td><td>Nyaheun (Mon-Khmer linguistic group)</td><td>Mon-Khmer linguistic group</td><td>Mainly Katu (Mon-Khmer linguistic group)</td></tr>
<tr><td rowspan="9">Evaluation</td><td>Economics</td><td>△</td><td>△</td><td>○</td></tr>
<tr><td>Technical</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Magnitude of Disturbance</td><td>△</td><td>×</td><td>△</td></tr>
<tr><td>Flora and Fauna</td><td>△</td><td>×</td><td>△</td></tr>
<tr><td>Impact on Land Use</td><td>△</td><td>△</td><td>△</td></tr>
<tr><td>Landscape</td><td>△</td><td>○</td><td>○</td></tr>
<tr><td>Resettlement</td><td>○</td><td>○</td><td>×</td></tr>
<tr><td>Impact on Community</td><td>△</td><td>△</td><td>△</td></tr>
<tr><td>Total Evaluation</td><td>Moderate impact on both natural and social.
Though economic efficiency is lower, the impact on the surrounding environment may be mitigated by ensure of relocation farmland and release of the environmental flow.</td><td>Large scale disturbance on natural environment.

Area of reservoir (22km^2) will relatively impact on natural environment. Protections of eco-system may be large scale.</td><td>Resettlement necessary

Resettlement of households may require large scale social mitigating measures. There are relatively unknown factors.</td></tr>
</table>

6.4.4 Comparison of Power Generation Types

Reservoir type design and run-of-river type design are compared. The run-of-river type has less social impact since relocation of farm land in the reservoir is not required. The impact on natural environment is also less because of reduced area to be altered. In terms of economics, run-of-river type has less construction cost per generating energy.

Table 6.4-9 Comparison of Power Generation Type

<table>
<tr><th colspan="2">Comparison Items</th><th>Reservoir Type</th><th>Run-of-river Type</th></tr>
<tr><td rowspan="5">Power Generation and Facilities</td><td>Output (MW)</td><td>83.1</td><td>81</td></tr>
<tr><td>Annual Generation (GWh)</td><td>383</td><td>299</td></tr>
<tr><td>Area of Reservoir (ha)</td><td>780</td><td>-</td></tr>
<tr><td>Dam</td><td>Main dam: Height 41.4 m, Length 420.5 m
Saddle dam: Height 13.7 m, Length 1,340 m</td><td>-</td></tr>
<tr><td>Access Road (km)</td><td>29.6km</td><td>16.3km</td></tr>
<tr><td>Economics</td><td>Construction cost and annual power generation</td><td>- Annual power generation: 383GWh</td><td>- Annual power generation : 299GWh
- Total project cost : 64% of the reservoir type [Construction cost per annual generation : 0.83]</td></tr>
<tr><td>Natural Environment</td><td>Impact on Flora and Fauna</td><td>There is possibility to impact on flora and fauna. The river flow reduction section of about 16km may impact on aquatic biota such as fishes.</td><td>The river flow reduction section about 9km may impact on aquatic biota such as fishes. However magnitude of impact is less than the reservoir type.</td></tr>
<tr><td rowspan="2">Social Environment</td><td>Landscape</td><td>The river flow of the Xe Katam Fall is reduced.</td><td>The river flow of the Xe Katam Fall is reduced.</td></tr>
<tr><td>Impact on local resident</td><td>The Project may affect 5 villages. Relocation of farm land in the reservoir is required.</td><td>The Project may affect 2 villages.</td></tr>
<tr><td rowspan="4">Evaluation</td><td>Technical</td><td>○</td><td>○</td></tr>
<tr><td>Economics</td><td>△</td><td>○</td></tr>
<tr><td>Natural Environment</td><td>×</td><td>△</td></tr>
<tr><td>Social Environment</td><td>△</td><td>○</td></tr>
<tr><td colspan="2">Comprehensive Evaluation</td><td>△</td><td>○</td></tr>
</table>

6.4.5 Alternatives of Transmission Line Route

Alternative transmission line route is described in Section 4.5.1.

The result of comparison with No.1 and No.2 routes is summarized in Table 6.4-10.

Table 6.4-10 Comparison of Transmission Line Routes

Comparison Items		No.1	No.2
Main Characteristics	Length (km)	About 45km	About 45km
Natural Environment	Impact on Fauna and Flora	Forest is assumed to be affected because the transmission line passes through the mountainous area.	The length passing mountainous area of No.2 is shorter than No.1, so the impact by No.2 is less than that by No.1.
Social Environment	Distance from Mining Development	The transmission line passes through the north area of mining development site.	Compensation may be required because the No.2 passes through the part of the mining development site.
	Distance from Large-Scale Plantation	The transmission line passes through the north area of the large scale plantation.	Compensation may be required because the No.2 passes through the part of the large scale plantation.
	Impact on Local Residence	The transmission line passes through the settlement of Houaykong, so the desirable tentative route should be selected (see Figure 4.5-6).	The transmission line passes through the settlement of Houaykong, so the desirable tentative route should be selected (see Figure 4.5-6).
Economics		Compensation costs are minimized.	The compensation cost of No.2 may be higher than No.1, because the No.2 passes through the mining development site and the large scale plantation.
Evaluation	Technical	○	○
	Economics	△	○
	Natural Environment	○	△
	Social Environment	○	△
Comprehensive Evaluation		○	△

6.5 Scoping

Evaluation of environmental and social impact was made following the JICA Guideline by examining previous survey. The result of the evaluation is shown in Table 6.5-1 to Table 6.5-3. In this and next sections, the subjects of the study are the run-of-river type and the No.1 route of the transmission line (see Section 6.4.5).

Table 6.5-1 Scoping (Power Plant Facilities)

Category	No	Environmental Item	Evaluation: Before/ during construction	Evaluation: Operation	Evaluation reason
Pollution Control	1	Air pollution	B-	C-	**During construction**: Generation of dust by land reclamation work is expected. Air pollution by construction machines and construction vehicles is expected. **Operation**: Traffic may increase by development of the road with the construction. Dust and air pollution are expected to increase. In addition, air pollution by operating emergency generator (diesel generator) is expected.
	2	Water quality	A-	B-	**During construction**: Water pollution by turbid water with excavation, oil spills from construction machines and construction vehicles, and waste water from construction camp is expected. **Operation**: - Oil spill to the river by breakdown of water turbine generator is expected. - Water pollution by domestic waste from the power plant is expected.
	3	Waste	B-	C-	**During construction**: Generation of waste soil and waste material is expected. **Operation**: There is a possibility of occurrence of waste lubricant and domestic waste from power plant operator.
	4	Soil pollution	B-	C-	**During construction**: Soil pollution by oil spills from construction machines and construction vehicles is expected. **Operation**: Soil pollution by oil spills by breakdown of outdoor machines such as transformers is expected.
	5	Noise and vibration	B-	B-	**During construction**: Occurrence of noise and vibration by operation of construction machines and construction vehicles is expected. **Operation**: - Traffic may increase by development of the road with the construction. Noise and vibration level is expected to be increased. - Occurrence of noise during operation of generator and transformer.
	6	Land subsidence	D	D	Works that cause land subsidence is not expected.
	7	Odor	D	D	Works that cause odor is not expected.
	8	Bottom sediment	B-	C-	**During construction**: Bottom sediment from turbid water with excavation, oil spills from construction machines and construction vehicles, and waste water from construction camp is expected. **Operation**: If large amount of organic matters flow into sediment of the pond of the intake weir, the mud may form at the bottom of the pond.
Natural environment	9	Protected area	D C-	D C-	There is no national protected are in the Project area. Natural regional specified protected areas shall be surveyed.
	10	Ecosystem	A-	A-	**During construction**: - Inhabits of fauna and flora will be divided and lost. - Temporary modification of inhabits of fauna by noise and human involvement associated with construction work is expected. - Change of river course will impact on aquatic biota. **Operation**: - Deforestation will cause loss and division of habitats of fauna and flora. - Decrease of flow in the recession area is expected to impact on aquatic biota. - Migratory fishes will be blocked by the intake weir. - Due to easier human access by development of roads, habitats of animals may be disturbed and hunting may increase. - Cumulative impact may occur by development activities induced by roads construction.

Category	No	Environmental Item	Evaluation: Before/ during construction	Evaluation: Operation	Evaluation reason
Natural environment	11	Hydrology	B-	A-	**During construction**: - Changes of water flow regime and riverbed profile are expected by construction of the intake weir. **Operation**: - Change of flow regime by occurrence of the recession area by water diversion is expected. - River flow amount will reduce between the intake weir and the outlet in the Xe Katam River.
	12	Topography and geology	B-	B-	**During construction/Operation** - Topography is expected to change by construction of tunnel and open cut excavation. - Landslide may occur by open cut excavation work.
Social environment	13	Resettlement and land acquisition	B-	D	**Before construction/planning**: No involuntary resettlement is expected by acquisition of land for power plant facilities. Land acquisition and compensation of farm land for construction area is necessary.
	14	Poverty	B-	B- B+	**During construction/Operation**: Land acquisition for power plant facilities will cause loss of farmland and livelihood source. **Operation**: Enhanced supply of rural electricity by development of the power plant and development of the roads may improve social service such as schools and hospitals and access to them.
	15	Ethnic minority and indigenous people	A-	A-	**During construction/Operation**: Affected people are Nyaheun. Following issues may impact on their livelihood; decrease of farmland by land acquisition for power facilities, decrease of regional natural resource by deforestation.
	16	Local economy, employment and livelihood	B- B+	B+	**During construction/Operation**: - Land acquisition will decrease the land for livelihood (i.e., agriculture, forest production, fishery, hunting). - Local residents may obtain opportunity of employment with construction work. **Operation**: Stable supply of rural electricity by development of the power plant and the roads may enhance diversification of livelihood and access to farmland.
	17	Land use and use of natural resource	B-	B-	**During construction**: Land acquisition causes loss of farmland and deforestation may reduce regional natural resource. **Operation**: Forest resource and fish population may decrease by change of land use, deforestation and change of river flow regime.
	18	Water use	C-	C-	**During construction**: Residents using the river water as potable water at the downstream of the intake weir may be affected by the following issues; occurrence of turbid water with excavation, oil spills from construction machines and construction vehicles, and waste water from construction camp. **Operation**: Residents using the river water as potable water at the downstream of the intake weir may be affected by the following issues; water pollution, occurrence of the recession area.
	19	Existing social infrastructure and service	B-	B^{+}	**During construction**: The passage of the road may be limited at a certain time zone. **Operation**: Enhanced supply of rural electricity by extension of development of the power plant and development of the roads may improve social service such as schools and hospitals and access to them.
	20	Social institutions and social organization such as decision-making body	B-	D	**During construction**: Social institutions and/or social organization may be affected by land acquisition procedure or compensation evaluation. **Operation**: The impact of social institutions or social organization is not expected.
	21	Uneven distribution of benefits and damages	B-	B^{+}	**During construction**: Unfair evaluation of compensation may cause uneven distribution of benefits and damage. **Operation**: Enhanced supply of rural electricity by extension of development of the power plant and development of the roads may improve social service such as schools and hospitals and access to them, which may benefit the region.
	22	Conflict of interest in the region	B-	D	**During construction**: Land acquisition procedure or compensation evaluation may cause conflict of interest in affected villages. **Operation**: Conflict of interest is not expected.

Category	No	Environmental Item	Evaluation		Evaluation reason
			Before/ during construction	Operation	
Social Environment	23	Cultural heritage	C-	D	**During construction**: Construction work may impact on spiritual sacred places (grave yard etc.) of residents. **Operation**: The operation of power plant will not impact on cultural heritage and sacred places.
	24	Landscape	D	A-	**During construction**: The impact on landscape is not expected. **Operation**: Diversion of water at the upstream of the Xe Katam Fall will decrease water volume of the fall.
	25	Gender	C	C	**During construction**: The impact on gender is not expected. Field survey will be necessary to confirm and evaluate the impact.
	26	Children's rights	D	D	**During construction/Operation**: The impact on children's rights is not expected.
	27	Infection, HIV/AIDS	C-	D	**During construction**: Influx of workers may cause spread of infection. **Operation**: Activities that cause infection are not expected.
	28	Working condition (including working safety)	C-	D	**During construction**: Accidents, infections such as malaria, injures and diseases may occur during construction. **Operation**: Activities that impact on working condition are not expected.
Others	29	Accidents	A-	B-	**During construction**: Construction and traffic accidents may occur during construction. As cluster bombs were dropped in Laos, unexploded ordnance (UXO) may remain in the construction area. **Operation**: Operational and traffic accidents may occur during operation.
	30	Impact of cross-border, and climate change	C-	C+/-	**During construction**: Auto exhaust from construction machines and construction vehicles will cause increase of CO_2 emission. Deforestation will cause decrease of absorption of CO_2. As the quantity is limited, the impact on climate change is not expected. **Operation**: Supply of electricity by hydropower will decrease use of fossil fuel and firewood and it contributes to reduce CO_2 emission.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

Table 6.5-2 Scoping (Access Road)

Category	No	Environmental Item	Evaluation		Evaluation reason
			Before/ during construction	Operation	
Pollution control	1	Air pollution	B-	B-	**During construction**: Generation of dust by land reclamation work is expected. Air pollution by construction machines and construction vehicles is expected. **Operation**: Traffic may increase by development of the road with the construction, Dust and air pollution are expected to increase. In addition,
	2	Water quality	B-	D	**During construction**: Water pollution by turbid water with excavation, oil spills from construction machines and construction vehicles is expected. **Operation**: Works that cause water pollution are not expected.
	3	Waste	B-	D	**During construction**: Generation of waste soil and waste material is expected. **Operation**: No waste is expected.
	4	Soil pollution	B-	D	**During construction**: Soil pollution by oil spills from construction machines and construction vehicles is expected. **Operation**: Soil pollution is not expected.
	5	Noise and vibration	B-	B-	**During construction**: Occurrence of noise and vibration by operation of construction machines and construction vehicles is expected. **Operation**: Traffic may increase by development of the road with the construction. Noise and vibration level is expected to increase.
	6	Land subsidence	D	D	Works that cause land subsidence are not expected.
	7	Odor	D	D	Works that cause odor are not expected.
	8	Bottom sediment	D	D	Works that cause bottom sediment are not expected.
Natural environment	9	Protected area	D C-	D C-	There is no national protected are in the Project area. Natural regional specified protected areas shall be surveyed.
	10	Ecosystem	B-	B-	**During construction**: Inhabits of fauna and flora may be divided and lost by access road construction or deforestation. **Operation**: - Due to easier human access by development of roads, habitats of animals may be disturbed and hunting may increase. - Cumulative impact may occur by development activities induced by roads construction.
	11	Hydrology	D	D	Works that cause change of hydrology is not expected.
	12	Topography and geology	B-	D	**During construction**: Topography is expected to change by construction of access roads **Operation**: Works that change topography and geology is not expected.
Social environment	13	Resettlement and land acquisition	B-	D	**Planning/Before construction/Operation**: No involuntary resettlement is expected by acquisition of land for access roads. Land acquisition and compensation of the farm land for access road construction is necessary.
	14	Poverty	B-	B- B+	**During construction/Operation**: Land acquisition for access road construction will cause loss of farmland and livelihood source. **Operation**: Enhanced supply of rural electricity by development of the power plant and development of the roads may improve social service such as schools and hospitals and access to them.
	15	Ethnic minority and indigenous people	B-	B-	**During construction/Operation**: Affected people are Nyaheun. Following issues may impact on their livelihood; decrease of farmland by land acquisition for access road construction, decrease of regional natural resource by deforestation.
	16	Local economy, employment and livelihood	B±	B±	**During construction**: Local residents may obtain employment opportunity with construction work. Land acquisition for access road will decrease the land of livelihood source. **Operation**: Stable supply of rural electricity may enhance diversification of livelihood. On the other hand, farmland will decrease by land acquisition for access road.
	17	Land use and use of natural resource	B-	B-	**During construction**: Land acquisition causes loss of farmland and deforestation may reduce regional natural resource. **Operation**: Land use will be changed. Forest resource may decrease by change of land use and deforestation.
	18	Water use	D	D	Works that cause change of water use is not expected.

Category	No	Environmental Item	Evaluation: Before/during construction	Evaluation: Operation	Evaluation reason
Social environment	19	Existing social infrastructure and service	B-	B+	**During construction**: The passage of the road may be limited at a certain time zone. **Operation**: Enhanced supply of rural electricity by extension of development of the power plant and development of the roads may improve social service such as schools and hospitals and access to them.
	20	Social institutions and social organization such as decision-making body	B-	D	**During construction**: Social institutions and/or social organization may be affected by land acquisition procedure or compensation evaluation. **Operation**: The impact of social institutions or social organization is not expected.
	21	Uneven distribution of benefits and damages	B-	D	**During construction**: Unfair evaluation of compensation may cause uneven distribution of benefits and damage. **Operation**: Uneven distribution of benefits and damages are not expected.
	22	Conflict of interest in the region	B-	D	**During construction**: Land acquisition procedure or compensation evaluation may cause conflict of interest in affected villages. **Operation**: Conflict of interest is not expected.
	23	Cultural heritage	C-	D	**During construction**: Construction work may impact on sacred places of residents. **Operation**: The operation of access road will not impact on cultural heritage and sacred places.
	24	Landscape	B-	B-	There is no resource of landscape in and around the planned access road area. But construction of access road may change a part of landscape.
	25	Gender	C	D	**During construction**: The impact on gender is not expected. Field survey will be necessary to confirm and evaluate the impact. **Operation**: The impact on gender is not expected.
	26	Children's rights	D	D	**During construction/Operation**: The impact on children's rights is not expected.
	27	Infection, HIV/AIDS	C-	D	**During construction**: Influx of workers may cause spread of infection. **Operation**: Activities that cause infection are not expected.
	28	Working condition (including working safety)	C-	D	**During construction**: Accidents, infections such as malaria, injures and diseases may occur during construction. **Operation**: Activities that impact on working condition are not expected.
Others	29	Accidents	A-	B-	**During construction**: Construction and traffic accidents may occur during construction. As cluster bombs were dropped in Laos, unexploded ordnance (UXO) may remain in the construction area. **Operation**: Road improvement may increase traffic and cause increase of traffic accidents.
	30	Impact of cross-border, and climate change	C-	C-	**During construction**: Auto exhaust from construction machines and construction vehicles will cause increase of CO_2 emission. Deforestation will cause decrease of absorption of CO_2. As the quantity is limited, the impact on climate change is not expected. **Operation**: CO_2 emission may increase by traffic growth with development of the road.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

Table 6.5-3 Scoping (Transmission Line)

Category	No	Environmental Item	Evaluation: Before/ during construction	Evaluation: Operation	Evaluation reason
Pollution control	1	Air pollution	B-	D	**During construction**: Generation of dust by construction work is expected. Air pollution by construction machines and construction vehicles is expected. **Operation**: Works that cause air pollution are not expected.
	2	Water quality	C-	D	**During construction**: The water pollution by turbid water with excavation from construction machines and construction vehicles is expected. **Operation**: Works that cause water pollution are not expected.
	3	Waste	B-	D	**During construction**: Generation of waste soil and waste material is expected. **Operation**: No waste is expected.
	4	Soil pollution	C-	D	**During construction**: Soil pollution by oil spills from construction machines and construction vehicles is expected. But these impacts are temporary and affected area is limited to around the transmission tower construction area. **Operation**: Soil pollution is not expected.
	5	Noise and vibration	B-	D	**During construction**: Occurrence of noise and vibration by operation of construction machines and construction vehicles is expected. **Operation**: Works that cause noise and vibration are not expected.
	6	Land subsidence	D	D	Works that cause land subsidence are not expected.
	7	Odor	D	D	Works that cause odor are not expected.
	8	Bottom sediment	D	D	Works that cause bottom sediment are not expected.
Natural environment	9	Protected area	D C-	D C-	There is no national protected area in the Project area. The natural regional specified protected areas shall be surveyed.
	10	Ecosystem	B-	B-	**During construction**: Inhabits of fauna and flora may be divided and lost by construction of transmission line or deforestation. **Operation:** - Inhabits of fauna and flora may be divided and lost by deforestation under transmission line. - Transmission line may disturb flying of birds. - Cumulative impact may occur by development activities induced by road construction.
	11	Hydrology	D	D	Works that cause change of hydrology are not expected.
	12	Topography and geology	B-	B-	**During construction/Operation**: Topography and geology may change by construction of towers and road.
Social environment	13	Resettlement and land acquisition	B-	D	**Planning/Before construction**: Involuntary resettlement will not occur to acquire the land for towers (required area of one tower is around 144m^2 each for every 350m). Land acquisition of private land and farmland, and limitation of land use within ROW will occur.
	14	Poverty	C-	C- B+	**During construction/operation**: If poverty groups use the land of towers for livelihood source, their livelihood may be affected by land acquisition. **Operation**: Enhanced supply of rural electricity by development of the power plant may improve social service such as schools and hospitals.
	15	Ethnic minority and indigenous people	C-	C-	**During construction**: The existence of an impact on ethnic minority and indigenous people in transmission line area will be confirmed and studied.
	16	Local economy, employment and livelihood	B±	B+	**During construction**: Local residents may obtain employment opportunity with construction work. On the other hand, land acquisition of towers (required area of one tower is around 144m^2 each for every 350m) will cause loss of land for their livelihood source. **Operation**: Stable supply of rural electricity may enhance diversification of livelihood.
	17	Land use and use of natural resource	B-	B-	**During construction/Operation**: The crop yields may reduce by land acquisition in farmland. Land use under transmission lines ROW will be restricted.
	18	Water use	D	D	Works that cause change of water use is not expected.
	19	Existing social infrastructure and service	B-	B+	**During construction**: The passage of the road may be limited at a certain time zone. **Operation**: Enhanced supply of rural electricity by extension of development of the power plant may improve social service such as schools and hospitals.

Category	No	Environmental Item	Evaluation: Before/during construction	Evaluation: Operation	Evaluation reason
Social environment	20	Social institutions and social organization such as decision-making body	C-	D	**During construction**: Social institutions and/or social organization may be affected by land acquisition procedure or compensation evaluation. **Operation**: The impact on social capital and organization is not expected.
	21	Uneven distribution of benefits and damages	B-	D	**During construction**: Unfair evaluation of compensation may cause uneven distribution of benefits and damage. **Operation**: Uneven distribution of benefits and damages are not expected.
	22	Conflict of interest in the region	C-	D	**During construction**: Land acquisition procedure or compensation evaluation may cause conflict of interest in affected villages. **Operation**: Conflict of interest is not expected.
	23	Cultural heritage	C-	C-	**During construction**: Construction work may impact on sacred places (grave yard for example) of residents. The existence of sacred planes and cultural heritages will be confirmed with field survey. **Operation**: The existence of cultural heritages will be confirmed with the survey.
	24	Landscape	B-	B-	There is no remarkable resource of landscape in and around transmission line area. But construction of transmission line will impact on landscape.
	25	Gender	C	D	**During construction**: The impact on gender is not expected. Field survey will be necessary to confirm and evaluate the impact. **Operation**: The impact on gender is not expected.
	26	Children's rights	D	D	**During construction/Operation**: The impact on children's rights is not expected.
	27	Infection, HIV/AIDS	C-	D	**During construction**: Influx of workers may cause the spread of the infection. **Operation**: The impact by infection is not expected.
	28	Working condition (including working safety)	C-	D	**During construction**: Accidents, infections such as malaria, injures and diseases may occur during construction. **Operation**: Works that impact on working condition are not expected.
Others	29	Accidents	A-	D	**During construction**: Construction and traffic accidents may occur during construction. As cluster bombs were dropped in Laos, unexploded ordnance (UXO) may remain in the construction area. **Operation**: The possibility of accident is low.
	30	Impact of cross-border, and climate change	C-	D	**During construction**: Auto exhaust from construction machines and construction vehicles will cause increase of CO_2 emission. Deforestation will cause decrease of absorption of CO_2. But the quantity is limited, so the impact on climate change is not expected. **Operation**: No impact on climate change is expected.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

6.6 TOR

According to the scoping, survey items are selected. The results for the selection are shown in Table 6.6-1 to Table 6.6-3. The survey for the access road was performed in that for the powerhouse.

Table 6.6-1 TOR of Survey for Environmental and Social Consideration (Power Plant Facilities)

Category		Survey Item	Contents of Survey (Plan)
Study on Alternative		①Study on alignment ②Design and construction planning	①Minimization of land acquisition area within keeping the Project economics ②Design and study for construction planning to minimize environmental impacts
Pollution control	1	Air pollution ①Confirmation on environmental standards, etc. ②Confirmation of residence, schools, etc. in the vicinity of the Project area ③Impacts during construction	①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, schedule, methods, heavy equipment plan, transportation of construction materials, etc. and study on preventive measures against air pollution
	2	Water quality ①River water quality ②Situation of domestic use of river water ③Impacts during construction	①Measurement of river water quality (pH, BOD, SS, etc.) at 6 sites in rainy and dry seasons ②Site survey and interview ③Confirmation of construction works, schedule, methods, heavy equipment plan, etc. and study on preventive measures against water pollution
	3	Waste ①Confirmation on environmental standards, etc. ②Methods of waste treatment	①Survey on standards for waste management ②Study on waste treatment methods
	4	Soil pollution ①Study on oil spill measures during construction ②Study on oil spill measures during operation	①Research on similar cases and study on applicability ②Research on similar cases and study on applicability
	5	Noise and vibration ①Confirmation on environmental standards, etc. ②Confirmation of residence and schools, etc. in the vicinity of the Project area and present status survey ③Impacts during construction	①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, method, heavy equipment plan, etc. and study on impacts of noise and vibration
	6	Land subsidence	Survey is not necessary because no impact are expected.
	7	Odor	Survey is not necessary because no impact are expected.
	8	Bottom sediment ①Treatment of waste water during construction	①Research on similar cases and study on applicability
Natural Environment	9	Protection Area ①Designation of regional protected areas other than national protected areas	①Identification of areas to be designated as regional protected areas such as protected forest, etc. other than national protected areas through survey on the similar cases and interview
	10	Ecosystem ①Situation of inhabitation and growth of animal ②Impacts during construction ③Impacts on aquatic biota ④Migratory fish ⑤Cumulative impact	①Survey on vegetation in the vicinity of the Project area and situation of inhabitation and growth of animal including rare species survey ②Study of impacts on fauna and flora by construction works ③Study of impacts on aquatic biota by change of river flow ④Research on similar cases and study on impacts regarding migratory fish ⑤Survey on induced development activities

Category		Survey Item	Contents of Survey (Plan)
Natural Environment	11	Hydrology ①Hydrological investigation ②Variation of river flow during construction ③Variation of river flow during operation ④Environmental flow	 ①Collection and analysis of hydrological data ②Confirmation of construction plan and schedule and study of impacts by variation of river flow during construction ③Confirmation of operation plan and study of impacts by variation of river flow during operation ④Analysis of hydrological data, study of impacts based on aquatic biota investigation and study on environmental flow
	12	Topography and geology ①Confirmation of geology	 ①Topographical and geological survey
Social Environment	13	Resettlement and land acquisition ①Survey of Project affected people ②Survey of related regulation, etc. ③Confirmation of area and scale of land acquisition ④Compensation regarding land acquisition	 ①Population census and social economic survey ②Research of related legal system and similar case ③Study on land acquisition area based on construction plan and site survey ④Survey of Project affected asset
	14	Poverty ①Confirmation of Project affected people	 ①Population census, social economic survey and present status survey by interview
	15	Ethnic minority and indigenous people ①Confirmation of Project affected people ②Identification of ethnic minority and indigenous people	 ①Population census and social economic survey ②Collection of existing information and survey on cultural characteristics of ethnic minority and indigenous people by interview survey, etc.
	16	Local economy, employment and livelihood ①Local economic survey ②Present status survey for Project affected people	 ①Survey of local employment conditions and income ②Present status survey by interview to objective households
	17	Land use and use of natural resource ①Land use survey ②Survey on utilization of regional natural resources	 ①Land use survey in the affected area by measurement at site ②Present status survey by interview to objective households
	18	Water use ①Survey on water use	 ①Interview survey to residents in a river basin and in the vicinity of Project area and survey on domestic water source and water utilization of residents
	19	Existing social infrastructure and service ①Survey of social infrastructure around the Project area	 ①Site survey and survey of social infrastructure such as education and medical infrastructure, etc. in the vicinity of the Project area by interview survey to related organizations
	20	Social institutions and social organization such as decision-making body ①Survey on social capital ②Survey on social organization	 ①Interview survey to related organizations ②Interview survey to related organizations and objective households
	21	Uneven distribution of benefits and damages ①Local economy survey	 ①Survey of local employment statistic and income, interview to objective households
	22	Conflict of interest in the region ①Survey on compensation system and grievance redress mechanism	 ①Interview survey for related organizations and study on compensation and grievance redress mechanism
	23	Cultural heritage ①Survey on cultural heritage	 ①Interview survey for related organizations and survey on historical, cultural and archaeological heritage by site investigation
	24	Landscape ①Survey on landscape ②Study on measures for landscape preservation	 ①Interview survey for related organizations and data collection for scenic are through site investigation ②Study on preservation measures for area with scenic value such as the Xe Katam Fall
	25	Gender ①Survey of actual situations regarding gender bias	 ①Population census and present status survey through interview
	26	Children’s rights	Survey is not necessary because no impacts are expected.

Category		Survey Item	Contents of Survey (Plan)
Social Environment	27	Infection, HIV/AIDS ①Survey on incidence of infection such as HIV/AIDS, etc. ②Study on preventive measures for outbreak of infection	①Present status survey through interview to related organizations ②Confirmation on construction implementation plan and study on preventive measures for outbreak of infection brought by migrant workers, etc.
	28	Working condition (including working safety) ①Measures for working safety	①Confirmation on construction implementation plan and study on measures for working safety in consideration of construction plan
Others	29	Accidents ①Study on preventive measures for accidents in relation to the construction works traffic accidents ② Study on preventive measures for accidents in relation to UXO during construction ③Study on preventive measures for accidents during operation and traffic accident	①Confirmation on construction plan, identification of causes of accident and study on preventive measures for accidents ②Survey on distribution of UXO and study on preventive measures for accidents ③Identification of causes of accident for operation and study on preventive measures for accidents
	30	Impact of cross-border, and climate change ①Study of impacts on cross-border	①Study of regional impacts such as climate change caused by change of deforestation.
Stakeholder Consultation		①Dissemination of Project development plan in site survey ②Discussion at the stage of draft EIA ③Discussion at the stage of final EIA	①Dissemination of the Project development plan and collection of opinions through Village Dissemination Meeting in compliance with laws and regulations of Lao PDR. ②Explanation of the Project development plan and collection of opinions at village and district level by Village Consultation Meeting and District Consultation Meeting in compliance with laws and regulations of Lao PDR. ③Explanation of the Project development plan and collection of opinions at provincial level by Provincial Consultation Meeting, joint survey and discussion with related governmental agencies in compliance with laws and regulations in Lao PDR.

Table 6.6-2 TOR of Survey for Environmental and Social Consideration (Access Road)

Category		Survey Item	Contents of Survey (Plan)
Pollution control	1	Air Pollution ①Confirmation on environmental standards, etc. ②Confirmation of residence, schools, etc. in the vicinity of the Project area ③Impacts during construction	①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, schedule, methods, heavy equipment plan, transportation of construction materials, etc. and study on preventive measures against air pollution
	2	Water Quality ①Impacts during construction	①Confirmation of construction works, schedule, methods, heavy equipment plan, etc. and study on preventive measures against water pollution
	3	Waste ①Confirmation on environmental standards, etc. ②Methods of waste treatment	①Survey on standards for waste management ②Study on waste treatment methods
	4	Soil pollution ①Study on oil spill measures during construction ②Study on oil spill measures during operation	①Research on similar cases and study on applicability ②Research on similar cases and study on applicability
	5	Noise and vibration ①Confirmation on environmental standards, etc. ②Confirmation of residence, etc. ③Impacts during construction	①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, schedule, methods, heavy equipment plan, etc. and study on preventive measures against noise and vibration.
	6	Land subsidence	Survey is not necessary because no impact are expected
	7	Odor	Survey is not necessary because no impact are expected
	8	Bottom sediment	Survey is not necessary because no impact are expected.
Natural Environment	9	Protection Area ①Designation of regional protected areas other than national protected areas	①Identification of areas to be designated as regional protected areas such as protected forest, etc. other than national protected areas through survey on the similar cases and interview
	10	Ecosystem ①Situation of inhabitation and growth of animal ②Impacts during construction ③Cumulative impact	①Survey on vegetation in the vicinity of the Project site and situation of inhabitation and growth of animal including rare species survey ②Study of impacts on fauna and flora by construction works ③Survey on induced development activities
	11	Hydrology	Survey is not necessary because no impact are expected.
	12	Topography and geology ①Confirmation of geology	①Topographical and geological survey
Social Environment	13	Resettlement and land acquisition ①Survey of Project affected people ②Survey of related regulation, etc. ③Confirmation of area and scale of land acquisition ④Compensation regarding land acquisition	①Population census and social economic survey ②Research of related legal system and similar case ③Study on land acquisition area based on construction plan and site survey ④Survey of Project affected asset
	14	Poverty ①Confirmation of Project affected people	①Population census, social economic survey and present status survey by interview
	15	Ethnic minority and indigenous people ①Confirmation of Project affected people ②Identification of ethnic minority and indigenous people	①Population census and social economy survey ②Collection of existing information and survey on cultural characteristics of ethnic minority and indigenous people by interview survey, etc.
	16	Local economy, employment and likelihood ①Local economic survey ②Present status survey for Project affected people	①Survey of local employment conditions and income ②Present status survey by interview to objective households

Category		Survey Item	Contents of Survey (Plan)
Social Environment	17	Land use and use of natural resource ①Land use survey ②Survey on utilization of regional natural resources	 ①Land use survey in the affected area by measurement at site ②Present status survey by interview to objective households
	18	Water use	Survey is not necessary because no impact is expected.
	19	Existing social infrastructure and service ①Survey of social infrastructure around the Project area	 ①Site survey and survey of social infrastructure such as education and medical infrastructure, etc. in the vicinity of the Project area by interview survey to related organizations
	20	Social institutions and social organization such as decision-making body ①Survey on social capital ②Survey on social organization	 ①Interview survey to related organizations ②Interview survey to related organizations and objective households
	21	Uneven distribution of benefits and damages ①Local economy survey	 ①Survey of local employment statistic and income and interview to objective households
	22	Conflict of interest in the region ①Survey on compensation system and grievance redress mechanism	 ①Interview survey for related organizations and study on compensation and grievance redress mechanism
	23	Cultural heritage ①Survey on cultural heritage	 ①Interview survey for related organizations and survey on historical, cultural and archaeological heritage by site investigation
	24	Landscape ①Survey on landscape ②Study on measures for landscape conservation	 ①Interview survey for related organizations and data collection for scenic are through site investigation ②Study on conservation measures for area with scenic value
	25	Gender ①Survey of actual situations regarding gender bias	 ①Population census and present status survey through interview survey
	26	Children's rights	Survey is not necessary because no impact is expected.
	27	Infection, HIV/AIDS ①Survey on incidence of infection such as HIV/AIDS, etc. ②Study on preventive measures for outbreak of infection	 ①Present status survey through interview survey to related organizations ②Confirmation on construction implementation plan and study on preventive measures for outbreak of infection brought by migrant workers, etc.
	28	Working condition (including working safety) ①Investigation of local working conditions ②Measures for working safety	 ①Present status survey through interview survey ②Confirmation on construction implementation plan and study on measures for working safety in consideration of construction plan
Others	29	Accidents ①Study on preventive measures for accidents in relation to the construction works accident and traffic accidents ② Study on preventive measures for accidents in relation to UXO during construction	 ①Confirmation on construction plan, identification of causes of accident and study on preventive measures for accidents ②Survey on distribution of UXO and study on preventive measures for accidents
	30	Impact of cross-border, and climate change ①Study of impacts on wider area during construction	 ①Study of regional impacts such as climate change by construction
Stakeholder Consultation		①Dissemination of plans in site survey ②Discussion at the stage of draft EIA	①Dissemination of the Project development plan and collection of opinions through Village Dissemination Meeting in compliance with laws and regulations of Lao PDR. ②Explanation of the Project development plan and collection of opinions at village and district level by Village Consultation Meeting and District Consultation Meeting in compliance with laws and regulations of Lao PDR.

Table 6.6-3 TOR of Survey for Environmental and Social Consideration (Transmission Line)

Category		Survey Item	Contents of Survey (Plan)
Study on Alternative		①Study on route of transmission line	①Comparison of routes of transmission line based on the field survey.
Pollution control	1	Air pollution ①Confirmation on environmental standards, etc. ②Confirmation of residence, schools, etc. in the vicinity of the Project area ③Impacts during construction	 ①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, schedule, methods, heavy equipment plan, transportation of construction materials, etc. and study on preventive measures against air pollution.
	2	Water quality ①Impacts during construction	 ①Confirmation of construction works, schedule, methods, heavy equipment plan, transportation of construction materials, etc. and study on preventive measures against water pollution.
	3	Waste ①Confirmation on environmental standards, etc. ②Methods of waste treatment	 ①Survey on standards for waste management ②Study on waste treatment methods
	4	Soil pollution ①Study on oil spill measures during construction ②Study on oil spill measures during operation	 ①Research on similar cases and study on applicability ②Research on similar cases and study on applicability
	5	Noise and vibration ①Confirmation on environmental standards, etc. ②Confirmation of residence ③Impacts during construction	 ①Survey on the existing standards, information, data, etc. ②Site survey ③Confirmation of construction works, schedule, methods, heavy equipment plan, transportation of construction materials, etc. and study on preventive measures against noise and vibration
	6	Land subsidence	Survey is not necessary because no impact are expected
	7	Odor	Survey is not necessary because no impact are expected
	8	Bottom sediment	Survey is not necessary because no impact are expected
Natural Environment	9	Protection area ①Designation of regional protected areas other than national protected areas	 ①Identification of areas to be designated as regional protected areas such as protected forest, etc. other than national protected areas through survey on the similar cases and interview
	10	Ecosystem ①Situation of inhabitation and growth of animal ②Impacts during construction ③Impact during operation ④Cumulative impact	 ①Survey on vegetation in the vicinity of the Project site and situation of inhabitation and growth of animal including rare species survey ②Study of impacts on fauna and flora by construction works ③Research on similar case and study of impact mitigation measure ④Survey on induced development activities
	11	Hydrology	Survey is not necessary because no impact are expected
	12	Topography and geology ①Confirmation of geology	 ①Topographical and geological survey
Social Environment	13	Resettlement and land acquisition ①Survey of Project affected people ②Survey of related regulation, etc. ③Confirmation of area and scale of land acquisition ④Compensation regarding land acquisition	 ①Population census and social economic survey ②Research of related legal system and similar case ③Study on land acquisition area based on construction plan and site survey ④Survey of Project affected asset
	14	Poverty ①Confirmation of Project affected people	 ①Population census, social economic survey and present status survey by interview
	15	Ethnic minority and indigenous people ①Confirmation of Project affected people ②Identification of ethnic minority and indigenous people	 ①Population census and social economy survey ②Collection of existing information and survey on cultural characteristics of ethnic minority and indigenous people by interview survey, etc.

Category		Survey Item	Contents of Survey (Plan)
Social Environment	16	Local economy, employment and likelihood ①Local economy survey ②Present status survey for Project affected people	①Survey of local employment conditions and income ②Present status survey by interview to objective households
	17	Land use and use of natural resource ①Land use survey ②Survey on utilization of regional natural resources	①Land use survey in the affected area by measurement at site ②Present status survey by interview to objective households
	18	Water use	Survey is not necessary because no impact are expected.
	19	Existing social infrastructure and service ①Survey of social infrastructure around the Project area	①Site survey and survey of social infrastructure such as education and medical infrastructure, etc. in the vicinity of the Project area by interview survey to related organizations
	20	Social institutions and social organization such as decision-making body ①Survey on social capital ②Survey on social organization	①Interview survey to related organizations ②Interview survey to related organizations and objective households
	21	Uneven distribution of benefits and damages ①Local economy survey	①Survey of local employment statistic and income and interview to objective households
	22	Conflict of interest in the region ①Survey on compensation system and grievance redress mechanism	①Interview survey for related organizations and study on compensation and grievance redress mechanism
	23	Cultural heritage ①Survey on cultural heritage	①Interview survey for related organizations and survey on historical, cultural and archaeological heritage by site investigation
	24	Landscape ①Survey on landscape ②Study on measures for landscape conservation	①Interview survey for related organizations and data collection for scenic are through site investigation ②Study on conservation measures for area with scenic value
	25	Gender ①Survey of actual situations regarding gender bias	①Population census and present status survey through interview survey
	26	Children's rights	Survey is not necessary because no impact are expected.
	27	Infection, HIV/AIDS ①Survey on incidence of infection such as HIV/AIDS, etc. ②Study on preventive measures for outbreak of infection	①Present status survey through interview survey to related organizations ②Confirmation on construction implementation plan and study on preventive measures for outbreak of infection brought by migrant workers, etc.
	28	Working condition (including working safety) ①Investigation of local working conditions ②Measures for working safety	①Present status survey through interview survey ②Confirmation on construction implementation plan and study on measures for working safety in consideration of construction plan
Others	29	Accidents ①Study on preventive measures for accidents in relation to the construction works traffic accidents ② Study on preventive measures for accidents in relation to UXO during construction	①Confirmation on construction plan, identification of causes of accident and study on preventive measures for accidents ②Survey on distribution of UXO and study on preventive measures for accidents
	30	Impact of cross-border, and climate change ①Study of impacts on wider area during construction	①Study of regional impacts such as climate change by construction
Stakeholder Consultation		①Dissemination of plans in site survey ②Discussion at the stage of draft IEE	①Dissemination of the Project development plan and collection of opinions through Village Dissemination Meeting in compliance with laws and regulations of Lao PDR. ②Explanation of the Project development plan and collection of opinions at village and district level by Village Consultation Meeting and District Consultation Meeting in compliance with laws and regulations of Lao PDR.

6.7 Result of Environmental and Social Consideration Study

6.7.1 Natural Environment

(1) Soil

The soils of the area have been classified as mainly haplic acrisols and alisols. They are the skeletal hill soils covering most of the Project area. They have shallow horizons with a contact with parent material within 25 cm of the surface or with more than 50 percent rock fragments within this depth. Such shallow soils are susceptible to erosion after vegetation is removed.

(2) Hydrology

There are three (3) rainfall gauging stations and two (2) discharge gauging stations around Project area. KANSAI has continued to implement hydrological observation such as rainfall gauging, water level gauging and discharge measurement at Nong Mek village since 2004. As a result of low flow analysis, 12.1 m^3/s is obtained as annual average inflow at the intake weir in the Xe Katam River.

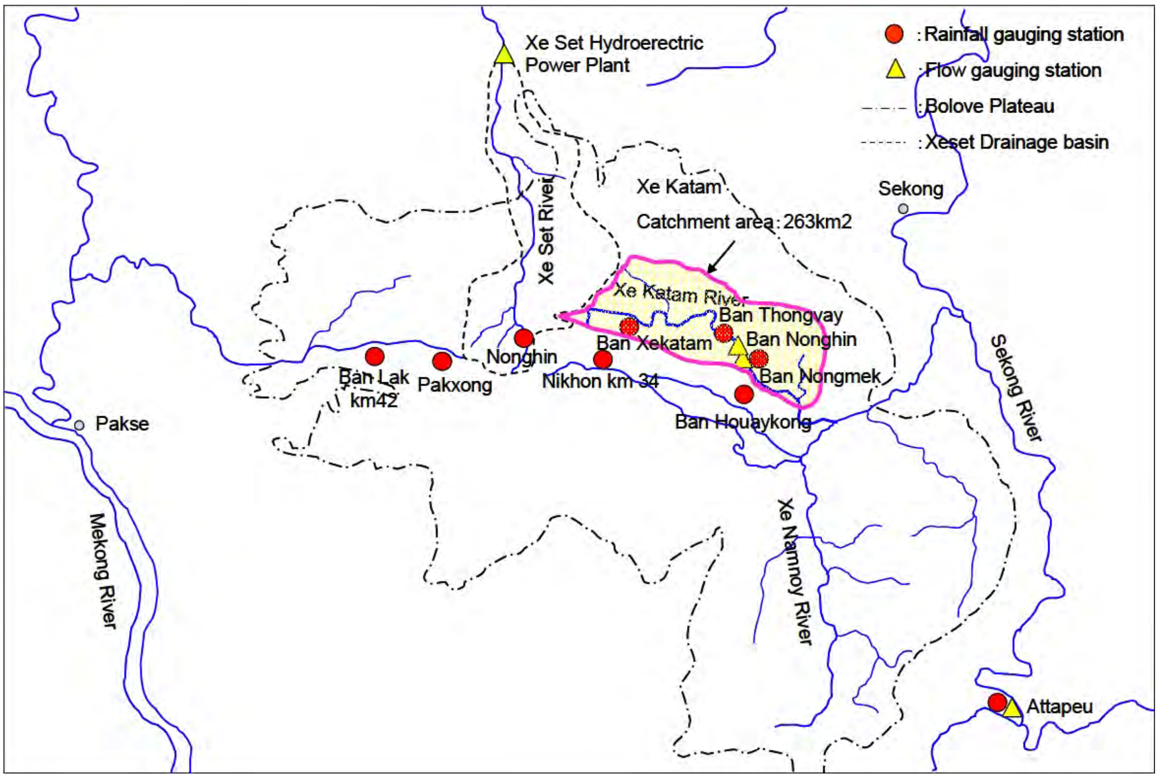


Figure 6.7-1 Hydrological Gauging Stations surrounding Xe Katam Site

Table 6.7-1 Monthly Inflow at Xe Katam (C.A 263km^2)

	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1985	4.4151	3.1005	2.7367	3.3485	7.4577	24.8205	20.3475	22.0094	21.5216	14.0225	8.0778	5.1096	11.41
1986	3.48	2.61	2.08	2.89	7.69	9.29	10.83	26.35	23.84	16.78	12.96	6.04	10.40
1989	3.23	2.23	1.74	2.81	9.70	18.70	23.65	32.89	38.03	18.09	7.20	4.50	13.56
1990	2.93	1.59	2.20	2.25	5.30	6.28	12.24	16.54	23.27	31.65	16.90	11.18	11.03
1991	3.08	1.41	1.28	1.28	3.49	5.51	26.83	41.07	34.07	28.79	6.83	3.56	13.10
1992	2.42	1.47	1.62	2.70	6.84	31.01	27.79	62.83	23.07	11.79	5.45	3.03	15.00
1993	2.13	1.50	1.57	1.81	6.27	10.47	26.94	21.46	28.20	9.22	4.18	2.94	9.73
1994	2.09	1.64	1.84	4.86	6.97	10.37	24.18	30.13	45.30	15.65	6.80	4.03	12.82
1996	2.68	1.93	1.57	3.00	8.09	19.40	25.72	28.19	48.44	21.37	17.20	7.80	15.45
1997	4.68	3.32	2.74	3.33	6.27	7.12	20.12	44.63	20.68	17.54	8.22	4.48	11.93
1999	2.64	1.79	1.54	2.80	7.30	12.44	41.54	52.55	27.58	17.49	9.92	6.51	15.34
2000	3.79	2.76	3.28	4.68	5.78	8.03	39.03	33.59	41.94	18.49	11.23	5.08	14.81
2001	3.27	2.03	2.12	2.03	4.60	8.38	25.88	27.71	29.74	18.30	8.96	4.87	11.49
2002	3.08	3.13	1.55	2.01	3.89	6.56	25.35	43.94	34.16	19.17	10.62	5.78	13.27
2003	3.62	2.75	2.34	3.20	7.50	12.69	19.73	31.77	41.92	16.53	7.60	4.25	12.83
2004	2.82	2.04	1.57	2.34	4.35	11.19	15.62	26.40	17.27	6.25	2.8424	1.52	7.85
2005	1.0301	0.73	0.77	1.59	5.20	6.26	33.94	46.59	39.08	10.70	4.74	2.93	12.80
2006	1.53	0.96	1.18	4.16	12.37	11.73	39.01	35.72	23.48	31.12	5.97	3.18	14.20
2007	2.01	1.45	1.46	2.41	5.98	7.74	28.26	24.57	23.79	24.75	5.51	2.61	10.88
2008	1.57	0.81	0.74	3.33	7.62	12.20	4.93	14.06	28.13	5.42	5.67	2.71	7.27
2009	2.18	1.82	1.23	2.98	7.41	7.87	24.51	23.89	19.94	26.54	6.20	3.11	10.64
2010	2.31	2.42	1.62	3.10	5.04	7.80	14.62	33.82	17.20	9.22	3.78	1.68	8.55
2011	0.98	0.67	1.0909	6.7979	8.5621	14.992	20.857	32.96	34.48	21.86	6.11	2.93	12.69
2012	1.56	1.03	1.05	2.97	8.80	16.27	19.83	18.42	37.61	11.19	4.19	2.17	10.42
2013	1.17	0.68	0.76	1.40	11.40	15.13	20.90	17.72	56.69	23.07	6.65	3.55	13.26
2014	2.08	1.35	1.50	3.17	10.82	24.17	35.57	37.87	38.45	10.73	4.89	3.08	14.47
Max	4.68	3.32	3.28	6.80	12.37	31.01	41.54	62.83	56.69	31.65	17.20	11.18	15.45
Average	2.61	1.85	1.67	2.86	6.71	11.48	22.46	30.19	30.32	17.44	7.70	4.22	**12.03**
Min	0.98	0.67	0.74	1.28	2.79	3.54	4.44	9.43	17.20	5.42	2.84	1.52	7.27

(3) Erosion/ Sedimentation

The erosion rate (or sediment yield) are used the data for nearby the Nam Sai River. The sediment yield of the Nam Sai River is about 430 tons/year/km^2. This estimate uses the data for the Nam Sai River, and assumes that all sediment is fed to the catchment areas of the intake weir that is 263 km^2. Therefore sedimentation is estimated to be about 113,000 tons/year.

(4) Water Quality

(a) Surface Water

The water quality of surface water was analyzed at the Nam Houng River, the Xe Katam River and the Xe Namnoy River (see Figure 6.7-2). The Result of the analysis is shown in Table 6.7-2. There were not most of items above the environmental standard except COD at WQ01 and WQ04.

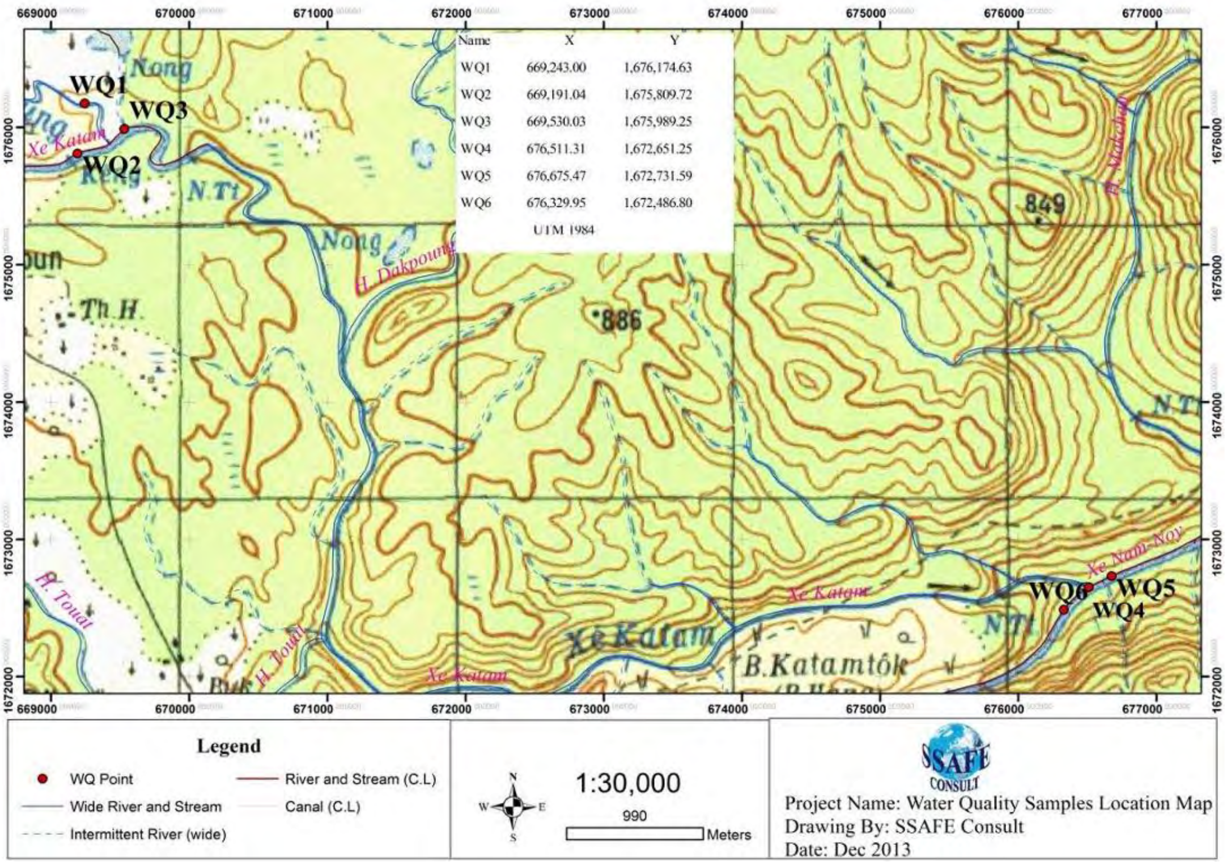


Figure 6.7-2 Location Map of Surface Water Sampling

Table 6.7-2 Result of Analysis of Surface Water

Sampling point		WS 01		WS02		WS03		WS04		WS05	
Parameters	Unit	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	**LNS**
pH		-	7.75	-	7.50	-	7.31	-	7.38	7.14	5.0-9.0
Chemical Oxygen Demand (COD)	mg/l	40.95	-	<0.4	-	1.95	-	6.02	-	-	5
Total Nitrogen (T-N)	mg/l	<0.01	0.357	<0.01	0.186	0,27	0.442	<0.01	0.447	0.266	<.7
Total Phosphorous (T-P)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.27	<0.01	<0.01	<0.01	<0.01	<.13
Total Suspended Solid (TSS)	mg/l	9.0	11.7	36	17.9	36	14.8	20	14.3	14.9	40*
Copper (Cu)	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.1
Nickel (Ni)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Manganese (Mn)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Zinc (Zn)	mg/l	0.033	<0.001	0.034	<0.001	0.040	<0.001	0.041	<0.001	<0.001	1
Cadmium (Cd)	mg/l	0.004	<0.002	0,006	<0.002	0.004	<0.002	0.002	<0.002	<0.002	0.005
Chrome (Cr)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Lead(Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05

The important items for habitat of aquatic organisms were analyzed on rainy (October, 2013) and dry (January, 2014) season. The result of the analysis is shown in Table 6.7-3. As a result, most of the sites have appropriate value for habitat of aquatic organisms.

Table 6.7-3 Surface Water Conditions for Habitat of Aquatic Organisms

Sampling Station		WS01		WS02		WS03		WS04		WS05		WS06		SANO
Parameters	Unit	16/10/13	10/1/14	17/10/13	9/1/14	18/10/13	11/1/14	19/10/13	8/1/14	20/10/13	8/1/14	21/10/13	7/1/14	(Reference)
AirTemp	°C	27	19.5	28	20	25	20	28	22	27	22.1	26	20.7	
Water Temp	°C	25	17.9	25	18.5	23	18.8	26	19.8	24	20.2	24	18.4	23-32
DO	mg/l	5.8	3.6	5.5	5.5	5.0	5.8	7.3	5.8	6.4	5.4	6.2	5.2	>3
pH		7.2	6.2	7.1	7.2	6.9	7.8	7.2	7.3	7.4	7.4	7.4	7.3	6.5-8.5
Hardness	mg/l	40	45	45	55	50	60	60	70	60.5	60	60.5	75	20-300
NH3	mg/l	0.02	0.03	0.02	0.01	0.03	0.01	0.01	0.01	0.03	0.01	0.03	0.01	
Conductivity	Cm		65		78		89		64		68.5		62	30-60

(b) Ground Water

In order to monitor the impact on the ground water, the water quality analysis of tube wells at Nong Thuam village was implemented. The result of the analysis is shown in Table 6.7-4. There were no items that depart from the environmental standards in Laos.

Table 6.7-4 Result of Analysis of Ground Water

Parameters	Unit	Nong Thuam Village	LNS Suitable Drinking
Conductivity	Cm	93	<1000
Turbidity	NTU	2	5
pH	pH	7.2	7-8.5
Iron (Fe)	mg/l	0.04	<0.5
Manganese (Mn)	mg/l	0.02	<0.3
Fluoride(F)	mg/l	0.08	<0.7
Nitrate (NO_3)	mg/l	5.2	<15
Total Hardness	mg/l	20	<300
Nitrite	mg/l	0.008	50
Fecal Coliform	Colonies	0	<2.2

(5) Mineral Resource

Substantial bauxite ore reserves are present in areas immediately south of the Xe Katam watershed. Two concessions are held by two corporations from China: Yuquida and Chinoma.

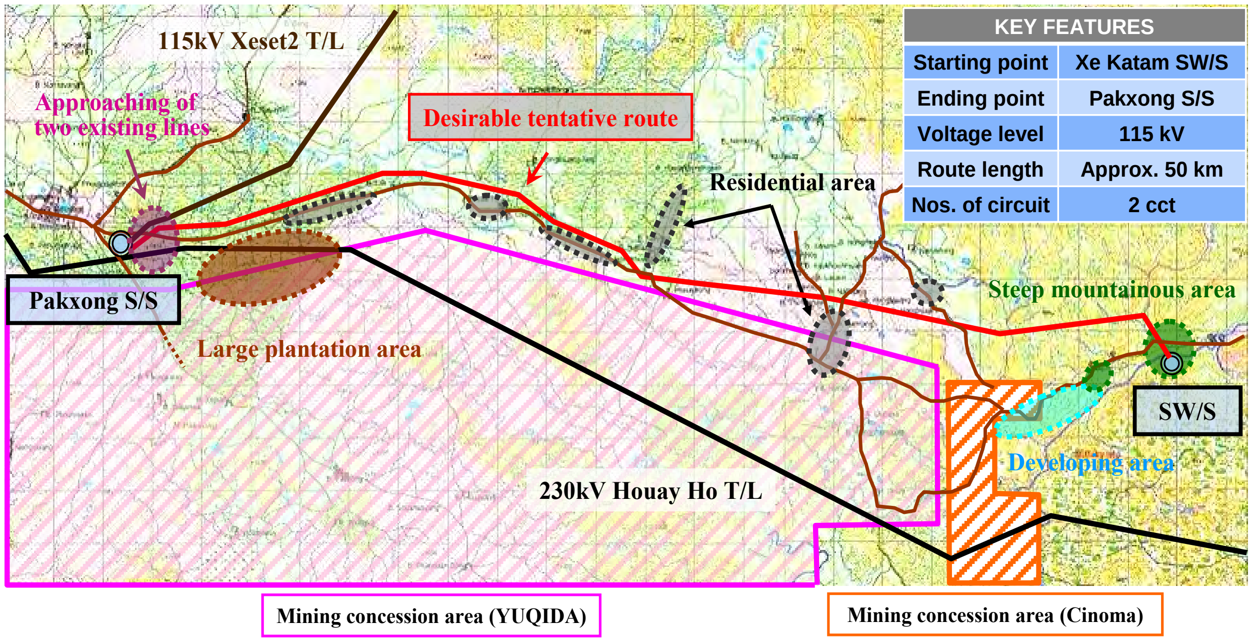


Figure 6.7-3 Map of Development Rights Area of Bauxite

(6) Air Quality

There is a lack of major pollutants in the Project area, and the present air quality is good: there are no industrial pollution sources in the vicinity at present and transportation density is still very low. The result measured air quality at Houaykong is shown in Table 6.7-5 as reference. The meteorological data of the measurement date is shown in Table 6.7-6. There are no items above the environmental standard.

Table 6.7-5 Air Quality Measurement Result in June 2009

Parameter	Result	LNES	Unit
TSP	0.035 0.042	0.33	mg/m^3
PM10	0.031 0.023	0.12	mg/m^3
SO_2	0.049 0.050 0.037	0.32	mg/m^3
NO_2	0.003 0.004 0.002	0.30	mg/m^3

Table 6.7-6 Meteorological Data on the Measurement Date

Parameter	Result	Unit
Wind speed	2.3-3.9	m/second
Wind direction	South west to north east	-
Air temperature	24-28	°C
Relative humidity	59-74	%

(7) Noise

Noise as well as air quality has been maintained good condition. As reference, the noise result measured at Houaykong Village is shown in Table 6.7-7.

Table 6.7-7 Noise Measurement Result in June 2009

No.	Date	Measuring Times	Unit	L(eq)	L_{max}
Ban Houyakang village club					
1	8/6/09	6 hrs(2:00-8:00)	dB(A)	56	90.6
2	8/6/09	12 hrs(18:00-6:00)	dB(A)	60.2	89
3	9/6/09	12 hrs(06:00-18:00)	dB(A)	58	88.4
4	8-9/6/09	24 hrs	dB(A)	57.9	91.3
5	9-10/6/09	24 hrs	dB(A)	63	83.3
Ban Houaykong close to cemetery					
7	9/6/09	10 minutes	dB(A)	53.1	70.3
The West of Houaykong village, Houaykong road to Pakxong road					
8	9/6/09	10 minutes	dB(A)	62.3	68.3
Houaykong Primary School					
9	9/6/09	10 minutes	dB(A)	46.8	63
LNES			dB(A)	50-70	115

(8) Protected Area

The Xe Katam catchment area contains Xe Katam Provincial Protected Forest (PPF) and Houay Lamphan PPF. These PPF have been already human-disturbed. They are linked with riparian and scattered forests.

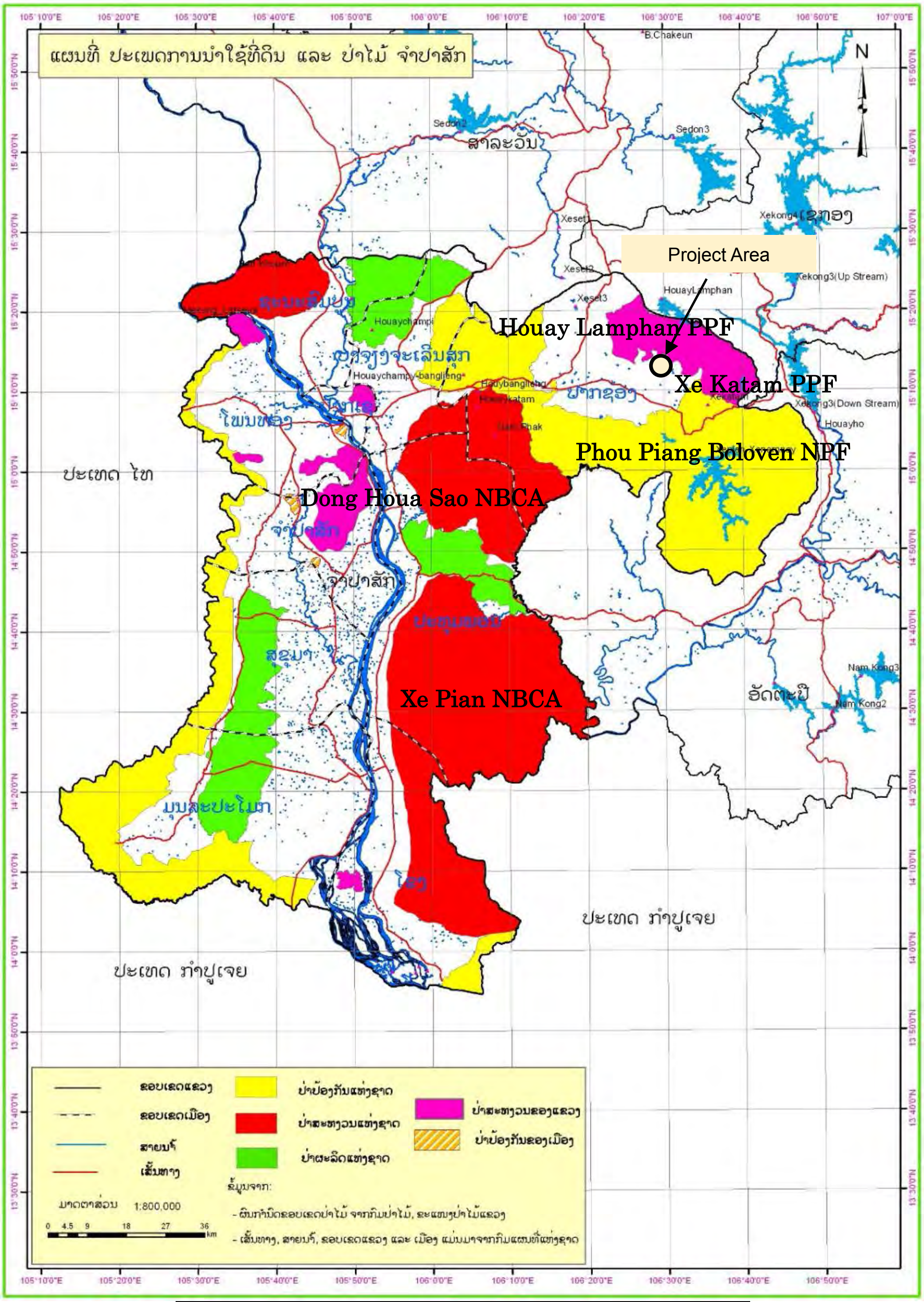
Appendix 1 of the JICA Guideline, "Environmental and Social Considerations Required for Intended Projects" states in "Compliance with Laws, Standard and Plans" that;

> *Projects must, in principle, be undertaken outside of protected areas that are specifically designated by laws or ordinances for the conservation of nature or cultural heritage. Projects are also not to impose significant adverse impacts on designated conservation areas.*

Although the Project area is partially located in the PPA, the Project satisfies the conditions of exemption stated by JICA in its Frequently Asked Question (July 20, 2011, revised on April 16, 2015) as indicated in Table 6.7-8. The implementation of the Project, therefore, is considered possible even it is partially located in the PPA.

Table 6.7-8 Conditions of JICA Guideline on Project Implementation in Protected Area

No.	Condition	Situation of the Project
1	There is no practical alternatives out of the area where the government specifies for conservation of nature or cultural heritage according to laws and regulations (hereinafter referred to as the “Protected Area”).	As shown in Section 6.4, the hydropower generation is an optimum solution for accommodating demand increase in the southern Laos, in which Xe Katam Project is considered best suited on economics and environmental aspects. As waterway has to pass through mountainous area which is specified as the Protected Area in order to obtain water head, it cannot avoid the Protected Area. Practical alternatives are not available in other area.
2	Developments in the Protected Area can be approved by laws and regulations of the host country.	As explained in Section 6.3.3, the Project can be approved by taking regulatory procedure to construct permanent buildings in natural and provincial protected areas of Laos according to Decree on Protection Forest (Decree No.333/PM July 2010).
3	The implementing agency of the project shall follow regulations and management plans related to the Protected Area.	The Project developer shall follow related laws such as Forest Law and Water and Water Resource Law and cooperate with Strategic Forest Management of Forest Resources of Champasak Province which includes reforestation, conservation of flora and fauna, education of villagers and strengthening surveillance of illegal acts for examples.
4	The implementing agency of the project shall consult with responsible administrative agencies of the Protection Area, local communities, and appropriate stakeholders if any, then obtain consensus to implement the project.	As explained in Section 0, the Project developer consulted with responsible administrative agencies and local communities through stakeholder consultation meetings, then obtained consensus to implement the Project.
5	The implementing agency of the project shall implement additional subprograms for effective management to conserve the Protected Area if necessary.	As explained in Section 6.10.1, the Project developer will support Department of Forest Resource Management of MONRE to implement fauna and flora protection measures (forest restoration, reforestation and relocation of important species).



Legend		
		National Protected Forest
		National Biodiversity Conservation Area
		Natural Production Forest
		Provincial Protected Forest

Figure 6.7-4 Location Map of Protected Area and Forest

(Source; Department of Forest Resource Management, MONRE)

Table 6.7-9 Category of Protected Forest

Category	Detail
Protection Forest	Protection Forests are created by Prime Minister or Provincial Governor Decree and forest areas selected to protect Laos natural resources such as water, river ecosystems, soil quality, protection from natural disasters and environmental conservation.
Conservation Forest	Conservation Forests are designated for conserving nature, preserving plant and animal species, ecosystems and other valuable areas of natural, historical, cultural, educational or scientific interest.
Production Forest	These are natural and planted forests for use and production. They are designated to support the production of wood and forest products and to satisfy the needs of socio-economic development. Article 12 of the Forest Law (2007) allows their allocation to individuals, communities and organizations for use, including customary usage used for long periods in the past.

(Source; Department of Forest Resource Management, MONRE)

Table 6.7-10 Establishment and Management Objective of Protected Forest

PA Name	Area (ha)	GOL Directive / Date	Objectives
Xe Katam PPF	24,000	866/PG / October 2009	Soil and water conservation on steep sloping lands in the Xe Katam watershed catchment area to prevent soil erosion, control surface water runoff rates and protect water quality for aquatic habitats and populations and human use. Flora and fauna conservation by providing protected habit conditions for wildlife breeding and survival and regeneration of forest destroyed by timber harvesting and slash and burn agriculture practices. Timber and non-timber forest products are used by local communities.
Houay Lamphan PPF	15,200	866/PG / October 2009	Same as Xe Katam. Provides protection from soil erosion and controls water runoff on steep lands and habitat protection for wildlife and conditions for natural forest regeneration following forest and agriculture exploitation in headwater streams of the Xe Pian catchment area. It also provides a forested biodiversity corridor for migration of terrestrial and avian fauna from Xe Katam to Phou Piang and Dong Hua Sao Protected Areas.

(Source; Department of Forest Resource Management, MONRE)

(9) Vegetation

The Project area has the vegetation types of the dry evergreen forest, the mixed deciduous forest, semi-dry mixed dipterocarp, grass land and follow forest. Semi-dry mixed dipterocarp and dry evergreen species forest types are dominant vegetation types in the Project area.

In the Project area most commercial timber trees have already been removed by logging companies and low quality forest with dense understory remains. Scattered trees that remain have low commercial value. At higher altitudes on the steep slopes in the northern half of the Xe Katam catchment and along the steep eastern escarpment of the Bolaven Plateau less disturbed forest remains.

Official publications indicate that the country has a forest cover of about 40% or 16 million hectares. Only 1.5 million hectares of them is reasonable quality high forest including 20 National

Biodiversity Conservation Areas. An estimated 1.2 million hectares has been lost since 1990. The main reasons for these losses are;

1) Population growth which has doubled in past 25 years caused loss of the forest of 500,000 ha per year, growing demand of woods for life and consumption of fuelwood of 7,000,000 tons per year;
2) Economic development caused large-scale development of forest and growing demand of high quality wood to construct houses;
3) The forestry is undeveloped for proper management of forest.
4) Economic development in China and Vietnam caused growing demand of high quality wood.

The southern Laos has a same trend with loss of forest at national level. The main reasons for forest losses in the southern Laos are;

1) GOL has issued concession to develop large scale plantation since 1990. In southern Laos, coffee plantation development has been increasing because of the climate, development of cultivation methods of coffee with high quality around the same time and rise of the unit price.
2) Forests are not properly managed and the border of national protected areas is indefinite. Peasants are developing coffee plantation within Dong Hua Sao NBCA.
3) The hydropower projects with the large reservoir caused forest loss, such as Houay Ho and Xe Pian - Xe Namnoy.

Table 6.7-11 Project Affected Area in PPF

Impact Zone	Vegetation Cover	Impact Area (ha)
Construction Zone		
Tunnel Intake Weir and Pond	Mixed deciduous forest	7.0
Canal and Service Road	Mixed deciduous forest	14.2
Temporary Yard No.2	Mixed deciduous forest	0.36
Temporary Yard No.3	Mixed deciduous forest	1.67
Temporary Yard No.8	Evergreen forest	0.06
Mouth headrace tunnel	Mixed deciduous forest	0.06
Mouth Upper Adit	Evergreen forest	0.02
Mouth Lower Adit	Evergreen forest	0.07
Penstock	Evergreen forest	0.02
Powerhouse	Evergreen forest	0.41
New Road (11.8km in forest)	Mixed deciduous forest	11.8
Transmission Line Zone		
Transmission Line in PPA forest (5.74 km)	Evergreen forest	14.3
	Total	**49.97 ha**

(10) Ecology

Confirmed species with site survey, interview, and literature survey are categorized in accordance with Red List of International Union for Conservation of Nature (IUCN), Appendix of Conservation on International Trade in Endangered Species (CITES), and category regarding usage of animals and plants described in Law on Aquatic Animal and Wildlife, 2007 in Laos.

IUCN defines risk of extinction by scientific approach while CITES restricts international trading for protecting endangered and economically valuable species. Wildlife and Aquatic Law in Laos purports not only protection but sustainable reproduction and utilization, therefore it include "management" category for controlling utilization.

Restriction list of Wildlife and Aquatic Law is periodically revised by referring to revisions of IUCN and CITES according to an expert of terrestrial and aquatic wildlife at Faculty of Engineering Department of Civil Engineering, Environmental Engineering in University of Laos.

Table 6.7-12 IUCN Red List Category

Category		Definition
EX	Extinct	There is no reasonable doubt that the last individual has died.
EW	Extinct in Wild	It is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.
CR	Critically Endangered	It is considered to be facing an extremely high risk of extinction in the wild.
EN	Endangered	It is considered to be facing a very high risk of extinction in the wild.
VU	Vulnerable	It is considered to be facing a high risk of extinction in the wild.
NT	Near Threatened	It is close to qualifying for or is likely to qualify for a threatened category in the near future.
LC	Least Concern	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DD	Data Deficient	It is has not yet been evaluated against the criteria.

Table 6.7-13 CITES Appendices Category

Category		Definition
I	Appendix I	Appendix I lists species that are the most endangered among CITES-listed animals and plants. They are threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial, for instance for scientific research. In these exceptional cases, trade may take place provided it is authorized by the granting of both an import permit and an export permit.
II	Appendix II	Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. It also includes so-called "look-alike species", i.e. species whose specimens in trade look like those of species listed for conservation reasons. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate.
III	Appendix III	Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation. International trade in specimens of species listed in this Appendix is allowed only on presentation of the appropriate permits or certificates.

Table 6.7-14 Category in "Law on Aquatic Animal and Wildlife, 2007" in Laos

Category	Definition
I	Hunting and capture is possible with the permission from the government in the following cases; - Research and study - Breeding
II	Conventional hunting and capture is possible in limited area and season. But capture with the way impacting on the population of the target species is prohibited. Commercial hunting and capture is necessary to obtain the permission from ministry of agriculture and forest.
III	Conventional hunting and capture is possible in limited area. But capture with the way impacting on the population of the target species is prohibited. Commercial hunting and capture is necessary to obtain the permission from department of agriculture and forest in province or city.

(a) Flora

The surveys of flora were conducted in the rainy season (July 2013) and the dry season (January 2014). The location of the survey points is shown in Figure 6.7-5.

As a result of the survey, approximately 200 species were confirmed, and the seven (7) of them are listed in IUCN Red List or CITES. The list of confirmed important species is shown in Table 6.7-15.

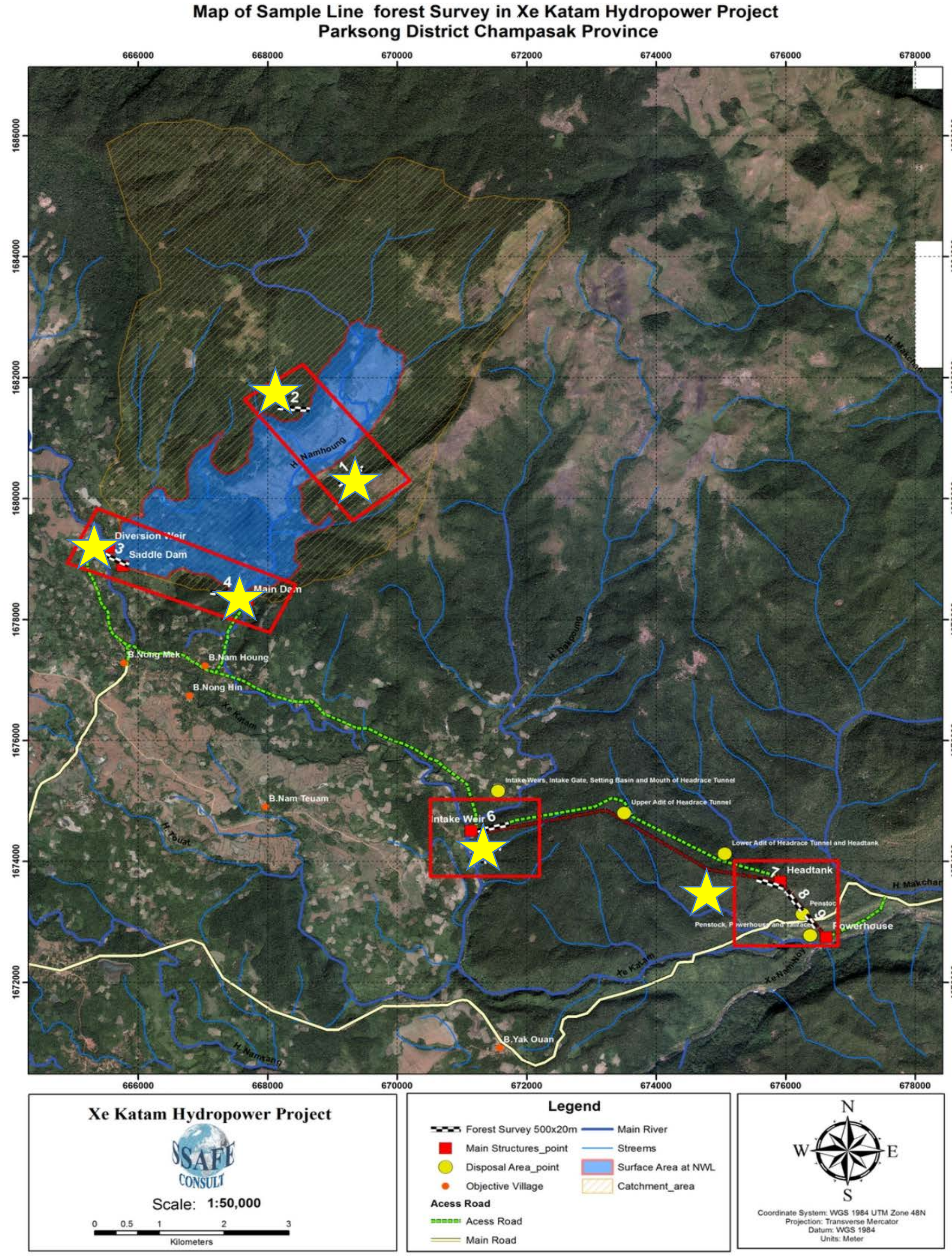


Figure 6.7-5 Location Map of Forest and Flora Survey

Table 6.7-15 List of Confirmed Important Species List

Scientific Name	Family Name	IUCN	CITES
Aglaia odorata	Meliaceae	NT	
Curcuma alismarifolia	Zingiberaceae	NT	
Dalbergia bariensis	Fabaceae	EN	
Dalbergia conshinshinensis	Fabaceae	VU	II
Dendrobium palpebrae	Orchidaceae		II
Dipterocarpus retusus	Dipterocarpaceae	VU	
Shorea thorelii Pierre ex Lanessan	Dipterocarpaceae	CR	

(b) Fauna

For identifying fauna species, interview for villagers including hunters and market survey were conducted.

From the interview, 12 species of mammals, 14 species of birds and 3 species of reptiles were confirmed in the last 5 years. One of them is Sambar (Cervidae) which is listed in IUCN Red List as VU. The list of confirmed species is shown in Table 6.7-16.

The fauna survey also observed the Nong Mek local market, which is the closest market nearby the Project area. Unfortunately, no wild animals were put on sale during that survey period. According to the interview with people at the local market, the wild animals that are commonly on sale at the market include: Muntjac, Sambar, Wild boar, Red Jungle fowl and Asiatic Brush Tailed Porcupine. JICA Study team noticed many Asiatic Brush Tailed Porcupines were kept in the freezers of the local communities and mostly guns were used to catch these animals. The local people at the market provided the information that mostly the wild animals were caught for household consumption and there were not enough for sale. The wild animals are difficult to find recently, and their populations are rapidly declining throughout the area.

In addition, kingfisher (*Alcedo atthis*) and eagles were confirmed during the flora survey.

Table 6.7-16 List of Confirmed Species in Last 5 Years (Fauna)

Lao Name	Common Name	Scientific Name	Con-firmed number of traces	Market	Laos Category	Lao Name	IUCN Red List
ກວາງ	Sambar	*Cervus unicolor, Rusa unicolor*	14	✔	I	-	VU
ເໝັ້ນ	Porcupine	*Hystrix brachyura*	13	-	II	-	LC
ນາກນ້ຳທຸກຊະນິດ	All Otters	*Lutra sp.*	13	-	I	I or II	
ລີງທຸກຊະນິດ	All macaques	*Macaca sp.*	11	-	II	II	
ຟານດົງ	Roosevelts' Muntjac	*Muntiacus rooseveltorum*	12	✔	II	-	DD
ລີງລົມທຸກຊະນິດ	All loris species	*Nycticebus sp.*	13	-	I	I	
ບ່າງລົ້ອ	Indian Giant Flying Squirrel	*Petaurista phillippensis*	9	-	I	-	LC
ເຫັງນຫາງບ້ອງ	Spotted Linsang	*Prionodon pardicolor*	5	-	I	I	LC
ອົ້ນໃຫຍ່	Large Bamboo Rat	*Rhizomys sumatrensis*	12	-	II	-	LC
ກະຮອກ	Non flying squirrel	*Sciuridae*	14	-	I	-	
ໝູປ່າ	Wild Boar	*Sus scrofa*	11	-	III	-	LC
ຫອນ	Asiatic Brush tailed Porcupine	*Atherurus macrourus*	11	✔	II	-	LC
ນົກເຕັນຊືວ	Common King Fisher	*Alcedo atthis*	12	-	II	-	LC
ນົກໄກ່ນາ	White Breasted Waterhen	*Amauromis phoenicurus*	10	-	I	-	LC
ນົກເງກາງ	Oriental Pied Hornbill	*Anthracoceros albirostris*	9	-	II	II	LC
ນົກກະທາ	Scaly-breasted Partridge	*Arborophila chloropus*	8	-	III	-	LC
ນົກເປັດນ້ຳ	Ringed teal	*Callonetta leucophrys*	10	-	I	-	LC
ນົກແຊວ	Drongo species	*Dicrurus sp.*	7	-	III	-	
ນົກຍາງນ້ອຍ	All Egrets	*Egretta sp.*	9	-	II	-	
ໄກ່ປ່າ	Red Jungle fowl	*Gallus*	14	✔	III	-	LC
ໄກ່ຂວາ	Siamese Fireback	*Lophura diardi*	14	-	I	-	LC
ນົກແກ້ວ	All Parakeets Species	*Psittacula sp.*	11	-	II	II	
ແຫລວທຸກຊະນິດ	All Changeable hawk Eagle	*Spizaetus cirrhatus*	13	-	I	II	LC
ນົກເປົ້າທຸກຊະນິດ	All green pigeons	*Theron sp.*	12	-	I	-	
ນົກເຄົ້າ	All Owls	*Tytonidae and Strigidae*	11	-	II	-	
ນົກຂີ້ຖີ່	Spot-bellied Eagle Owl	*Bubo nipalensis*	5	-	I	-	
ກະທ້າງ	Water Dragon	*Pysignathus cocincinus*	11	X	I	-	
ແລນ	Bengal Monitor	*Varanus bengalensis*	8	X	II	I	LC
ງູສີງທຸກຊະນິດ	Rat snake	*Zamenis sp.*	13	X	III	-	

(c) Aquatic Biota

The depletion of the natural fishery in all catchment areas on the Bolaven Plateau over the past 30 years is frequently recorded. Interviews with local residents indicate fishing the Xe Katam is not a key source of protein and main sources of supply are traders sourcing fish from the Mekong and the Xe Kong Rivers.

Aquatic biota surveys were conducted in the rainy season (October 2013) and in dry season (January 2014). The items of the survey are fish, benthic animals, zooplankton and phytoplankton. The survey locations are the same as the water quality survey (see Figure 6.7-2).

53 species were confirmed by interview survey. 18 of these species were identified by the field survey in the rainy season. 6 species were identified additionally in the dry season. According to expert of Department of Livestock and Forestry, Ministry of Agriculture and Forest, no species are endemic to the area, they are found elsewhere in the region.

The list of confirmed important species is show in Table 6.7-17.

Table 6.7-17 List of Important Species (Fish)

Scientific name	Lao name	Interview	Field	IUCN	CITES	Lao
Cyprinus carpio	Pa nai	✔	✔	VU		
Cirrhinus microlepis	Pa phone	✔		VU		III
Bangana behri	Pa van a nor	✔		VU		
Ompok bimaculatus	Pa siem	✔	✔	NT		
Clarias macrocephalus	Pa douk o	✔	✔	NT		
Bagarius yarrelli	Pa kae kouay	✔		NT		III
Bagarius suchus	Pa kae ngua	✔		NT		

Table 6.7-18 List of Confirmed Species (Phytoplankton, Zooplankton)

	Phylum	Class	Wet season	Dry season
Phytoplankton	Chromophyta	Diatomophyceae,	✔	✔
		Chrysophyceae		✔
		Xanthophyceae		✔
	Chlophycophyta	Euchlorophyceae	✔	✔
		Ulothricophyceae	✔	✔
	Chlorophyta	Chlorophyceae	✔	✔
		Zygophyceae		✔
	Euglenophyta	Euglenophyceae	✔	✔
	Pyrrhophyta	Dinophyceae	✔	✔
		Gymnodimium	✔	
Zooplankton	Aschelmintes	rotatoria the Protozoa	✔	✔
	Ciliophora	Peritrichia	✔	✔
		Crustaceae	✔	✔

Crustacean like crabs and prawns was confirmed. These were found more commonly at one site where the river flow was slow and shallow adjacent to rice fields.

Three (3) species of benthic organisms were confirmed present, the highest number being collected at the slow and shallow water flow site.

Zooplankton population was also higher at one site characterized by shallow and slow water flow. 2 phyla and 3 classes of zooplankton were confirmed. Phytoplankton was represented by 5 phyla and 10 classes.

6.7.2 Social Environment

(1) Community

The intake weir, headrace and powerhouse are located in Nong Thuam village and Nam Touad village. Villagers of two villages are utilizing the Project-affected river reach of the Xe Katam River. Those two villages are directly affected by the Project.

(2) Demographics

Population statistics of two affected villages are summarized in Table 6.7-19.

Table 6.7-19 Demographic Characteristics of the Affected Villages

Affected Villages	No. of HH	No. of Families	Total Population
Nong Thuam	48	48	247
Nam Touad	31	31	204
Total	**79**	**79**	**451**

(3) Living Environment

Project area is dominated by the Nyaheun ethnic group. Most of the Nyaheun villages are found on the Bolaven Plateau and are typically located between 700 and 1,000 meters amsl. Their houses are stilted wooden house or are made of jute. The typical house of Nyaheun Ethnic Group is shown in Figure 6.7-6.

Figure 6.7-6 General House of Nyaheun

(4) Education

(a) Educational Institution

Two (2) villages have primary schools, but are not complete Grade 1 to Grade 5 according to the definition standard of the Ministry of Education. The closest completed primary school and secondary school are located in Houaykong village.

(b) Enrollment Ratio

208 people (about 46%) of the 451 people living in affected villages were asked to provide

their education attainment level. The proportion of the surveyed people who have attained secondary education level was reported to be 12.0%. No one was reported to have attained higher diploma degrees.

The enrollment rate of females is lower than one of males in 5 villages around the Project site (see Figure 6.7-7).

Table 6.7-20 Education Attainment Level in the Affected Villages

Villages	Total Population	No. Surveyed	Education Attainment Level				
			No School	Primary	Secondary	Higher Diploma	College or University
Nong Thuam	247	53	20	23	10	0	0
Nam Touad	204	155	30	110	15	0	0
Total	**451**	**208**	**50**	**133**	**25**	**0**	**0**
% of Surveyed			**24.0%**	**63.9%**	**12.0%**	**0%**	**0%**

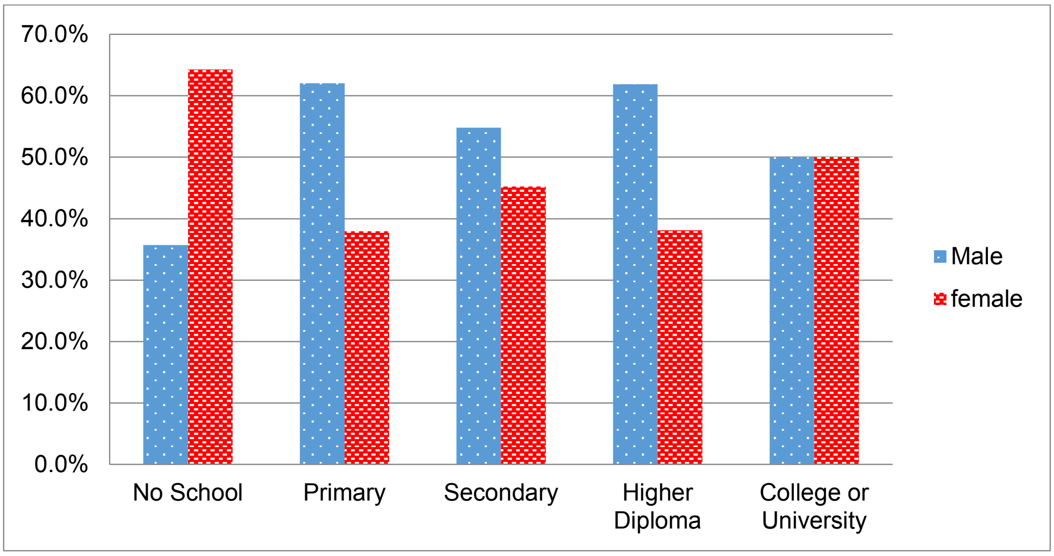


Figure 6.7-7 Enrollment Ratio among Male and Female

(5) Health

(a) Health Facilities

The major health service for the people for the living in the Project impacted area is the district hospital in Pakxong District, equipped with 25 beds and Champasak Provincial Hospital (150 beds) located in Pakse. Additionally, with the Project impacted area, one health center exists and is located at Houaykong village.

The distance between affected villages and health center in Houaykong is from 3 to 5 km, that between affected villages and Pakxong District Hospital is around 30km, and that between affected villages and Champasak Provincial Hospital is around 80km.

Table 6.7-21 Access from Affected Villages to Health Facilities

Impacted Village	Health Facilities			
	Nearest Souksala (Health Center)	Approx. Distance (km)	Nearest Hospital	Approx. Distance (km)
Nong Thuam	Houaykong	5	Pakxong District	30
Nam Touad	Houaykong	3	Pakxong District	30

When affected villagers take the disease, most of them go to the health center in Houaykong, some take over the counter medicine and the traditional treatment.

Table 6.7-22 Health Seeking Behavior of the Households

Village	Health Seeking Behavior (% of Household)			
	Traditional Healer / Traditional Medicine	Over the counter medicine / Pharmacy	Village Health Center	Hospital
Nong Thuam	12.5%	27.0%	40.1%	4.0%
Nam Touad	10.1%	18.0%	45.5%	5.5%

(b) Health Condition

The mortality in 5 villages around the Project site is lower than Champasak Province, the data of the last two years includes death under 5 years old.

Table 6.7-23 Birthrate and Mortality

Location	No. of live birth	No. of deaths	Crude birth rate (per 1000)	Crude death rate (per 1000)
Lao PDR	191,405	35,888	28.8	5.4
Champasak Province	22,940	9,150	33.7	13.5
Project impact villages	130	18	30.4	8.6

Table 6.7-24 Mortality by Age Group

Impacted Villages	Mortality (No of Persons)		
	Children under 5 years who died in the past 2 years	People aged 20-65 who have died in the past 2 years	Others
Nong Thuam	1	2	3
Nam Touad	2	1	2
Total	3	3	5

According to the data collection undertaken for the health baseline and provided by village health staff and head of village, the most common cause of infectious diseases around the Project site were diarrhea, influenza, malaria and common cold.

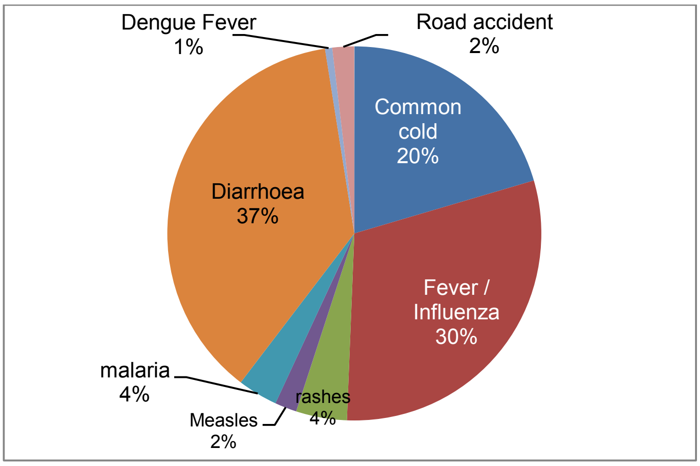


Figure 6.7-8 Most Prevalent Infectious Diseases around the Project Site

(c) Nutrient Intake

A survey was carried out to seek information on diet and nutrition of households in the Project impacted villages.

Table 6.7-25 provides a summary of the protein intakes of households in the Project impacted villages. Households who take nutrition three times a day are only 0.7% of all. In fact, 44.9% of the surveyed household indicated that they consume meat or fish at least once a week. Another 9.8% revealed that they seldom consumed meat or fish more than a week.

Table 6.7-26 provides a summary of rice sufficiency. 35.4% of the surveyed households have rice sufficient for a year. 9.7% of households in Nam Touad do not produce the rice.

Table 6.7-25 Household Protein Consumption

Village	Protein consumption (% of Household)				
	Three times a day	At least once a day	At least three times a week	At least once a week	Go more than a week without consumption
Nong Thuam	1.10%	6.60%	42.00%	39.00%	11.30%
Nam Touad	0.00%	5.50%	33.00%	54.00%	7.50%
Average	0.67%	6.17%	38.47%	44.89%	9.81%

Table 6.7-26 Rice Sufficiency of Households

Villages name	Rice sufficiency (No. of HH)				
	Sufficient for a year	Sufficient for 9 months	sufficient for 6 months	Sufficient for 3 months	No rice production
Nong Thuam	37.50%	25.00%	29.17%	8.33%	0.00%
Nam Touad	32.26%	38.71%	0.00%	19.35%	9.68%
Average	35.44%	30.37%	17.72%	12.65%	3.79%

(6) Poverty

The definition of poverty in Decree 201/PM2012 for the Standard of Poverty and Development is shown below;

> *"Poverty is the deprivation of basic needs for the daily livelihood such as shortage of food that cannot provide the energy of 2100 Kcal/day/person, deprivation of clothes, durable shelter, inability to afford for the health care in case of sickness, inability to afford for the elementary education, inability to access to public services"*

Grouping of household level is defined by the GOL Technical Guidelines for Compensation and Resettlement 2010. Other group livelihood standards classifications are those used in EIA reports approved by MONRE described using the key indicator income sources in the local economy. In Pakxong District these are coffee and rice. The household classified to the poverty are comprised to Vulnerable Income Group. In the affected villages, 6 households were classified to Vulnerable Income Group.

Table 6.7-27 Household Livelihood Classification

Household Livelihood Status	Definition
Well Off Income Groups	Households with primary income sources mainly trading and services sector and some farming. Adequate income for basic household needs, education and finance and other resources for conducting business operations.
Sufficient Income Groups	Adequate income from coffee and/or rice production yields and other economic activities to provide adequate nutrition and other basic necessities 12 months a year and meet basic education and health expenses.
Insufficient Income Groups	Inadequate income from coffee and/or rice production yields and other economic activities to provide adequate nutrition and other basic necessities 12 months a year and meet basic education and health expenses.
Vulnerable Income Groups	• Households with persons falling within the definition of Poverty in Decree 201/ PM (April 2012) for the Standard of Poverty and Development • Households defined as vulnerable by Decree 192 /PM 2013. • Are landless for food production and shelter; • Divorced or widowed female headed households with dependents and low income; • Households with disabled or invalid persons; and • Elderly households with no means of support.

Table 6.7-28 Poverty of Households

Villages name	Total of HH	Poverty HH			
		Well-off	Sufficient	Insufficient	Vulnerable
Nong Thuam	48	32	7	7	2
Nam Touad	31	10	16	1	4
Total	**79**	**42**	**23**	**8**	**6**

(7) Ethnic Group

(a) Outlook of Ethnicity in Lao P.D.R

Lao PDR is a culturally diverse country with a recorded 49 ethnic groups that have been divided into four main linguistic groups as indicated in Table 6.7-29. Specialists and experts have classified up to 132 sub-groups within these four broad categories and 49 main groups. The National Assembly has ratified this classification in the Agreement No. 213/NA dated 24 November 2008.

Table 6.7-29 Ethnic Group in Lao P.D.R

Group	Number of Sub-group	Characteristic
Lao-Tai	8	Lao-Tai (sometimes also referred to as Tai-Kadai), includes the ethnic groups which form the majority of the Lao population including Lao-Tai, Tai-Dam, Tai Deng, Tai Lue, and Tai Phuan. These groups reside primarily in the lowland regions of the country and for the most part cultivate paddy, practice Buddhism and are highly integrated into the national economy. These group represent approximately 60% of the population.
Mon-Khmer	32	Mon-Khmer groups dominating the middle hills that for the most part practice swidden agriculture (shifting cultivation) are reliant on forest products and to some extent are isolated from the dominant lowland culture. Many groups, however, exhibit varying degrees of assimilation and adaptation to Tai-Lao culture. These groups: Khmu, Katu, Makong, Katang, Yuroo/Laven, Lavae, Xouay, Lamet, Brou, Salang, Atel and many smaller groups are the original inhabitants of South-East Asia and consist of the Austro-Asiatic or Mon-Khmer ethnic groups approximately 25% of the population.
Hmong-Iumien	7	Hmong-Iumien Groups, including the Hmong and Yao, are also referred to as highland Lao since they tend to inhabit remote, steep, highland areas in northern and central part Lao PDR. Similar to the Mon-Khmer groups they practice swidden agriculture and largely subsistent communities. In terms of the history of Lao PDR, these groups are relatively recent arrival from Southern China comprise about 10% of population.
Sino-Tibetan/ Hmong-Mien	2	Sino-Tibetan groups, like Hmong-Iumien groups, live in highland areas in the northern region of the country. These groups, Akha, Singsily, Lahu, Lisu, and Phou Noi among others, are also relatively recent arrivals from Southern China and comprise about 5% of population.

Source : National Assembly Ratification

(b) Governmental Policy on Ethnics

The 1991 Constitution defined Lao PDR as a Multi-Ethnic State with "Equality among all ethnic groups" as described under Article 8 and Article 22.

The Lao government's policy regarding indigenous people[2] is linked to efforts for poverty alleviation and the elimination of unsustainable shifting cultivation. This is manifested in a number of ways; relocation of more isolated groups in the highlands to lowland areas near existing infrastructure and services, village consolidation of smaller unit, increased

2 The term "indigenous people" was used in documents of World Bank group, Asian Development and other international organization, but Lao Government encourages to uses "ethnic people" instead..

urbanization and migration to cities from the surrounding countryside, increased mobility of populations and increased interaction between ethnic groups including intermarriages, and increased self-identification with the mainstream Lao culture.

On the other hand, the policy to respect ethnic culture is specified. In Land Law, 1997 and Forestry Law, 2007, the ownership of the traditional land use and forest products in highlanders ethnic is admitted.

(c) Ethnic Composition in Affected Villages

Only Nyaheun belonging to Mon-Khmer groups and Laven (Yuroo) inhabit around the Project area. All of inhabitants in affected villages, Nong Thuam and Nam Touad are Nyaheun. But 866 of total 1460 villagers in Houaykong, which is relatively large and close to the Project area are Laven (Others are Nyaheun and Lao).

Table 6.7-30 Ethnicity Composition in Affected Villages

	Nyaheun		Laven		Total	
	Household	Population	Household	Population	Household	Population
Nong Thuam	48	247	0	0	48	247
Nam Touad	31	204	0	0	31	204
Total	79	451	0	0	79	451

(d) Characteristic of the Ethnic People

The Nyaheun live in small scattered villages in Champasak, Attapeu and Sekong Provinces, with a small concentration of villages on the southern and eastern part of the Bolaven Plateau around Pakxong District in Champasak Province. Due to their small number and small villages in forested areas, the Nyaheun is little known to outsiders. The Nyaheun people are one of the smaller ethnic groups in southern Laos with a population of a little over 5,000. The Nyaheun have their own distinct dialect, classified among the Bahnaric branch of the Mon-Khmer language groups. But also in the Nyaheun are bilingual, speaking the Lao language for generations beside their mother tongue.

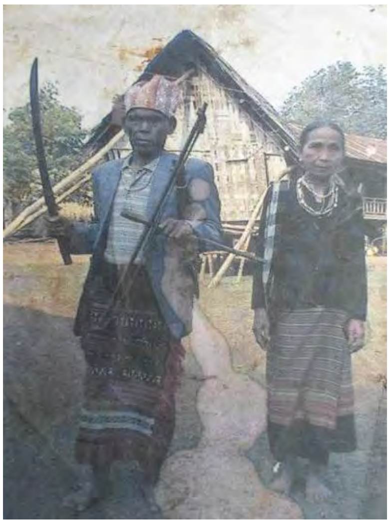


Figure 6.7-9
Traditional Nyaheun Clothing

It is noted that they were once semi-nomadic people who settled in permanent villages at the beginning of the twentieth century. Traces of a semi-nomadic lifestyle are still visible as shown in the very rudimentary way their huts are constructed. They often build their dwellings or shelters for temporary use, and move to another location whenever more fertile land is available or to earn some cash as laborers.

The Nyaheun were agriculturists of forested upland areas, using the slash-and-burn cultivation method to establish their swiddens. There they grew dry rice, maize, sweet potatoes, millet and a variety of vegetables and fruits. In recent years, however, the Nyaheun have produced the wet rice. The Nyaheun living around the Project site has been settled and made a livelihood in farming at present.

The border of their residing area is mostly neighboring to Laven's territory. Nyaheun villages are for the most part autonomous and independent of one another. The Nyaheun live in nuclear family units; they have no clan system. Nyaheun society has a matriarchal tendency.

The Nyaheun believe in a large pantheon of spirits associated with the natural surroundings of their habitat, such as rivers, forest, trees, stones, sky, soil and many more. There are spirits who can influence the crops and some can cause illness or other misfortune. Sacrifices of buffaloes, pigs and chicken can appease these malevolent spirits. Shaman, called *muan,* organizes a healing ceremony.

World Bank OP 4.10 defines "indigenous people" for those groups which have below characteristics.

a. Self-identification as members of a distinct indigenous cultural group and recognition of their identify by others,

b. Collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories,

c. Customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture, and

d. An indigenous language, often different from the official language of the country or region.

Table 6.7-31 shows the comparison of Nyaheun characteristics in terms of the "indigenous people" in OP 4.10 of World Bank.

Table 6.7-31 Identification of Ethnic People

Criteria	Nyaheun
a. Self-identification as an indigenous group.	Yes: They are Lao citizens under Article 8 of Constitution and ethnicity is retained on official identification card and village location in Laos.
b. Collective attachment to land	Yes: They historically live in limited area; South – east Bolaven Plateau region and close to Vietnam border (total about 5000 families).
c. Customary, cultural, and economic and political institutions.	Yes: They have their own cultural customs at village and village group levels. But the village organization institutions same as rest of Laos. There is no distinct political institution – under Lao Laws.
d. An indigenous language (different from official language of region)	Yes: They speak Mon-Khmer language which is different from the official language – Lao. Own language spoken at family and community level only.

(8) Religion

Within the Project Area two main belief systems co-exist, and often within one village; animism and Buddhism. The affected villages are mainly animist.

Table 6.7-32 Religion in Affected Villages

Affected Villages	Total No. HH	Buddhism	Animism
Nong Thuam	48	Yes	Yes
Nam Touad	31	No	Yes

(9) Village Organization

The village level organization is structured and functions as follows. These organizations are common regardless of the ethnicity in Laos.

Table 6.7-33 Village Organization

Position	Role
Village Headmen (*Nay Ban*)	- To keep all formal relations with district authorities and with other villages - To collect taxes, appoint other officials in the village, judge disputes - To implement of law and order - To manage all activities in the village
Deputy Head of Village (*Hong Nay Ban*)	- To supervise and ensure that all village activities follow the policies and guidelines of the Lao People Revolutionary Part
Village Representative (*Kam Ma Kan Ban*)	- To assist the village headman in decision making and in carrying out his work in the village
Youth Organisation (*Sao Num*)	- To be responsible for youth affairs and activities, relating to protection and construction of village, including recruiting youth for village militia
Village Militia (*Kong Lon*)	- To be responsible for patrolling the area around the village and for public security at meetings and ceremonies.
Village Women's Union (VWU - *Sahaphan Mereying Ban*)	- To be the only official organization in which women play a direct role to address the women's concerns and to protect the benefits of village women. The activities of the Lao Women's Union cover a number of activities
Village Development Front (*Niaw Hom*)	- To be mainly responsible for organizing large communal projects and ensuring government policy is carried out and taken action at the village level. Members of this organization mainly are former members of village committee, village elders, retired officials, etc.

(10) Socio-Economic

The main industry in the Project area is agriculture. Villagers make mainly a living from agriculture. Some of them obtain an income from daily employee, state employee, merchants, livestock, the wood products and fishery. Amount of income from the agriculture is most. Nam Touad village has the low income, 9.1 million kip/year/household.

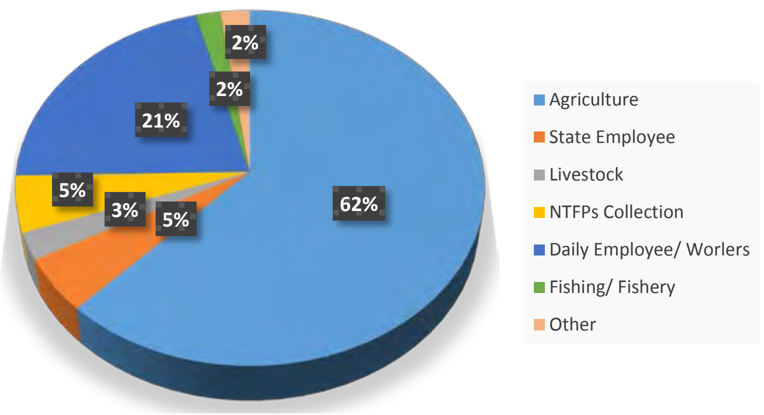


Figure 6.7-10 Sources of Incomes for Affected Villages

Table 6.7-34 Income in Each Village and Industry

Unit: million kip

Village	Nong Thuam	Nam Touad	Average
HH	48	31	39.5
Population	247	204	225.5
Agriculture	720	155	437.5
State Employee	0	70	35
Livestock	20	15	17.5
NTFPs Collection	72	0	36
Daily Employee/ Workers	300	0	150
Business Service	0	0	0
Fishing/ Fishery	14	12	13
Handicraft/ Small Scale Industry	0	0	0
Other	0	31	15.5

Table 6.7-35 Income Condition in Each Household

Unit: million kip

Village	HH	Population	Total Income	Income / HH	Income / PP	Income / pp / Month
Nong Thuam	48	247	1,126	23.4	4.6	0.4
Nam Touad	31	204	282	9.1	1.4	0.1
Average	39.5	225.5	704	16.25	3.0	0.25

(11) Infrastructure

(a) Transportation

National Road 16A, running from Pakse to Attapeu through Pakxong and Hating, provides main trunk road access for the Project impact area. National Road 16A connected from Pakse to Attune runs on the south of the Project area. This road connects to the villages in the Project area, but it is not paved and has delays in the development of the bridge. In addition, construction of the road by development companies is in progress around the Project area.

(b) Drinking Water

Villagers in the Project area use the water of the rivers, streams and wells as a drinking water and daily life water. There are wells at only Nong Thuam village.

Table 6.7-36 Main Water Supply of Affected Villages

Impacted Villages	Water supply	Water Well	Tube Well	Rivers
Nong Thuam	0	0	2	1
Nam Touad	0	0	0	1
Total	**0**	**0**	**2**	**2**

(c) River use in the Water Reduction Area

The river use was surveyed from intake weir to powerhouse which is a river recession area. As the result of survey, villagers of Nong Thuam use the river water for river-bank farming during dry season. Villagers of Nong Thuam and Nam Touad do fishing.

Table 6.7-37 Result of River Use in the Water Reduction Area

Description	Nong Thuam	Nam Touad
Total Household (HH)	48	31
Household Sample	20 (42%)	10 (32%)
No Persons/Household	6.7	6.9
No HH use XKT for Drinking/Washing (use for gardens near river only)	6	0
HH Fishing frequency Times/Week	2.75	3.4
HH Fishing frequency Times/Month	11.10	13.6
Main Fishing Equipment		
- Hook	30%	10.6%
- Fishing Net	30%	47.4%
- Trawl Net	23.6%	42.0%
- Others	16%	0%
Number of Fish Species	9	3
Main Species/		
Grinocheilus sp	17%	9%
ByPoroputius sp	32.5%	45.5%
Lobochelios sp	19.1%	45.5%
Average fish catch kg/time	2.13	0.67
Average fish catch value/kg	20,000 kip	20,000 kip
Average fish incomes/HH/time	42,500 kip	17,400 kip
Average fish incomes/HH/year	5,661,000 kip	2,839,680 kip
2013 Average HH Total Income/year	23.4 MM Kip	9.1 MM kip
Fish catch % of Total Income	26%	31%

(d) Electricity Supply

Distribution lines have been extended to affected villages in 2013 to 2014. However, no household connects to the electricity grid. Villagers cook with wood.

As electric power is ready for affected people if they put up the electric wires, the Project is considered not to disturb their self-efforts such as installation of pico hydropower for electricity supply regardless of the Project.

Table 6.7-38 Electricity Coverage

Impacted Villages	Total No. of HH	No. HH with Electricity	% of HH with electricity
Nong Thuam	48	0	0%
Nam Touad	31	0	0%
Total	**79**	**0**	**0%**

(12) Cultural Heritage

(a) World Heritage

There are two world heritages in Laos, town of Luand Prabang, Vat Phou and Associated Settlements within the Champasak Cultural Landscape. These are apart from the Project area.

(b) Sacred Place/ Graveyard

Since most of villagers have a faith of animism, temples were not found in the Project area. On the other hand, there are places used for celebrations, cultural sacred places and graveyard of Nyaheun around the Project site. Most of graveyards are covered by trees and outsiders are prohibited to enter into. Confirmed sacred places and graveyards are shown in Table 6.7-39 and Figure 6.7-11.

Table 6.7-39 Sacred Places and Graveyards of Nyaheun found in Affected Villages

Cultural Asset	Explanations	UTM Coordinates (Zone 48)
Phou Dok Don	Sacred mountain which villagers believe an owner of forest is residing. People who wants to harvest in the mountain shall pray to the spirit,	
Tham Phi Pop	Phi Pop cave where a spirit is residing.	
Lak Ban	There are 4 poles at the accessing points to the village for preventing evil spirit from entering into the village.	
Village Spirit Hut (Ho Phi Ban)	Villagers make offerings to the hut at Lao New Year and certain occasions of the year.	X= 668,209.27 Y= 1,674,856.42
Cemetery 1	It is called Pa Sa Nong Yeung.	X=668,302.74 Y=1,674,945.23
Cemetery 2	It is called Pa Sa Nong Pad. Cemetery for accidental death.	X=668.956.76 Y=1,674,422.34
Cemetery 3	It is called Pa Sa Nong Sa Phad, old cemetery.	X=669,299.59 Y=1,674,187.59
Cemetery 4	It is called Pa Sa Nong Aenr. A coffee plantation company disturbed the cemetery. This is for Nong Thuam and Nong Hin villages.	X=667,539.63 Y=1,675,589.07

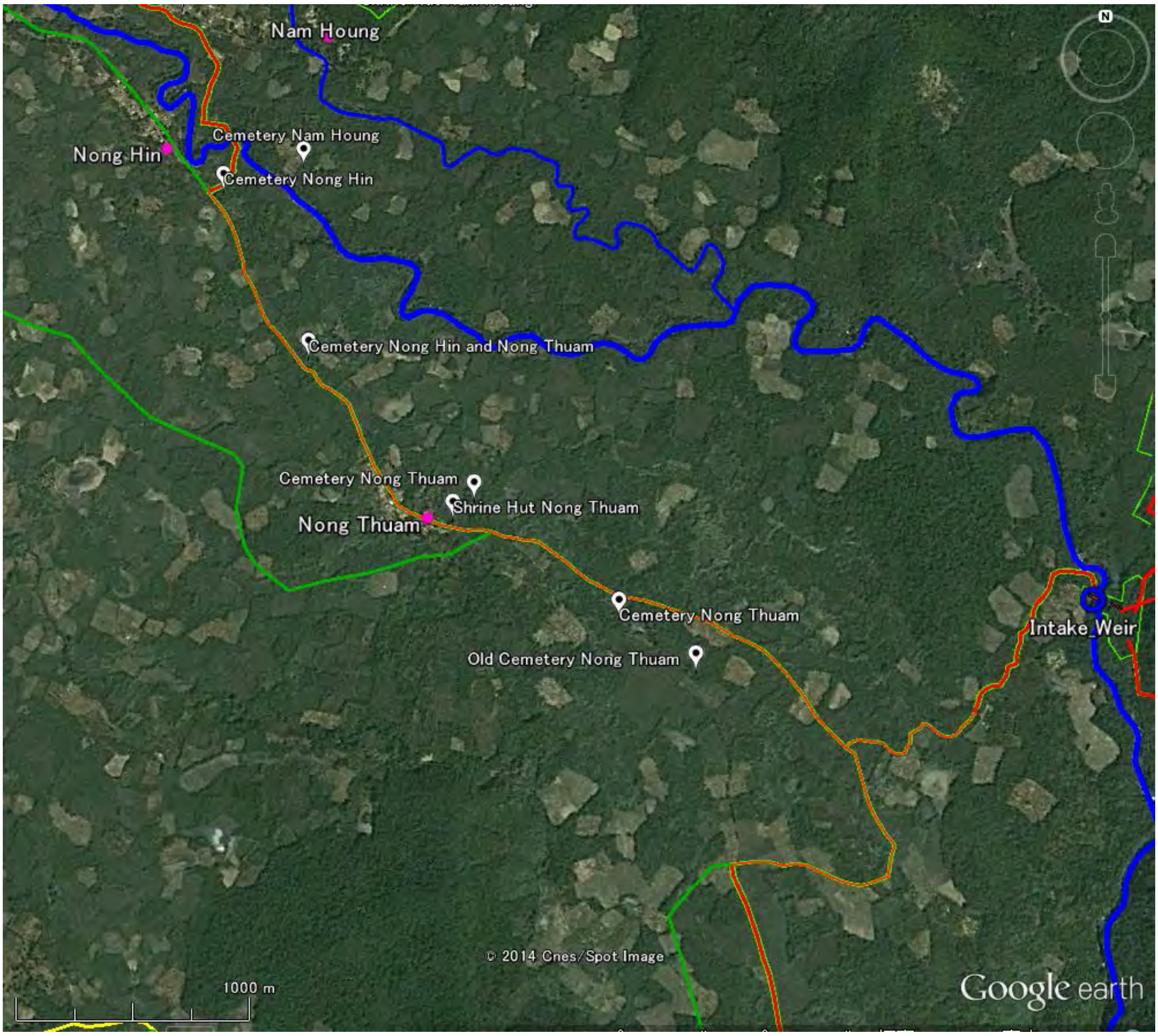


Figure 6.7-11 Location Map of Sacred Places and Graveyards

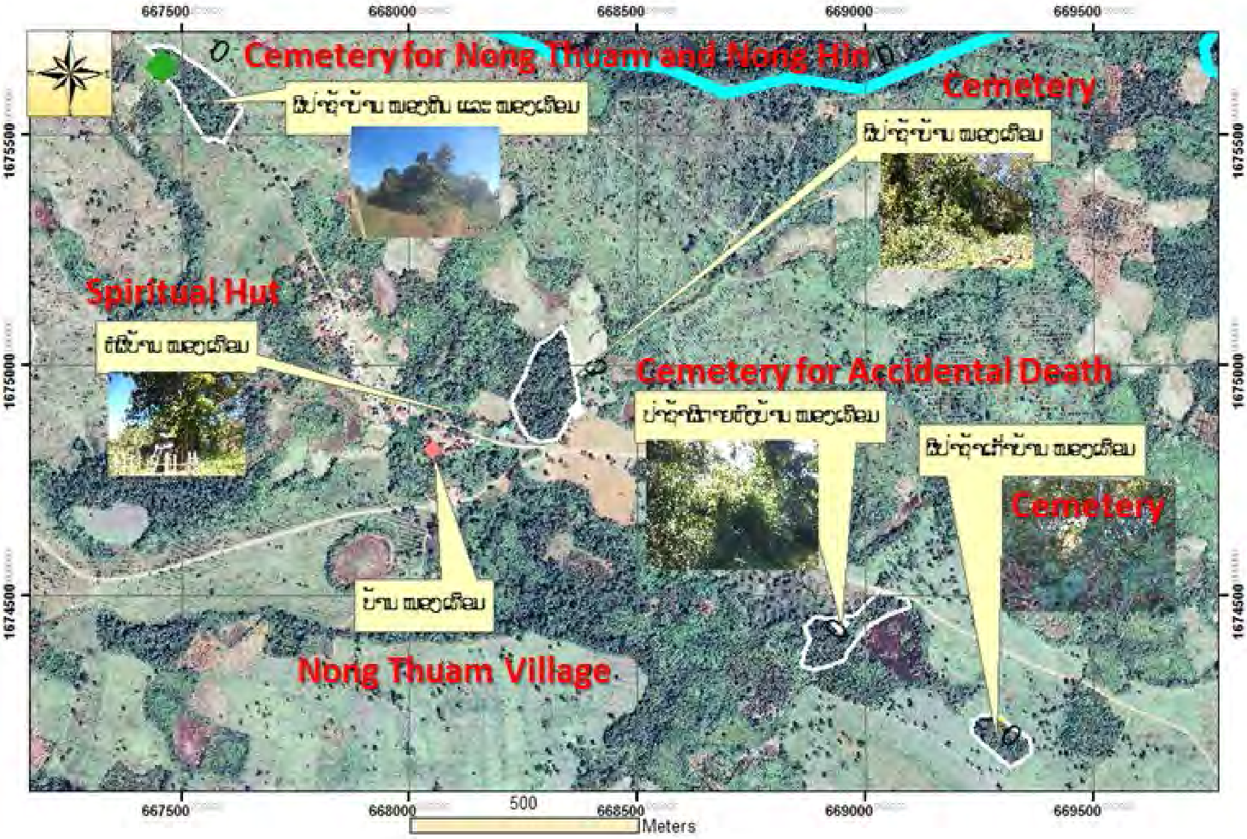


Figure 6.7-12 Detailed Map of Graveyards

Figure 6.7-13 Graveyard of Nyaheun

(13) Landscape

The Xe Katam Fall is a tourism resource. It is located at the upstream of powerhouse. Its landscape is expected to be affected by the reduction of water volume especially in dry season.

Figure 6.7-14 Xe Katam Fall

(14) Tourism

Champasak Province is one of tourism destinations of the top 3 in Laos because of abundant natural and cultural attractions. It had approximately 300,000 tourists in 2010 out of which 245,000 were foreign tourists. Tourists have increased year by year.

In Pakxong District, there are famous tourist destinations such as Tham Khoulap pan Pi Kilivongkol (cave 1,000 years ago), Tad Fane (waterfall), Tad Nuang (waterfall) and 7 stage waterfall of Touay Gnai River. However, these are apart from the Project area (see Figure 6.7-15).

On the other hand, the Project area contains many waterfall such as the Xe Katam Fall and diverse area. Income may be able to arise from tourism of eco-tour such as trekking in the future.

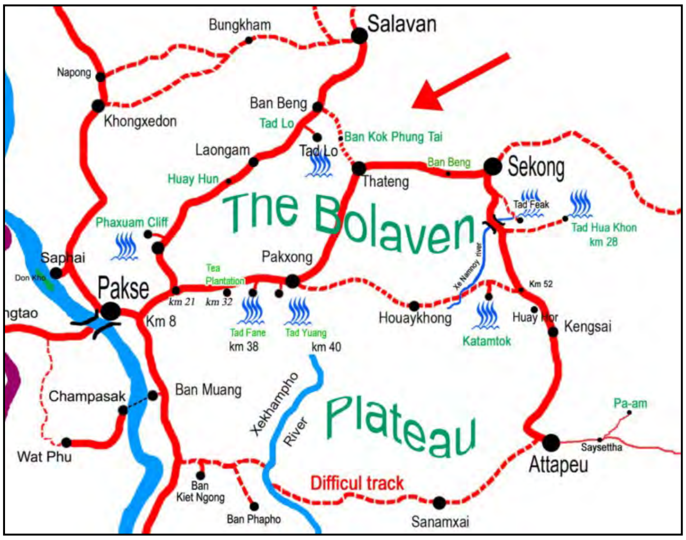


Figure 6.7-15 Main Tourist Destinations in Pakxong District

(15) Unexploded Ordnance

Between 1964 and 1973, cluster bomb or other bombs were dropped onto Laos. It was estimated by the Lao National Unexploded Ordnance Programme that approximately 25% of villages in Laos are contaminated with Unexploded Ordnance (UXO). The Lao National Unexploded Ordnance Programme also estimated that about 80 million UXO remained in Laos (UXO Lao, 2010).

In Champasak Province, where the Xe Katam Hydropower Project is located, UXO contamination can be found most heavily in the northern to north-eastern part of Champasak Province. Pakxong District is also slightly contaminated by unexploded ordnance. In the Project area, there is potential contamination. However, the contamination level is low compared to other part of Lao PDR and Champasak Province. Nonetheless, care must be given during site preparation, access road construction and installation of transmission line towers.

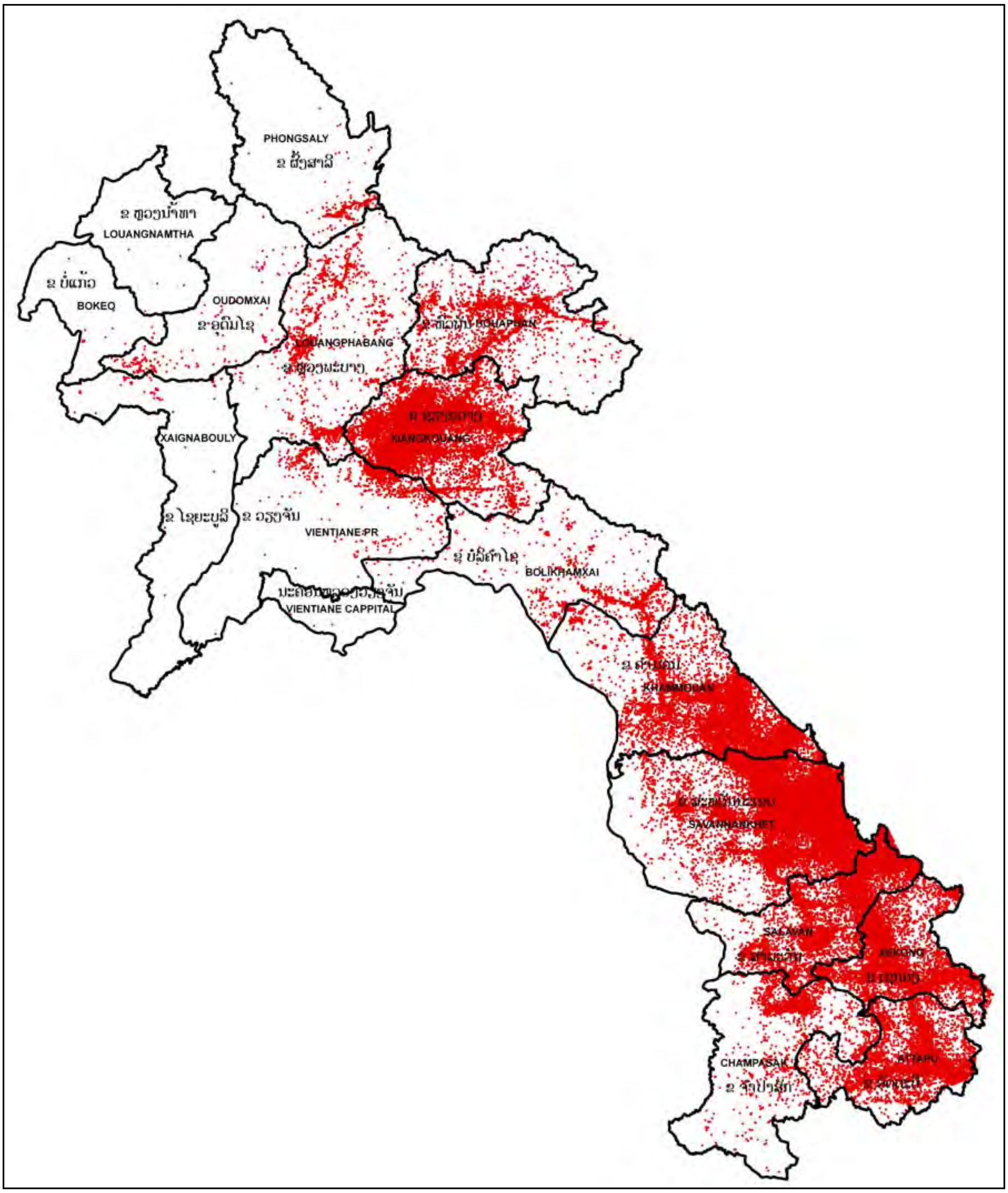


Figure 6.7-16 Unexploded ordinances in Lao PDR

6.7.3 Socio-Economic Condition in Transmission Line

Transmission line between the Xe Katam switchyard and EDL's Pakxong sub station is 45km length and passes 15 villages. Socio-economic condition of these 15 villages is shown hereinafter;

Table 6.7-40 Affected Villages in Transmission Line

No.	Village	No.	Village
1	Nam Touad	9	Nong Kin
2	Nong Tuang	10	Chan Sa vang
3	Nong Thuam	11	Km15
4	Lasasin	12	Km 12
5	Houaykong	13	Km 11
6	Nam Tang	14	Nong Chan
7	Nong Keuang Yai	15	Bangliang
8	Nam Pod		

(1) Demography and Ethnic Composition

There is a population of over 10,000 persons present representing 5 ethnic groups living in 1,347 households.

Table 6.7-41 Ethnicity at Transmission Line Affected Villages

Ethnic group	Population	Households	Families
Laven (Yuroo)	6,688	835	1235
Nyaheun	2,528	378	383
Ta oy	813	130	135
Keumeu	10	3	3
La Vea	5	1	1
Total	10,044	1,347	1,757

(2) Land Use

The right of way (ROW) for transmission line is 25m width. Table 6.7-42 shows land use in the ROW.

Land use cover estimates were obtained for 8 villages covering 14,982 hectares.

The main land uses are Xe Katam Provincial Protected Forest and agricultural lands being developed for coffee plantations and rice field. Apart from hydropower, development of bauxite ore resource deposits is in the planning and approval process phases.

Table 6.7-42 Land Use in ROW of Transmission Line

Land cover type	Area (ha)
Forest	8,697
Fruit trees (mainly coffee)	841
Up land rice (swidden framing)	285
Paddy rice field	228
Company coffee plantation	1017
Household garden plats	4,004
Total	14,928

Most of forest areas are extensively used for slash and burn agriculture for production of rice and corn, timber trees for villages housing, collection of non-timber forest products and development of coffee gardens.

(3) Hearth Condition

Health conditions are unsatisfactory. In the past 2 years most households have experienced cases of malaria, diarrhea and influenza. 706 households (around-30%) have pit toilets. Water supply is mainly from wells but must be boiled before consumption. 30% of surveyed households access tube wells, 3% use dug wells, and others use local streams. Villagers purchase medical products at pharmacy in Houaykong.

(4) Infrastructure

- Electricity from the national gird is connected to 1104 households in 8 villages.
- Primary schools are in 13 villages and lower secondary schools in 3 villages.
- A public bus provides a transport service on the unsealed all weather road between Houaykong and Pakxong.
- Houaykong village is the main commercial center on the transmission line route with many service shops and small goods stores. 10 villages have small shops selling basic goods.

6.7.4 Socio-Economic Condition in Downstream of the Project Area

After passing the powerhouse of the Project the Xe Namnoy River flows toward northwest direction for about 13 km through steep mountain forest covered terrain, then 15 km across flat alluvial terrain to join the Xe Kong River. The large Xe Kong River flows from its junction with the Xe Namnoy River for a distance of about 150 km toward south west direction to join the Mekong River in the Cambodian territory.

As dam type design of the Project cause change of hydrology of the Xe Namnoy River due to annual regulation of the dam, socio-economic conditions of the downstream villages (Bengphoukham, Meuanhuameuang and Nam Hieng villages, all belong to the Attapeu Province) were surveyed. Because of the design change from dam type to run-of-river type and thus annual river flow will not be changed, the Project will cause no impact on those villages.

(1) Demography and Ethnic Composition

The population of the 3 villages in 2010 was 1.880 persons in 6 ethnic groups. The largest group are Harak (803 persons) followed by Triang (463 persons).

Table 6.7-43 Demographics of Downstream Villages

Village	Ethnic Group	No. of Household	No. of Family	Population	Female
Meuanhuameuang	Nyaheun	75	75	362	207
	Triang	58	63	398	148
	Lao	13	13	83	49
Subtotal		*246*	*151*	*843*	*404*
Beng Khoukham (Khounkham)	Triang	10	10	65	34
	Lao	18	18	154	80
	Harak	84	102	397	198
Subtotal		*112*	*130*	*616*	*312*
Nam Hieng	Oy	1	1	4	2
	Laven	-	-	2	-
	Lao	2	2	9	5
	Harak	60	85	406	202
Subtotal		*63*	*85*	*421*	*209*
Total		**319**	**369**	**1880**	**925**

(2) Enrollment Rate

Enrollment rate are very low standard, especially in Nam Hieng village (7.13%) due to lack teachers and education materials. Most children, however, are currently attending school or have some education in spite of available GOL data.

Table 6.7-44 Enrollment Rate at Downstream Villages (in 2010)

Village	Literacy	Primary school	Lower secondary school	Upper secondary school	College/ University
Meuanhuameuang	34.99%	1.78%	0.71%	0.12%	0.00%
Beng Khoukham	30.03%	30.68%	0.65%	0.65%	0.32%
Nam Hieng	7.13%	NA	NA	1.43%	0.00%

NA: information not available

(3) Socio-Economic

(a) Agriculture

Only subsistence farming agriculture is practiced for rice and other food crop production. Self-sufficiency in rice production for 88 families in Nam Hieng village is shown in the table below (only available data).

Table 6.7-45 Self-Sufficiency at Nam Hieng Village

Villages name	Rice sufficiency (No. of Family)				
	Sufficient for a year	Sufficient for 9 months	sufficient for 6 months	Sufficient for 3 months	No rice production
Nam Hieng	11.36%	57.95%	22.73%	7.95%	0.00%

(b) Fishery

Little households are engaged in fishery for income source. Fishery for self consumption is also not active. Villagers are only engaged in fishing in the Xe Namnoy River when there is a shortage of household protein supply from other sources, and daily catches are small. Most fishes for diet are purchased in local markets from traders who source fishes from the Mekong River and aquaculture ponds in Vietnam and Thailand.

(c) Collecting of NTFP and Hunting

Collection and hunting for non-timber forest products is a common activity practiced by most households. Forest plants are an important supplementary nutrition source and for traditional medicines for common health problems. Hunting for wild mammals, birds and reptiles for household consumption and sometimes for sales is also undertaken.

(d) Income Source

Household income statistics are not available for the 3 villages. Recent household survey data of indicative household incomes in nearby area is available for Xe Namnoy village where is located within 8 km from those villages.
About 70 % of families sources income from NTFP and only 2 % (1 family) sources from fishing.

Table 6.7-46 Income Resource at Xe Namnoy Village

Income from	# Families	% of total Family	Total income	% of total Income
Small animals raising	4	8.33%	1,488,000	0.28%
Fish catch	1	2.08%	300,000	0.06%
Income Timber and NTFP new village	34	70.83%	400,000	0.08%
Income Timber and NTFP old village	6	12.50%	9,242,000	1.76%
Crop production	34	70.83%	305,660,000	58.23%
Tree production	3	6.25%	2,760,000	0.53%
Other sources of income	34	2.08%	205,052,000	39.06%
Total Families' income (LAK)	41	85.42%	524,902,000	100.00%

Source: Xe Pian – Xe Namnoy Project studies 2012-2013

Table 6.7-47 Income Resource From Agriculture at Xe Namnoy Village

Activity	# Families	% of total Families	Total other income	% of total other income
Business	1	2.1%	4,000,000	2.0%
Loans	1	2.1%	0	0.0%
Handicraft	1	2.1%	1,500,000	0.7%
Rent	0	0.0%	0	0.0%
Remittance	1	2.1%	2,040,000	1.0%
Salary	8	16.7%	73,320,000	35.8%
Labour	27	56.3%	106,642,000	52.0%
Incurred loans	7	14.6%	9,750,000	4.8%
Other	1	2.1%	7,800,000	3.8%
Total other income by Families	34	70.8%	205,052,000	100.0%

Source: Xe Pian – Xe Namnoy Project studies 2012-2013

6.7.5 Greenhouse Gas Emission

Greenhouse gas (GHG) emission is evaluated by utilizing the JICA Climate Finance Impact Tool (JICA Climate-FIT Ver. 2.0). Assuming combined margin of grid-connected coefficient be 0.5450 t-CO_2/MWh and expected annual generation, reduction of GHG is computed as 161,360 t-CO_2/year by the Project.

6.8 Environmental Impact Assessment

6.8.1 Setting of the Environmental Impact Assessment Area

Based on the result of environmental and social consideration survey, impact on the natural and social environment by construction and operation of the Project is assessed and mitigation measures are studied. Following the characteristics of impacts, the assessment is made to two (2) zones of the Project area.

Zone 1: Area affected by the construction and operation of intake weir, powerhouse and access roads.
Zone 2: Area affected by the construction and operation of the transmission line.

Affected village of each zone is summarized in Table 6.8-1.

Construction area is in Nong Thuam and Nam Touad villages and those villages are affected by access road, change of surrounding environment of which land will be altered by construction of roads and spoil area, and change of river flow regime passing through those villages. Mitigation measures are therefore studied for Nong Thuam and Nam Touad villages as affected villages.

Table 6.8-1 Affected Villages and People for Each Zone

Zone	Affected People and Villages
1	2 villages: Nong Thuam, Nam Touad
2	15 villages (2 villages out of 15 is duplicated with Zone 1)

6.8.2 Environmental Impact Assessment

Assessment of environmental and social impact is made for concerning items based on Appendix 5 of JICA Guideline for each Zone during construction period and operation period. The evaluation of impact is presented in Table 6.8-2 (for Zone 1) and Table 6.8-3 (for Zone 2).

Table 6.8-2 EIA (Zone 1)

Environmental Item		Duration	Evaluation		Evaluation Reason
			Scoping	After Study	
Pollution Control					
1	Air pollution	During construction	B-	B-	There is no air pollution at present, but air quality will be deteriorated by construction machines and construction vehicles.
		Operation	C-	B-	Air quality will be deteriorated by increased traffic due to development of the roads, and by operation of emergency generator (diesel generator).
2	Water quality	During construction	A-	A-	River work will cause water pollution.
				B-	Accidental spill of fuel, lubricant oil or chemicals will cause water pollution.
		Operation	B-	B-	Oil spill by breakdown of turbine or generator will cause water pollution.
				B-	Domestic waste water from the power plant will cause water pollution.
3	Waste	During construction	B-	B-	Waste soil and waste material by construction work will arise.
		Operation	C-	B-	Waste lubricant and domestic waste from power plant operator will arise.
4	Soil pollution	During construction	B-	B-	Accidental spill of fuel, lubricant oil or chemicals will cause soil pollution.
		Operation	C-	B-	Oil spills due to breakdown of outdoor machines such will cause soil pollution.
5	Noise and vibration	During construction	B-	B-	Construction activities will cause noise and vibration.
		Operation	B-	D	Traffic will increase due to development of the roads, but the impact is limited.
6	Land subsidence	During construction/ Operation	D	D	Works that cause land subsidence is not expected.
7	Odor	During construction	D	B-	Spill of toxic substance will cause odor.
		Operation	D	D	Works that cause odor is not expected.
8	Bottom sediment	During construction	B-	B-	River works and domestic waste water from construction camp will cause bottom sediment pollution.
		Operation	C-	B-	If large amount of organic matters is contained in deposit at the intake weir, mud may accumulate on the bottom.
Natural Environment					
9	Protected area	During construction/ Operation	C-	B-	As headrace tunnel, head tank, penstock and access roads are located in the Provincial Protected Forest, deforestation will cause impact.
10	Ecosystem	During construction	B-	B-	Construction work is expected to disturb the ecosystem.
				B-	Construction-related noise and increased human activity will possibly result in temporary displacement of disturbance-sensitive fauna.
				B-	Change of the river passage will impact on aquatic biota.
		Operation	A-	A-	Decrease of river flow due to power generation operation will impact on the river ecosystem.
				B-	Intake weir will block migratory fish.
				B-	Increase of human activity by development of roads and hunting will impact on wildlife.
				B-	Cumulative impact may occur due to act of development induced by road construction.
11	Hydrology	During construction	B-	B-	Construction of intake weir will cause change of river flow regime.
		Operation	A-	A-	The river flow will reduce from the intake weir to the powerhouse by operation.
12	Topography and geology	During construction/ Operation	B-	B-	Excavation and slope cut work will cause change in terrain and landslide.
Social Environment					
13	Resettlement and land acquisition	During construction	B-	B-	There is no involuntary resettlement. Land acquisition and compensation for the farm land in power facility area is necessary.
		Operation	D	D	Involuntary resettlement and land acquisition is not expected during operation.
14	Poverty	During construction	B-	B-	Loss of farmland as livelihood source will cause loss of income.
		Operation	B+	B+	Enhanced supply of rural electricity by development of the power plant and development of the roads will improve social service such as schools and hospitals and access to them.

Environmental Item		Duration	Evaluation		Evaluation Reason
			Scoping	After Study	
15	Ethnic minority and indigenous people	During construction	A-	A-	All of affected people are Nyaheun. Loss of farmland will cause loss of their income.
		Operation	D	D	Ethnic people is not expected to be affected.
16	Local economy, employment and livelihood	During construction	B-	B-	Land acquisition will decrease the land for livelihood (i.e., agriculture, forest production, fishery, hunting).
			B+	B+	Employment opportunity will increase for construction work.
			—	B-	Influx of temporary workers will cause confusion of local economy.
		Operation	B+	B+	Increase of employment opportunity and development of local economy will increase opportunity for improvement of living standard.
17	Land use and use of natural resource	During construction	B-	B-	Land acquisition and deforestation will cause decrease of agricultural products and local resources.
		Operation	B-	B-	Deforestation will cause decrease of forest resources, and change of river flow regime will impact on fishery.
18	Water use	During construction	C-	B-	Water pollution by construction work will impact on river water use.
		Operation	C-	B-	Water pollution and reduction of river flow will impact on river water use.
19	Existing social infrastructure and service	During construction	B-	B-	Increase in traffic of construction vehicles will disturb access to social service.
		Operation	B+	B+	Enhanced supply of rural electricity by development of the power plant and development of the roads will improve social service such as schools and hospitals and access to them.
20	Social institutions and social organization such as decision-making body	During construction	B-	B-	Social institutions and/or social organization will be affected by land acquisition procedure or compensation evaluation.
		Operation	D	D	No impact is expected.
21	Uneven distribution of benefits and damages	During construction	B-	B-	Unfair evaluation of compensation will cause uneven distribution of benefits and damages.
		Operation	D	D	No impact is expected.
22	Conflict of interest in the region	During construction	B-	B-	Land acquisition and compensation will cause conflict of interest within local community.
		Operation	D	D	No impact is expected.
23	Cultural heritage	During construction/ Operation	C-	B-	There are sacred places near construction area.
24	Landscape	During construction	D	D	No impact is expected.
		Operation	A-	A-	Reduction of river flow will impact on landscape of the Xe Katam waterfall.
25	Gender	During construction	C	D	There are differences in education and work opportunity by gender, but the Project will cause no impact.
		Operation	D	D	No impact is expected.
26	Children's rights	During construction/ Operation	D	D	No impact is expected.
27	Infection, HIV/AIDS	During construction	C-	B-	Influx of construction workers will cause spread of infection.
		Operation	D	D	No impact is expected.
28	Working condition (including working safety)	During construction	C-	B-	Accidents, injuries and diseases will occur during construction.
		Operation	D	D	No impact is expected.
Others					
29	Accidents	During construction	A-	A-	Construction and traffic accidents and unexploded ordinance (UXO) will increase risk of accident.
		Operation	B-	B-	Risk of operational and traffic accidents will increase.
30	Impact of cross-border, and climate change	During construction	C-	B-	Auto exhaust from construction machines and construction vehicles will cause increase of CO_2 emission. Deforestation will cause decrease of absorption of CO_2.
		Operation	C+/-	D	No impact is expected.

Table 6.8-3 EIA (Zone 2)

Environmental Item		Duration	Evaluation		Evaluation Reason
			Scoping	After Study	
Pollution Control					
1	Air pollution	During construction	B-	B-	There is no air pollution at present, but air quality will be deteriorated by construction machines and construction vehicles.
		Operation	D	D	No impact is expected.
2	Water quality	During construction	C-	B-	Excavation work will cause water pollution.
		Operation	D	D	No impact is expected.
3	Waste	During construction	B-	B-	Waste soil and waste material by construction work will arise.
		Operation	D	D	No impact is expected.
4	Soil pollution	During construction	C-	B-	Accidental spill of fuel, lubricant oil or chemicals will cause soil pollution.
		Operation	D	D	No impact is expected.
5	Noise and vibration	During construction	B-	B-	Construction work will cause noise and vibration.
		Operation	D	D	No impact is expected.
6	Land subsidence	During construction/ Operation	D	D	No impact is expected.
7	Odor	During construction/ Operation	D	D	No impact is expected.
8	Bottom sediment	During construction/ Operation	D	D	No impact is expected.
Natural Environment					
9	Protected area	During construction/ Operation	C-	B-	Part of transmission line will pass the Provincial Protected Forest. Deforestation and construction work will cause impact.
10	Ecosystem	During construction	B-	B-	Construction work is expected to disturb the ecosystem.
		Operation	B-	B-	Transmission line may disturb flying of birds.
11	Hydrology	During construction/ Operation	D	D	No impact is expected.
12	Topography and geology	During construction/ Operation	B-	B-	Change in terrain by excavation work may increase risk of landslide.
Social Environment					
13	Resettlement and land acquisition	During construction	B-	B-	Resettlement of one residence and 5 huts are required.
				B-	Land acquisition for towers of transmission line is required.
		Operation	D	D	No impact is expected.
14	Poverty	During construction	C-	B-	Land acquisition for towers will cause loss of farmland.
		Operation	B+	B+	Enhanced supply of rural electricity by development of the power plant and development of the roads will improve social service such as schools and hospitals.
15	Ethnic minority and indigenous people	During construction/ Operation	C-	B-	Most of affected people are ethnics. Though ethnic people will receive negative and positive impact, impacts are limited to direct impact, which is loss of assets. There is no important place for their culture and religion.
16	Local economy, employment and livelihood	During construction	B+	B+	Employment opportunity will increase for construction work.
			-	B-	Influx of temporary workers will cause confusion of local economy.
		Operation	B+	B+	Increase of employment opportunity and development of local economy will cause increase of life improvement opportunity.
17	Land use and use of natural resource	During construction/ Operation	B-	B-	Land acquisition and deforestation will cause decrease of agricultural products and local resources.
18	Water use	During construction/ Operation	D	D	No impact is expected.

Environmental Item		Duration	Evaluation		Evaluation Reason
			Scoping	After Study	
19	Existing social infrastructure and service	During construction	B-	B-	Increase in traffic of construction vehicles will disturb access to social service.
		Operation	B+	B+	Enhanced supply of rural electricity by development of the power plant and development of the roads will improve social service such as schools and hospitals.
20	Social institutions and social organization such as decision-making body	During construction	C-	B-	Social institutions and/or social organization will be affected by land acquisition procedure or compensation evaluation.
		Operation	D	D	No impact is expected.
21	Uneven distribution of benefits and damages	During construction	B-	B-	Unfair evaluation of compensation will cause uneven distribution of benefits and damages.
		Operation	D	D	No impact is expected.
22	Conflict of interest in the region	During construction	C-	B-	Land acquisition and compensation will cause conflict of interest within local community.
		Operation	D	D	No impact is expected.
23	Cultural heritage	During construction/ Operation	C-	D	No impact is expected.
24	Landscape	During construction/ Operation	B-	B-	Transmission line will impact on landscape.
25	Gender	During construction/ Operation	C	D	No impact is expected.
26	Children's rights	During construction/ Operation	D	D	No impact is expected.
27	Infection, HIV/AIDS	During construction	C-	B-	Influx of construction workers will cause spread of infection.
		Operation	D	D	No impact is expected.
28	Working condition (including working safety)	During construction	C-	B-	Accidents, injuries and diseases will occur during construction.
		Operation	D	D	No impact is expected.
Others					
29	Accidents	During construction	A-	A-	Construction and traffic accidents and unexploded ordinance (UXO) will increase risk of accident.
		Operation	D	D	No impact is expected.
30	Impact of cross-border, and climate change	During construction	C-	D	Auto exhaust from construction machines and construction vehicles will cause increase of CO_2 emission. Deforestation will cause decrease of absorption of CO_2. But the impact is limited, so no impact on climate change is expected.
		Operation	D	D	No impact is expected.

6.9 Land Acquisition and Resettlement

6.9.1 Necessity of Land Acquisition and Resettlement

Land acquisition is required for intake weir, access road and transmission line towers. The right of way (ROW) of transmission line requires 25m width. Buildings and vegetation above 3m height is not allowed in ROW. Resettlement is required for buildings in ROW of transmission line.

Table 6.9-1 Project Components related to Land Acquisition and Resettlement

Facility	Number	Area/ length
Intake weir		2.51ha
Access road: new road		13.0km
renovation		3.3km
Tower	131	12m*12m*131=1.89ha
Transmission line		45.0km

6.9.2 Legal Framework related to Land Acquisition and Resettlement

(1) Laws and Regulations related to Land Acquisition and Resettlement

Land acquisition requires amendment of land category and transfer of land use right holder in accordance with the Land Law (see Section 3.1). Land categories related to the Project are Agricultural Land, Forest Land and Water Area Land, which need to be amended to Industrial Land. This amendment requires approval from the National Assembly. Land use right needs to be transferred from current legally registered land user to the project company. As land users of this region have only customary land use rights without registration under the Land Law, it is required to register the land use rights for customary land users and then those rights will be transferred. Note that the customary land use right is a legally recognized right under the Degree of the Land Law. Those transactions are managed under the Land Law by responsible governmental agencies, Ministry of Agriculture and Forestry, related agencies and local government agencies.

Compensation and resettlement are governed by the Decree on Compensation and Resettlement of the Development Project (No. 192/PM, 7 July, 2005) and the Regulation for Implementing Degree 192/PM on Compensation and Resettlement of People Affected by Development Project (No. 2432/STEA, 11 November 2005). GOL also established the Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects (Prime Minister's Office, Water Resource and Environment Administration (WREA), March 2010).

(2) JICA's Policy on Involuntary Resettlement

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

(3) Gap between Laws of Laos and JICA Guideline

Table 6.9-2 shows comparison between JICA Guideline for Environmental and Social Consideration and laws and regulations in Lao PDR. No gap was found between them.

Table 6.9-2 Comparison of JICA Guideline and Lows of Lao

No.	JICA Guideline	Lows of Lao	Gap
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Article 4 of Decree on Compensation and Resettlement of the Development Project, 2005 (Decree 192) stipulate that the developer shall "make every attempt so that displacement and other direct adverse impacts on peoples' assets and income are avoided or, if unavoidable, minimized by examining all design options available to the project".	No gap is found
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Article 6 of Decree 192 stipulate compensation principles including preferable "land for land" arrangement. Article 23 of Regulations for Implementing Decree 192/PM on Compensation and Resettlement of People Affected by Development Projects (Regulation 2432) stipulates the resettlement site's characteristics, namely, comparable environment, geographical features better than, or at least equivalent to the affected land. Article 23 of Regulation 2432 also stipulates the resettlement land must be selected in consultation with Affected People (AP). Article 2.1.2 of the Technical Guidelines on Compensation and Resettlement of People Affected by Development Project (TGCR) stipulate that the negative social impact shall be avoided or minimized by exercise of various design options in the early stage of project planning.	No gap is found
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Article 1 of Decree 192 stipulates that the decree "aims to ensure that project affected people are compensated and assisted to improve or maintain their pre-project incomes and living standards, and are not worse off than they would have been without the project". The Decree 192 also regulates sufficient compensation, assistance during relocation and transition period and economic rehabilitation.	No gap is found
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Article 6 of the Decree 192 stipulates that "project owners shall compensate project affected people for their lost rights to use land and for their lost assets affected in full or in part, at replacement cost".	No gap is found
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Article 6 of the Decree 192 stipulate that "prior to commencement of project construction, APs shall be fully compensated and resettled and rehabilitations measures shall be in place".	No gap is found
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	Article 14 and 15 of the Decree 192 requires project owner to establish a Resettlement Plan (RP) for government's approval. Article 29 of the Regulation 2432 stipulates that the draft RP shall be disclosed to PAPs in a form and manner they can understand and in an easily accessible place for collecting PAPs' comments and that the final RP will be disclosed to PAPs at including provincial and district office. Article 12 of the Regulation 2432 regulates the projects which require resettlement of more than 200 people (about 40 to 50 households) need RP. The contents of RP are defined in the TGCR.	No gap is found
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	Article 14 of the Decree 192 stipulates public participation and consultation. Article 13 of the Regulation 2432 requires project owner "hold consultations with stakeholders (including APs) to obtain their inputs for RP design". Article 29 of the Regulation 2432 regulates disclosure and APs' input to RP (refer to the item 6 above).	No gap is found
8.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	Article 12 of the Decree 192 and Article 7 and 8 of the Decree on Environmental Impact Assessment (Decree 112) stipulates the need of consultation. Chapter 11 of the TGCR and Annex 24 of the TGCR explain the details of the consultation including the language and manner.	No gap is found

No.	JICA Guideline	Lows of Lao	Gap
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Article 12 of the Decree 192 and Article 7 and 8 of the Decree 112 stipulates the public involvement in planning, implementation and monitoring stage.	No gap is found
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Article 13 of the Decree 192 stipulate the establishment of the Grievance Redress mechanism. Article 31 of the Regulation 2432 and Chapter 12 of the TGCR regulate the detailed procedure of the grievance mechanism including easy accessibility.	No gap is found
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	Article 16 of the Regulation stipulates the cut-off date. Chapter 7 of the TGCR stipulates that the detailed procedure of census and inventory survey after setting the cut-off date in the planning stage.	No gap is found
12.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Article 8 of the Decree 192 stipulates eligibility of compensation for legal users, tenants and those who do not have legal land use certificate which read “all APs, regardless of land use right, will be entitled to compensation for lost assets at replacement cost, and provided with other assistance during the transition period, and economic rehabilitation assistance to ensure that they are not worse off due to the project”. Chapter 8 of the TGCR explain details of the entitlement.	No gap is found
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Article 6 of the Decree 192 stipulates that “where significantly large or entire land holding is affected by a project namely agriculture, residntial or commercial land, the compensation shall be through provision of “land for land” arrangement of equivalent size and productivity and be acceptable to APs and project owners”. Article 22 of the Regulation 2432 defines APs who need “land for land” arrangement. Chapter 10 of the TGCR explains detailed approach of “land-for-land” compensation.	No gap is found
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Article 7 of the Decree 192 stipulates assistance during relocation and transition period. Chapter 8 of the TGCR stipulates details of material transportation allowance, transition subsistence allowance, repair allowance, special allowance for loss of business, rehabilitation allowance and other assistance including types of special assistance to vulnerable groups.	No gap is found
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Article 8 of the Decree 192 stipulates economic rehabilitation, specifically focusing on vulnerable groups. It requires the project owner to provide adequate assistance to enable such APs to achieve household income targets set above the national poverty line in addition to compensation for affected assets and other allowance.	No gap is found
16.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Article 11 of the Regulation 2432 stipulates that “in case the impacts of the project are mostly marginal such that less than 200 persons (about 40-50 families) are affected by the project either marginally or with limited displacement, project owner will prepare a Land Acquisition and Compensation Report (LACR)” rather than RP.	No gap is found

(4) Policy on Land Acquisition and Involuntary Resettlement of the Project

Land acquisition and resettlement for the Project will be conducted according to laws and regulations of Laos PDR and JICA Guideline.

6.9.3 Scope of Land Acquisition and Resettlement Impact

(1) Population Census

(a) Affected Persons

Resettlement of one (1) house and five (5) huts are required for transmission line ROW, which affect six (6) households.

Land acquisition is required for intake weir, pond, access roads, temporary yards and towers of transmission line, which affects 110 households and 3 companies. 20 households out of those are affected by temporary yards, which is a temporary impact. Land acquisition for a transmission line tower base is required 144m^2 per tower, this area is equal to 1.5% of average farmland per household. Therefore the impact on each household is limited.

Table 6.9-3 Number of Project Affected Area and Units (Resettlement)

	Project Affected Area			Project Affected Units (PAU's)		
Type of Loss	**Legal**	**Illegal**	**Total**	**Legal**	**Illegal**	**Total**
Zone 2 – Transmission Line						
Permanent House re-location	1 house		1 house	1 HH		1 HH
Permanent Farm shelter relocation	5 shelters		5 shelters	5 HH		5 HH
Zone 2 – Total	1 house + 5 shelter			6 HH		
Grand Total	1 house + 5 shelter			6 HH		

Table 6.9-4 Number of Project Affected Area and Units (Land Acquisition)

	Project Affected Area			Project Affected Units (PAU's)		
Type of Loss	**Legal**	**Illegal**	**Total**	**Legal**	**Illegal**	**Total**
Zone 1 – Construction and Operation - Intakes, Headrace Tunnel and Adits, Head Tank Penstock, Powerhouse						
Permanent						
Intake weirs and Pond	8.1 ha		8.1 ha	3 HH		3 HH
Headrace Tunnel, adit and Intake weirs	Provincial Protected Forest					
Head Tank & Penstock	Provincial Protected Forest					
Power house	Provincial Protected Forest					
Road Upgrade Household Occupier Lands (HH)	2.2 ha		2.2 ha	37HH		37 HH
Road Upgrade Private Company Lands (CBE)	3.4 ha		3.4 ha	2 CBE*		2 CBE
Road Upgrade Village and Government Lands	Provincial and Village forest 10.8 ha					
Zone 1 - Permanent Total	24.5 ha			40 HH + 2 CBE		
Temporary						
Temporary yard No 2	2.5 ha			3HH		3 HH
	Nong Thuam Village Land - Unstocked forest (0.4 ha)					
Temporary yard No 3	12.2 ha			14 HH		14 HH
	Nong Hin Village Land - Unstocked forest (1.7 ha)					
Temporary yard No 4	Provincial Protected Area					
Temporary yard No 5	Nam Touad Village Land - Riverbank Forest					
Temporary yard No 6	Provincial Protected Area					
Temporary yard No 7	Provincial Protected Area					
Temporary yard No 8	Provincial Protected Area					
Construction Worker Camp	4.9 ha		4.9 ha	2 HH		2 HH
Disposal Area No 1&2	Provincial Protected Area (see tree survey species/volume data)					
Disposal Area No 3	Provincial Protection Area					
Disposal Area No 4	Provincial Protection Area					
Disposal Area No 5	Provincial Protection Area					
Zone 1 - Temporary Total	19.6 ha			19 HH		
Zone 1 – Total	44.1 ha			59 HH + 2 CBE		
Zone 2 – Transmission Line						
Permanent						
Transmission Tower Pads (excluding Gov. Land) - 131 towers	1.6 ha		1.6 ha	40 HH +1 CBE		40 HH + 1 CBE
Zone 2 – Permanent Total	1.6 ha			40 HH + 1 CBE		
Temporary						
Abandoned old coffee garden (9.0ha) + Agarwood garden (0.2 ha)	9.2 ha			11 HH		
Zone 2 - Temporary Total	9.2 ha			11 HH		
Zone 2 – Total	10.8 ha			51HH + 1 CBE		
Permanent Total	26.1 ha (Zone 1: 24.5 ha, Zone 2: 1.6 ha)			80 HH +3 CBE (Zone 1: 40 HH, Zone 2: 40 HH)		
Temporary Total	28.8 ha (Zone 1: 19.6 ha, Zone 2: 9.2 ha)			30 HH (Zone 1: 19 HH, Zone 2: 11 HH)		
Grand Total	54.9 ha (Zone 1: 44.1 ha, Zone 2: 10.8 ha)			110 HH +3 CBE (Zone 1: 59 HH, Zone 2: 51 HH)		

*CBE: Commercial and business enterprises

(b) Cut off Date

Cut-off-date is determined by a provincial compensation committee at Project implementation phase followed by re-survey of affected assets. Buildings and residents entering after cut-off-date are not subject to compensation. Cut-off-date is announced to affected people and residents before commencement of the asset survey to prevent new inflow to the Project area.

The tentative cut-off-date in the Preparatory Survey for the Project is 10th April, 2015, which is the last day of the social and economic survey.

(2) Asset and Land Survey

(a) Land

Area and land use for acquired land are shown below.

Table 6.9-5 Land Use for Compensation_Zone 1

No.	Village	Land Type															Total
		Housing Land	Fish Pond	Nursery Farm	Swidden	Garden	Paddy Field	Coffee Garden	Abandoned Coffee Garden	Khaem Garden	Bong Garden	Pepper Garden	Camp Garden	Banana Garden	Bamboo	Unstocked Forest	
1	Nong Thuam	4093	0	899	0	0	0	0	27,666	0	0	670	156	21,169	1,827	39,545	77,214
2	Nam Touad	0	669	0	27,543	8,226	0	0	0	0	0	0	0	0	0	3,841	168,369
3	Nong Hin	0	0	0	0	0	4,250	28	25,576	8,904	3,086	0	0	0	0	64,966	106,810
4	Nam Houng	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87,729	87,729
Total Area		4,093	669	899	27,453	8,226	4,250	28	53,242	8,904	3,086	670	156	21,169	1.827		440,122

Table 6.9-6 Land Use for Compensation_Zone 2_Tower

Village	Agarwood Garden	Agricultural Plantation	Coffee Garden	Abandoned Coffee Garden	Forest	Garden	Pasture Land	Potato Garden	Village Protection Forest	Swidden	Tall Reed Garden	Tavoy Garden	Unstock Forest	Yang Bong	Total
Nong Thuam		1,152	144	144		288									1,728
Nam Touad															2,880
Nong Tuang			576								144		288	144	1,152
Lasasin				144							144	144			432
Nam Tang			144	144									144		432
Huay Kong			864			288				144			576		1,872
Nong Kin			288										720		1,008
Nam Pot			432	288											720
Nongkuang Gnai			1,152			288									1,440
Chansavang			144			144			144				720		1,152
Km 15			144										288		576
Km 12			432			144							144		720
Km 11			144					144					432		720
Nonchan			288	2,160			288								2,736
Nongking Kham	288		144	288	144	144	288						144		1,440
Total Area	288	1,152	4,896	3,168	144	1,296	576	144	144	144	288	144	3,456	144	19,008

(b) Buildings

There are one (1) house and five (5) huts for rice storage in the ROW of transmission line.

Table 6.9-7 Affected Structures_Zone 2_ROW of Transmission Line

Village	House	Hut	Total
Nong Tuang		1	1
Nong Kin		2	2
Km 15		1	1
Km 12		1	1
Km 11	1		1
Total Unit	1	5	6

(3) Household Budget and Livelihood

Described in Section 6.7.2.

(4) Vulnerable

Described in Section 6.7.2.

6.9.4 Compensation Measures

(1) Compensation Criterion

A compensation criterion will be determined by a provincial compensation committee of the Project after an approval of the Project by GOL. An underlying plan is proposed in line with GOL's laws and regulations and in consideration with experiences of prior projects around the Project area. The compensation criterion is prepared based on the following policy;

1) The cost of land is the pre-project or pre-displacement, whichever higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.

2) Entitled project affected persons (PAPs) for land replacement are given option to "cash or in-kind" land compensation for those with permanent land rights.

3) Replacement cost of structures is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

4) Graves or other structures that will be affected by the Project will be replaced or compensated through consultation with PAPs and/or community.

5) For perennial crop a transition period for culture will be taken into account. This period may be more than one year for some crops. Also for trees a compensation rate will be convene for their permanent loss. For annual crops there is no specific provision and income restoration

support will be provided.

6) If non-titled owners of land or assets who don't have formal legal rights to land but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying will be found, they are entitled to compensation or benefit in accordance with the applicable regulation or guidelines and consultation.

Table 6.9-8 and Table 6.9-9 show an entitlement matrix for PAPs by power plant facilities and the transmission line, respectively. Note that the area of affected land became smaller along with the change of design from the dam type to the run-of-river type, compensation is changed from land replacement to cash compensation following laws and regulations. There are available lands which most of PAPs are able to go on foot from their houses and afford to buy. No available land was found for three (3) PAPs by the intake weir nearby their houses, but they agreed cash compensation.

Notes: Abbreviations in Table 6.9-8 and Table 6.9-9 show the following (see Table 6.14-1)

XKHC : Xe Katam Hydropower Company (a project implementing body)
CC : Compensation Committee (established in provincial government)
DWG : District Working Group
VC : Village Committee
LURC : Land Use Right Certification

Table 6.9-8 Entitlement Matrix (Zone 1)

Type of Loss	Application	Definition of Entitled Person	Compensation Policy	Implementation Issues / Guidelines	Responsible Organization
Arable land	Permanent loss of arable land which affects less than 20% of household income	a) Legal user of affected land with permanent land rights, and AP's who meet the criteria for permanent land use rights and will therefore be issues with permanent LURC in due time	- Cash compensation for crops and trees at market price - Cash compensation for acquired land at 100% of replacement cost	- Official inventory survey (land area, ownership and affected assets) will be done by cC. - Market price of affected assets and replacement cost of land will be determined by CC with consultation with PAPs.	- XKHC is responsible for cash expense for survey, documentation assistance to PAPs and payment of compensation. - CC is responsible for determination of market price. - And DWG are responsible for conducting inventory survey and supervising XKHC's performance. - VC is responsible to cooperate with XKHC and government activities.
		b) Legal user of affected land with temporary land rights	- Cash compensation for crops and trees at market price - (a) Cash compensation for affected land corresponding to 100% of the replacement cost of affected land: OR - (b) Cash assistance for lost income from the affected land for the remaining period of the temporary land use right	Same as a)	Same as a)
		c) Legal user of affected land with lease land rights	- Cash compensation for crops and trees at market price - Cash assistance for loss of income for the remaining lease period	Same as a)	Same as a)
Fish resources	Loss of fish resource due to, reduced river flow	River users in Nong Thuam, and Nam Touad villages	- Fishery program will be promoted by: - Development of Fish - Develop community based fishing in weir and village pools and restocking program.	- Fishery program and training will be established by experts with consultation with PAPs and local authorities.	- XKHC is responsible for funding for establishment of fishery pools and training. -
Water use	Less accessibility to river water due to reduced river flow	No impact	- None required	-	-

Table 6.9-9 Entitlement Matrix (Zone 2)

Type of Loss	Application	Definition of Entitled Person	Compensation Policy	Implementation Issues / Guidelines	Responsible Organization
Arable land	Permanent loss of arable land which affects less than 20% of household income	a) Legal user of affected land with permanent land rights, and AP's who meet the criteria for permanent land use rights and will therefore be issues with permanent LURC in due time	- Cash compensation for crops and trees at market price - Cash compensation for acquired land at 100% of replacement cost	- Official inventory survey (land area, ownership and affected assets) will be done by CC. - Market price of affected assets and replacement cost of land will be determined by CC with consultation with PAPs.	- XKHC is responsible for cash expense for survey, documentation assistance to PAPs and payment of compensation. - CC is responsible for determination of market price. - And DWG are responsible for conducting inventory survey and supervising XKHC's performance. - VC is responsible to cooperate with XKHC and government activities.
		b) Legal user of affected land with temporary land rights	- Cash compensation for crops and trees at market price - (a) Cash compensation for affected land corresponding to 100% of the replacement cost of affected land: OR - (b) Cash assistance for lost income from the affected land for the remaining period of the temporary land use right	- Same as a)	- Same as a)
		c) Legal user of affected land with lease land rights	- Cash compensation for crops and trees at market price - Cash assistance for loss of income for the remaining lease period	- Same as a)	- Same as a)
	Temporary loss of arable land due to temporary facility, quarry, borrow area and disposal area	Legal user of affected land	- Cash compensation for crops and trees at market price	- Same as a)	- Same as a)
Structures	Temporary loss of structures due to construction activities	Legal owner of affected structure	- Cash compensation for affected structures at 100% of replacement cost of the affected structure	- Same as a)	- Same as a)

6.9.5 Implementing System of Monitoring

An Environment Community Office (ECO) established in the XKHC will conduct monitoring and reporting to government agencies (see Table 6.14-1).

6.10 Mitigation Measures and Cost

6.10.1 Mitigation Measures

Mitigation measures are studied on negative impact items based on the environmental impact assessment. Mitigation measures, implementation and responsible organizations are shown in Table 6.10-1 and Table 6.10-2.

Table 6.10-1 Mitigation Measures (Zone 1)

No	Impact	Period	Impact	Mitigating Measures	Implementing Agency	Responsible Agency
1	Air pollution	Con.	Air pollution is expected due to dust and deterioration of air ambient from heavy equipment and vehicles.	The Contractor will adopt risk mitigating measures such as spraying water for access road in its Contractor's Environmental Monitoring and Management Plan (CEMMP).	HC	XKHC
		Ope.	Increased traffic by road improvement may result in increased dust from transportation of vehicles.	The Project Company will monitor the increased traffic.	XKHC	XKHC
2	Water quality	Con.	Water pollution is expected by earthwork in and around the river.	The Contractor will adopt risk mitigating measures such as silt fence, appropriate construction method for earthwork in the CEMMP	HC	XKHC
				Water quality will be monitored.	XKHC	XKHC
			Pollution risk is expected from potential spillage of fuels, lubricants and/or chemicals at construction sites.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP	HC	XKHC
				Water quality will be monitored.	XKHC	XKHC
		Ope.	Accidents on electromechanical equipment may possibly spill lubricant oil to the river.	The appropriate procedure for handling lubricant oil will be established.	XKHC	XKHC
				Water quality will be monitored.	XKHC	XKHC
			Domestic wastes water from operation office may deteriorate water quality of the river.		XKHC	XKHC
					XKHC	XKHC
3	Waste	Con.	Inadequate treatment and disposal of solid waste from worker compounds could adversely affect water quality and aquatic and terrestrial flora and fauna.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP.	HC	XKHC
		Ope.	Risk of contamination by wastes lubricant oil and disposal of non-toxic solid waste from powerhouse is expected.	Appropriate procedure of waste treatment will be established including substations liquids.	XKHC	XKHC
4	Soil pollution	Con.	Improper treatment of fuels, lubricants and other chemicals at the construction sites could impact soil contamination.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP.	HC	XKHC
		Ope.	Possible oil leakage may cause soil pollution (e.g., oil leakage in case malfunction of transformer).	Appropriate procedure of waste treatment will be established.	XKHC	XKHC
5	Noise and vibration	Con.	Construction work and transportation of machinery and construction material will increase noise and vibration level above standard.	The Contractor will adopt appropriate measures for preventing excess noise and vibration in its CEMMP.	HC	XKHC
7	Odor	Con.	Accidental spillage of toxic or chemical material may cause offensive odor.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP.	HC	XKHC
8	Bottom sediment	Con.	In case turbidity from earth work, fuel/ lubricant spillage from heavy machines and/or waste water from labour camp flow into the river, they cause bottom sediment pollution.	The Contractor will adopt the appropriate procedure for earthwork and handling such hazardous material in the CEMMP.	HC	XKHC
		Ope.	Excess organic material may accumulate in the tunnel intake zone during floods.	Periodic debris clearance at tunnel intake.	XKHC	XKHC

No	Impact	Period	Impact	Mitigating Measures	Implementing Agency	Responsible Agency
9	Protected area	Con.	Headrace tunnel, head tank, penstock and access road to those facilities are located in the Provincial Protected Forest.	Support to GOL for protection of flora and fauna (afforestation, forest regeneration, relocation of rare/ endangered species) under Decree 333 will be implemented.	GOL	GOL
		Ope.			GOL	GOL
10	Ecosystem	Con.	Construction activities disturb surrounding eco-system.	Forest areas temporarily disturbed will be restored in CEMMP.	HC	XKHC
			Construction-related noise and increased human activity will possibly result in temporary displacement of disturbance-sensitive fauna.	The Contractor will establish appropriate protection measures for eco-system in its CEMMP	HC	XKHC
			Increased hunting pressure by migrant workers	Prohibition on hunting by workers and ensuring workforce has proper nutrition.	HC	XKHC
		Ope.	Reduced river flow during operation will impact aquatic biota.	Environmental flow from the intake weir shall be released to mitigate the negative impact.	XKHC	XKHC
				River flow, water quality and fish will be monitored.	XKHC	XKHC
			Intake weir will block migratory fish species.	Fishery plan will be promoted considering the migratory fish species.	XKHC	XKHC
			Upgraded site access roads could increase human access to natural habitat, thereby increasing wildlife disturbance and illegal hunting pressure.	Support to GOL for illegal wildlife hunting control under Decree 333.	GOL	GOL
			Induced development activities due to the improvement of access	Development activities will be regulated by the province.		
11	Hydrology	Con.	River diversion during construction of the dam may change river flow regime and cause river bank erosion and impact on eco-system.	The Contractor will monitor the river condition and take appropriate actions if necessary.	HC	XKHC
		Ope.	Diversion at intake weir will reduce river flow amount down to tailrace outlet. The negative environmental impact is expected to eco-system and fishery.	The river maintenance flow will be released from the intake weir to mitigate the negative impact.	XKHC	XKHC
				River flow, water quality and fish will be monitored.	XKHC	XKHC
12	Topography and geology	Con. Ope.	Earthwork such as slope cut and excavation will change topography, which increase the risk of land slide.	Appropriate design of earthwork and slope protection measures will be introduced in the CEMMP.	HC	XKHC
13	Resettlement and land acquisition	Con.	land acquisition of farmland and forest is required	Appropriate compensation will be implemented.	XKHC	XKHC
				Proper organisational system for compensation and community development activities and grievance redress mechanism will be established.		XKHC /GOL
14	Poverty	Con.	Poverty group has less opportunity for increasing living standard.	Community development plan will be implemented for rising level of living.	XKHC	XKHC
				Community development unit will be supported.		
		Ope.	-	Community development plan will be continued.		
15	Ethnic minority and indigenous people	Con.	Since the Project affected people are classified as Nyaheun ethnic group, the Project will affect ethnic group.	Community development plan will be conducted.	XKHC	XKHC
				Community development unit will be supported.		
		Ope.	-	Community development plan will be continued.		
16	Local economy, employment and livelihood	Con.	Influx of migrant workers may cause disruption of social network and pressure on social infrastructure and social services.	Appropriate education for migrant workers will be established in the CEMMP.	HC	XKHC

No	Impact	Period	Impact	Mitigating Measures	Implementing Agency	Responsible Agency
17	Land use and use of natural resource	Con.	Land acquisition, deforestation and limitation of land use for the Project will cause loss of some agricultural products and other local resources.	Appropriate compensation will be conducted.	XKHC	XKHC
				Community development plan will be conducted.		
				Community development unit will be supported.		
		Ope.	Land use will be limited at the Project site. Local resources like fish species may be impacted by flow change.	Community development plan will be continued.		
18	Water use	Con.	Water quality deterioration by turbidity will impact water use for fishery.	The Contractor will adopt risk mitigating measures such as silt fence, appropriate construction method for earthwork in the CEMMP.	HC	XKHC
				Fishery plan will be implemented.	XKHC	XKHC
		Ope.	Reduced water flow from intake weirs to powerhouse will affect fishery activity.	Fishery plan will be continued.	XKHC	XKHC
19	Existing social infrastructure and service	Con.	Potential disruption of traffics caused by construction vehicles is expected.	The Contractor will establish a proper procedure for avoiding the disruption of traffics in the CEMMP.	HC	XKHC
20	Social institutions and social organisations such as decision-making body	Con.	Negotiation regarding compensation and land acquisition has a potential to affect social system and organisation.	Proper organisational system for compensation and community development activities and grievance redress mechanism will be established.	XKHC	XKHC / GOL
21	Uneven distribution of benefits and damages	Con.	Unfair compensation evaluation is expected.	Proper organisational system for compensation and community development activities and grievance redress mechanism will be established.	XKHC	XKHC / GOL
22	Conflict of interest in the region	Con.	Land acquisition and compensation may cause conflict of interest within local community.	Proper implementation of organisational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.	XKHC	XKHC / GOL
23	Cultural heritage	Con.	Cemeteries and sacred places around the Project site will be affected by construction works.	Construction works will be conducted taking cemeteries and sacred places into account.	HC	XKHC
24	Landscape	Con.	Construction activities will disturb landscape.	The Contractor will take appropriate action to keep construction activities within designated construction area.	HC	XKHC
		Ope.	Reduced river flow will impact on the Xe Katam waterfall and other waterfalls.	The environmental flow and flow for conservation of landscape will be released for keeping aesthetic value of waterfalls.	XKHC	XKHC
27	Infection, HIV/AIDS	Con.	Infection risk of new communicable diseases may increase due to the influx of migrant workers.	The Contractor will establish an appropriate program for prevention of communicable diseases in its CEMMP.	HC	XKHC
				Health and sanitary support for PAPs will be implemented.	XKHC	XKHC
28	Working condition (including working safety)	Con.	Some risks for labours are expected such as occupational disease or accident during construction activities.	The Contractor will establish mitigation measures for labour's security, health and safety condition in the CEMMP.	HC	XKHC
29	Accidents	Con.	There are risks of accidents affected to public by construction work, increased traffics and UXO.	The Contractor will establish public safety programs in its CEMMP.	HC	XKHC
				The UXO survey and removal plan will be established and conducted.		
		Ope.	Increased traffic or operation of power plant may cause accident.	Appropriate safety procedure will be established.	XKHC	XKHC
30	Impact of cross-border, and climate change	Con.	Carbon dioxide is expected to increase by heavy machines and traffics and absorption ability of them is reduced due to deforestation.	Support to GOL for protection of flora and fauna (afforestation, forest regeneration, relocation of rare/ endangered species) will be implemented under Decree 333.	HC	XKHC / GOL
		Ope.	-	Support to GOL for protection of flora and fauna will be continued.		

HC: Head Contractor, XKHC: Xe Katam Hydropower Company, EPC: Engineering, Procurement and Construction contract, TBD: To be determined at implementation stage

Table 6.10-2 Mitigation Measures (Zone 2)

No	Impact	Period	Impact	Mitigating Measures	Imple-menting Agency	Respon-sible Agency
1	Air pollution	Con.	Air pollution is expected due to dust and deterioration of air ambient from heavy equipment and vehicles.	The Contractor will adopt risk mitigating measures such as spraying water for access road in its Contractor's Environmental Monitoring and Management Plan (CEMMP).	HC	XKHC
2	Water quality	Con.	Water pollution is expected by excavation work.	The Contractor will adopt risk mitigating measures such as silt fence, appropriate construction method for earthwork in the CEMMP	HC	XKHC
3	Waste	Con.	Solid waste from construction area is expected.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP.	HC	XKHC
4	Soil pollution	Con.	Improper treatment of fuels, lubricants and other chemicals at the construction sites could impact soil contamination.	The Contractor will adopt the appropriate procedure for handing such hazardous material in the CEMMP.	HC	XKHC
5	Noise and vibration	Con.	Construction work and transportation of machinery and construction material will increase noise and vibration level above standard. .	The Contractor will adopt appropriate measures for preventing excess noise and vibration in its CEMMP.	HC	XKHC
9	Protected area	Con.	Part of transmission line is located in the Provincial Protected Forest.	Support to GOL for protection of flora and fauna (afforestation, forest regeneration, relocation of rare/ endangered species) under Decree 333 will be implemented.	GOL	GOL
		Ope.			GOL	GOL
10	Ecosystem	Con.	The construction of transmission lime may cause disturbance of flora and fauna habitat.	The Contractor will establish appropriate protection measures for eco-system in its CEMMP	HC	XKHC
		Ope.	Transmission line conductor may disturb the flying bird.	Mitigation measures will be reviewed such as a bird diverter with EDL.	HC	XKHC
12	Topography and geology	Con. Ope.	Earthwork such as slope cut and excavation will change topography, which increase the risk of land slide.	Appropriate design of earthwork and slope protection measures will be introduced in the CEMMP.	HC	XKHC
13	Resettlement and land acquisition	Con.	Resettlement of one (1) residential house and five (5) huts within ROW is required. Land acquisition for towers is also required.	Proper resettlement will be implemented.	XKHC	XKHC
				Proper compensation will be implemented.		
				Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.		XKHC/ GOL
14	Poverty	Con.	Loss of productive land may cause impact due to land acquisition for towers.	Proper compensation will be implemented.	XKHC	XKHC
				Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.		XKHC/ GOL
15	Ethnic minority and indigenous people	Con.	Resettlement and land acquisition will impact on ethnic people.	Proper resettlement shall be implemented.	XKHC	XKHC
				Proper compensation shall be implemented.		
				Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.		XKHC/ GOL
16	Local economy, employment and livelihood	Con.	Influx of migrant workers may cause disruption of social network and pressure on social infrastructure and social services.	Appropriate education for migrant workers will be established in the CEMMP.	HC	XKHC
17	Land use and use of natural resource	Con.	Loss of agricultural production due to the land acquisition and restriction in ROW area will cause the loss of productivity of land.	Proper compensation will be implemented.	XKHC	XKHC
				Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.		
19	Existing social infrastructure and service	Con.	Occasional limitation of traffic due to construction activity is expected.	Appropriate traffic control rule will be introduced in the CEMMP.	HC	XKHC
20	Social institutions and social organisation such as decision-making body	Con.	Negotiation regarding compensation and land acquisition has a potential to affect social system and organization.	Proper resettlement will be implemented.	XKHC	XKHC
				Proper compensation will be implemented.		
				Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.		XKHC/ GOL

No	Impact	Period	Impact	Mitigating Measures	Imple-menting Agency	Respon-sible Agency
21	Uneven distribution of benefits and damages	Con.	Unfair compensation evaluation is expected.	Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.	XKHC	XKHC/ GOL
22	Conflict of interest in the region	Con.	Land acquisition and compensation may cause conflict of interest within local community.	Proper implementation of organizational structure for rendering social impact mitigation measures and grievance redress mechanism will be established.	XKHC	XKHC/ GOL
24	Landscape	Ope.	Transmission line may spoil the landscape.	The impact is unavoidable.	—	—
27	Infections, HIV/AIDS	Con.	Infection risk of new communicable diseases may increase due to the influx of migrant workers.	The Contractor will establish an appropriate program for prevention of communicable diseases in its CEMMP.	HC	XKHC
28	Working condition (including working safety)	Con.	Some risks for labors are expected such as occupational disease or accident during construction activities.	The Contractor will establish mitigation measures for labor's security, health and safety condition in the CEMMP.	HC	XKHC
29	Accidents	Con.	There are risks of accidents affected to public by construction work, increased traffics and UXO.	The Contractor will establish public safety programs in its CEMMP. The UXO survey and removal plan will be established and conducted.	HC	XKHC

6.10.2 Study of Environmental Flow

(1) Study Method of Environmental Flow

Generally environmental flow is studied taking into account of aquatic biota, especially for impact on migratory fishes and eco-system, navigation and river use of nearby people. Study measures are varied considering importance of the river in terms of aquatic bio-diversity and social lives from simple method based on hydrological data to detailed field survey on eco-system. Examples of study measures are shown in Table 6.10-3.

Table 6.10-3 Environmental Flow Example

	Overall Management Objective	Flow/level objective	Approach used
River Babingley	Maintain a wild brown trout population	Ecologically acceptable flow duration curve	Physical habitat modelling (PHABSIM) and naturalized flow duration curve from rainfall-run-off model
River Kennet	Maintain a wild brown trout population	Flow should not below that which results in a reduction in physical habitat for brown trout of more than 10%	Physical habitat modelling (PHABSIM)
River Avon	Protect salmon migration	Minimum flows at critical times of the year	Radio tracking of salmon
Pevensey Levels Wetland	Restore and maintain ecology at 1970 level	Maintain ditch water levels not more than 300mm below ground level Mar-Sept not more than 600mm below ground level Oct-Feb	Expert research opinion on water requirement of ecology of wetland species
Somerset Moor & Levels	Restore numbers of breeding waders to 1970 level	Raise water levels in Winter to produce splash-flooding and maintain water levels within 200 mm of ground surface in Spring	Expert opinion on ecology of wading birds
Chippenham, Wichen, Fulbourn Flubourn Fens	Protection of vegetation communities	Target flows identified in the River Granta and Lodes	Lodes-Granta ground water mode, test pumping, hydrological studies

Source: IUCN

According to the aquatic survey and socio-economic survey, catchment area of the Xe Katam River has characteristics below;

a. Aquatic Eco-system

Aquatic survey found 53 fish species. Dominant species is *CYPRINIDEA*. Out of 53 species, six (6) fish species are on the IUCN list. Those species, however, are widely found in the Mekong River and tributaries in Lao PDR according to survey institution and government.

b. Socio-economics Aspect

Villagers of affected villages are engaged in fishery throughout the year. The income from fishery accounts for about 26 to 31 % of their annual income. (see Section 6.7.2 (11) (c))

c. Visual Aspect

Within the river reach where the Project has influence, there are ten (10) water falls. The Xe Katam Fall (*Katam Tok*) is the biggest and is regarded as one of the tourism resource. Xe Katam Fall is easily accessible and is seen from the national road.

Considering the characteristics of the Xe Katam River, environmental flow is determined by historical hydrological data and catchment area index. The catchment area index method is widely used in Japan to determine the environmental flow for hydropower projects. In Japan's case, standard environmental flow is determined by 0.1 to 0.3 m^3/s per 100 km^2 of catchment area. Generally the catchment area and hydrological data are correlated to a certain extent, this method is considered as a simplified method of hydrological analysis. Environmental flow at other hydropower projects in Lao PDR was referred to for the comparison purpose.

Environmental flow at other hydropower projects in Lao PDR is shown in Table 6.10-4.

Table 6.10-4 Environmental Flow in Lao PDR

Name of the project	Catchment area (km^2)	Minimum discharge (m^3/s)	Specific discharge ($m^3/s/100km^2$)	Maximum plant discharge (m^3/s)	Installed capacity (MW)
Nam Theun 2	4,031	2.00	0.05	201	1,075
Theun Hinboun	8,937	5.00	0.06	110	210
Houay Ho	192	0.00	-	22	150
Nam Song diversion	1,303	2.00-6.00*1	0.15-0.46	80.6	-
Nam Leuk	274	0.00	-	9.6	60
Nam Mang 3	82	0.00	-	4.1	40
Xeset 1	320	0.00	-	18	45

*1: The Nam Song diversion is the weir to divert river water to the Nam Ngum reservoir in the form of a trans-basin scheme. At first the minimum discharge had been $2m^3/s$, it was changed to 6 m^3/s to mitigate the great impacts on livelihood of local people downstream.

(2) Evaluation of Environmental Flow

Table 6.10-5 indicates minimum flow of the month at the water flow discharge station in Nong Mek village during water flow measurement period. The catchment area of the station is 263 km^2. Table 6.10-6 shows specific discharge of minimum flow of the month per 100 km^2.

Table 6.10-5 Minimum Discharge at Nong Mek Flow Measurement Station

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
2004	-	-	-	-	-	-	-	-	9.91	3.92	2.00	1.20	4.26
2005	0.82	0.61	0.61	0.61	2.18	3.68	9.13	19.46	25.74	5.87	3.68	2.00	6.20
2006	1.07	0.82	0.82	1.66	5.87	6.18	18.63	25.10	14.77	6.50	4.71	2.18	7.36
2007	1.66	1.20	1.07	0.66	2.77	3.32	11.14	14.77	12.22	8.39	3.32	2.18	5.23
2008	1.07	0.61	0.42	0.42	2.89	6.91	5.57	13.75	14.20	8.23	3.42	2.05	4.96
2009	1.88	1.56	0.64	0.85	4.88	5.02	6.45	13.31	12.45	8.93	4.37	2.22	5.21
2010	1.88	1.96	1.02	1.08	2.79	2.79	8.93	17.29	9.67	5.71	2.40	1.15	4.72
2011	0.79	0.39	-	-	-	-	-	19.34	19.34	9.85	3.42	1.96	7.87
2012	1.28	0.69	0.39	0.59	3.31	8.40	11.21	10.42	17.79	6.00	2.59	1.49	5.35
2013	0.79	0.28											0.54
Ave	1.2496	0.9043	0.7117	0.8402	3.5288	5.1869	10.1528	16.6795	15.1202	7.0455	3.3248	1.8254	
Min	0.7943	0.2826	0.3863	0.4244	2.1793	2.7902	5.5680	10.4247	9.6650	3.9248	1.9969	1.1471	

Source: KANSAI

Table 6.10-6 Specific Minimum Discharge of the Month

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
2004	-	-	-	-	-	-	-	-	3.7695	1.4923	0.7593	0.4581	1.62
2005	0.3137	0.2325	0.2325	0.2325	0.8286	1.3987	3.4733	7.3974	9.7870	2.2320	1.3987	0.7593	2.36
2006	0.4069	0.3137	0.3137	0.6297	2.2320	2.3498	7.0833	9.5450	5.6149	2.4707	1.7912	0.8286	2.80
2007	0.6297	0.4581	0.4069	0.2517	1.0548	1.2641	4.2364	5.6149	4.6464	3.1893	1.2641	0.8286	1.99
2008	0.4069	0.2325	0.1614	0.1614	1.0993	2.6287	2.1171	5.2285	5.3989	3.1300	1.3016	0.7782	1.89
2009	0.7144	0.5949	0.2441	0.3227	1.8568	1.9075	2.4520	5.0608	4.7337	3.3970	1.6608	0.8448	1.98
2010	0.7144	0.7460	0.3887	0.4121	1.0609	1.0609	3.3970	6.5730	3.6749	2.1712	0.9141	0.4362	1.80
2011	0.3020	0.1469	-	-	-	-	-	7.3528	7.3528	3.7461	1.3016	0.7460	2.99
2012	0.4863	0.2627	0.1469	0.2262	1.2598	3.1957	4.2636	3.9638	6.7638	2.2815	0.9861	0.5667	2.03
2013	0.3020	0.1074											0.20
Ave	0.4751	0.3439	0.2706	0.3195	1.3417	1.9722	3.8604	6.3420	5.7491	2.6789	1.2642	0.6941	
Min	0.3020	0.1074	0.1469	0.1614	0.8286	1.0609	2.1171	3.9638	3.6749	1.4923	0.7593	0.4362	

Source: KANSAI

Environmental flow for affected river reach caused by construction and operation of the Project is determined 0.2 $m^3/s/100km^2$-catchment area by referring to the minimum environmental flow requirement at other hydropower projects in Lao PDR. Table 6.10-7 shows actual minimum discharge at the intake weir. This flow amount occurs in around 10 months out of recorded 26 dry season months and represents around 4% or 1/25 of annual average flow.

Table 6.10-7
Minimum Environmental Flow

Location	Catchment Area (km^2)	Environmental Flow (m^3/s)
Intake Weir	263	0.52

(3) Evaluation of Landscape Preservation Flow

Minimum environmental flow for preserving aesthetic value of the Xe Katam Fall and keeping the value of tourism resource was evaluated from correlation between actual discharge and visibility of the Xe Katam Fall. Table 6.10-8 and Figure 6.10-1 present measured discharge in 2004 and 2005 and pictures of the Xe Katam Fall at each discharge, respectively.

The minimum requirement for preserving visual value was determined by consultation with governmental officers of Champasak Province. Conclusively, it was determined that 0.73 m^3/s is required. This amount corresponds to the 0.67 m^3/s at the intake weir. The water from intake weir for the purpose of preserving visual value will be released during daytime.

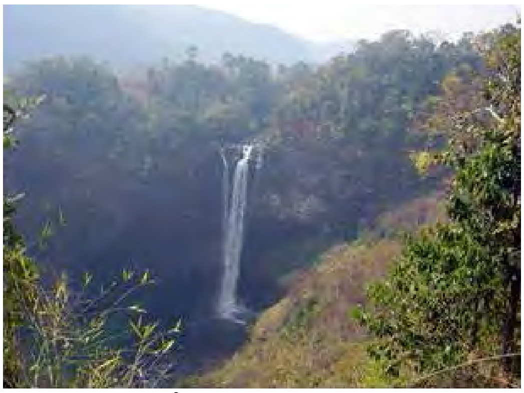
The larger volume of the environmental flow and the landscape preservation flow will be actually discharged from the intake weir.

Table 6.10-8 Converted Discharges at Waterfall on the Date of Photographing

(Unit m³/s)

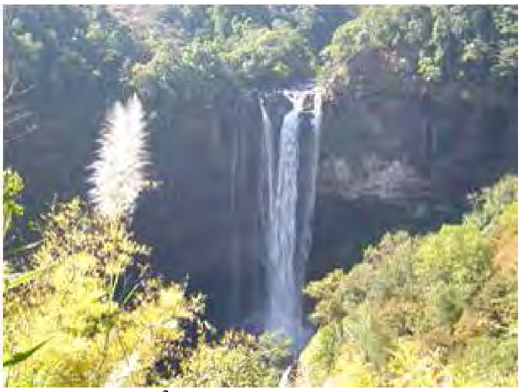
Location	CA (km^2)	2004		2005									
		11/10	12/26	01/22	02/21	04/06	05/13	06/27	07/18	08/15	09/24	10/30	11/22
Gauging Station	178	2.21	0.94	0.58	0.51	0.43	1.91	4.33	8.16	26.06	23.24	4.01	2.87
Intake Weirs	263	3.26	1.39	0.86	0.75	0.64	2.83	6.40	12.06	38.51	34.34	5.93	4.24
Waterfall	300	3.72	1.58	0.98	0.85	**0.73**	3.22	7.30	13.75	43.93	39.17	6.77	4.83

0.73m^3/s, April 6, 2005



0.85 m^3/s, February 21, 2005

0.98 m^3/s, January 22, 2005



1.58 m^3/s, December 26, 2004

13.75 m^3/, July 18, 2005

43.93 m^3/s, August 15, 2005

Figure 6.10-1 Photos of Xe Katam Fall at Each Discharge

6.11 Environmental Management Plan

6.11.1 Natural Environmental Management Plan

(1) Environmental Management Plan during Construction

Head Contractor shall prepare a Contractor's Environmental Management and Monitoring Plan (CEMMP) during construction as shown in Table 6.11-1. The project developer shall prepare the unexploded ordnances (UXO) plan and put it in Environmental Management Plan.

Table 6.11-1 Environmental Management Plan during Construction

Plan	Contents	Implementing Agency
Soil Disposal Management Plan	The objective of this activity is to minimize negative impacts from disposal of spoil from excavation activities. ・ Topsoil removal for landscaping after closure. ・ Re-vegetation and permanent drainage of sites after closure	HC
Domestic Waste Management Plan	The objective is to minimize the pollution associated with handling and disposal of domestic waste at the construction sites and camps in order to avoid water pollution. ・ Domestic waste segregation ・ Proper disposal of discharged water ・ Seeding of topsoil and revegetation after construction	HC
Emergency Plan for Hazardous Materials	The objective is to minimize or prevent impacts in the event of spills or accidental releases of hazardous materials. ・ Procedures for immediate actions specified for all relevant hazardous materials used in the construction processes. ・ Complete list of equipment of available for use in emergency situations. ・ Warning procedures for neighbors and downstream in cases of accidental release of hazardous substances. ・ Procedures for immediate information to XKHC/ECO in case of discharges and standards for reporting. ・ Program for training of key staff in emergency responses.	HC
Emission, Dust Control and Noise Plan	The objective is to minimize emissions of pollutants and noise from vehicles and equipment used for construction activities, and minimize dust from construction areas and unpaved roads within the construction areas. ・ Ensure spraying water on unpaved access roads ・ Monitor noise and vibration ・ Establish working hours for construction activities with consultation of neighboring village authority	HC
Waste Water Management Plan	The HC will develop a Waste Water Plan, for proper management of liquid waste from construction activities. ・ Adherence of the effluent standard by proper disposal of sanitary and grey water ・ Control of soil erosion and sediment rich water from construction activities by sedimentation ponds or silt traps ・ Discharge from the silt trap to the existing drainage system and rivers shall be less than 50 mg/L of TSS ・ Monitor water quality	HC
Traffic Management Plan	The objective is to control traffic and access to construction sites. ・ Speed limits for different road sections ・ Specification of parking sites for all vehicle types ・ Signal and warning sign measures	HC

Plan	Contents	Implementing Agency
Landscaping and Re-vegetation Plan	The objective is to reshape and revegetate construction sites for erosion control and visual appearance. ・ Restoration of land where the natural vegetation has been destroyed or damaged to its original cover. ・ Only local plant species should be used for replanting and erosion control.	HC/ XKHC
Unexploded Ordinances (UXO) Plan	The XKHC and the HC shall prepare a UXO Survey and Clearance Plan for all construction sites. ・ Contracting a qualified firm with detailed procedures for identifying, securing and disposing of UXO's. ・ Clear instructions to all staff on how to behave if a UXO is found.	HC /XKHC
Protection of Eco-system Plan	The objective is to establish and conduct a comprehensive plan for protection of eco-system. ・ Prohibition of hunting and fishing inside and the vicinity of the Project area ・ Prohibition of unnecessary tree cutting ・ Awareness of protected area (including Xe Katam Provincial Protected Forest) and specific flora and fauna species which are important ・ Educational program for workers	HC
Health, Safety and Security Management Plan	The objective is to establish and conduct for keeping labors' health, avoiding accident and prevention of interruption from outsiders. ・ Organization of education, monitoring and reporting ・ Establishment of prevention programs for avoiding diseases, accidents for labors ・ Education of communicable diseases such as tuberculosis, HIV/AIDS	HC
Education Program	Planning activities shall be properly documented and disseminated to labors by periodical education. The education shall include the awareness of local community, ethnicity, culture, historical importance and other public related matters.	HC

Note: HC : Head Contractor, XKHC : Xe Katam Hydropower Company (project developer),
ECO : Environment and Community Office (See Section 6.14.1),

(2) Environmental Management Plan during Operation

ECO of the XKHC will be responsible for preparing and implementing the action plans shown in Table 6.11-2.

Table 6.11-2 Environmental Management Plan during Operation

Plan	Contents	Implementing Agency
Discharged Water/ Wastes Disposal Plan	・ Establishment of Permanent system for wastewater treatment, solid waste handling, oil collection ・ Monitoring	XKHC
Emergency Response Plan in case of an accidental release of oil	・ Establishment of Emergency Response Plan in case of an accidental release of oil from transformers or other installations at the power plant control site.	
Emergency Response Plan in the case of intake failures	・ Establishment of Emergency System in the case of intake failures or unexpected floods.	
Water Flow Management Plan	・ Establishment of monitoring system of released water from the intake weir	
Downstream Safety Plan	・ Downstream Safety Plan for release of the water by either generating operation or flooding operation. It shall include: - Caution siren at water release - Controlling measures of water release considering the incremental rate of water level - The monitoring plan of river conditions after big flood event	

(3) Monitoring Plan of River Flow, Water Quality and Aquatic Biota

The change of river flow regime will potentially cause fluctuation of river flow, and will impact on the followings;

(a) Residential water usage
(b) Scenery of the Xe Katam Water Fall
(c) Population and diversification of species of aquatic biota

For the purpose of identifying the impacts and studying/implementing mitigation measures, water quality, river profile and fish/aquatic habitat will be monitored. Water quality and aquatic biota will be monitored at the locations shown in Figure 6.11-1. Water level, water cross section and water flow will be monitored at the locations shown in Figure 6.11-2.

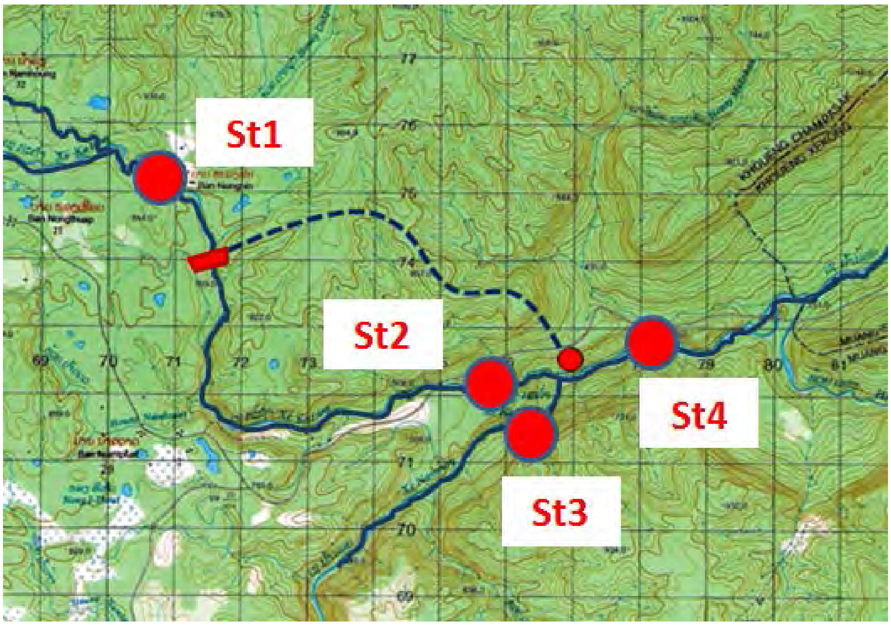


Figure 6.11-1 Surface Water Quality and Aquatic Habitat Sampling Locations

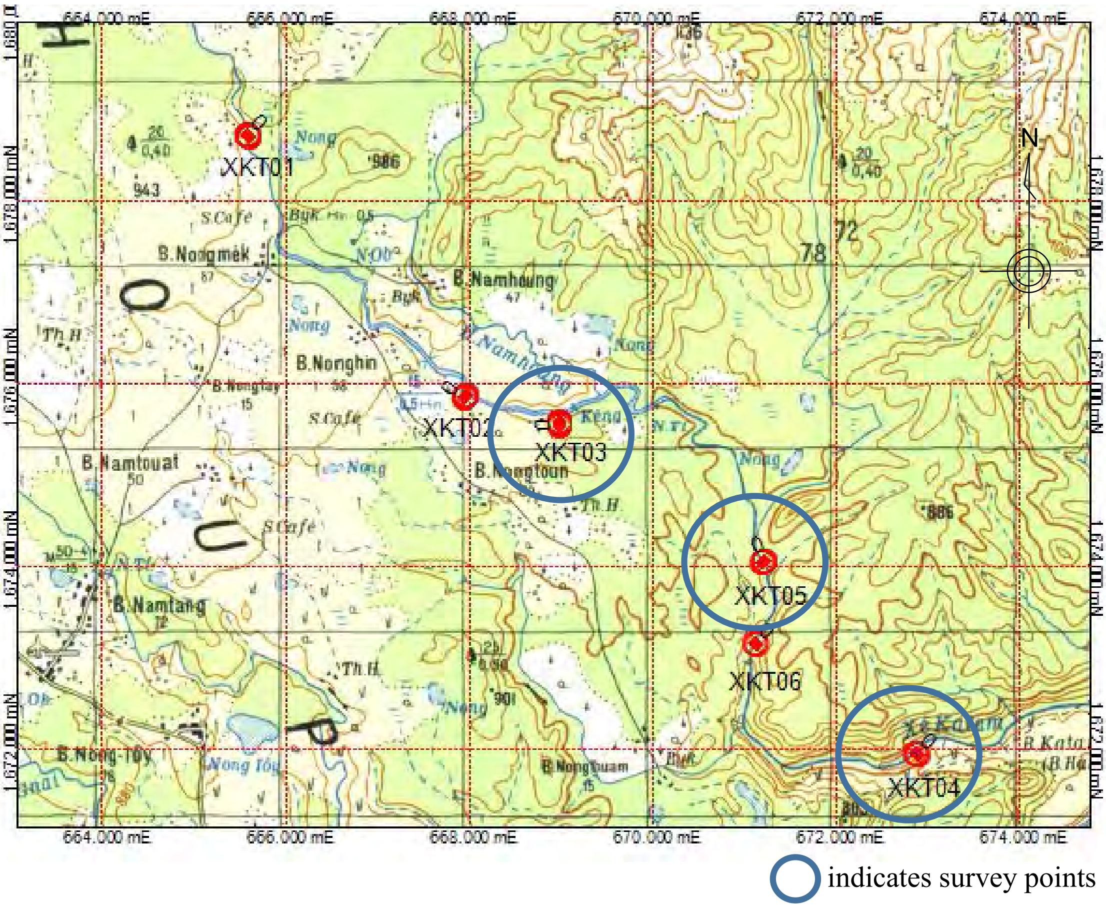


Figure 6.11-2 Location Map of River Section Survey

6.11.2 Social Environment Management Plan

As an implementation and management plan of mitigation measures for impacts on social environment, Compensation and Community (Ethnic People) Development Plan was prepared. This plan is considered as a simplified resettlement action plan in JICA Guideline though regulations in Lao do not require a Resettlement Plan for projects which involve relocation of one house. Besides procedures of compensation, implementing organization and grievance redress mechanism, this plan includes Community Development Plan, Ethnic People Development Plan, Vulnerable Group Development Plan and Gender Development Plan. Note that this Compensation and Community (Ethnic People) Development Plan was prepared referring to opinions from experts of Lao Academy of Social Science and Village Focus International (NGO, assisting sustainable development in villages at rural area).

(1) Community Development Plan

The community development plan was prepared based on the result of consultation meetings and the socio-economic survey. Summary of community development plan is shown in Table 6.11-3. Concrete contents of the development plan will be decided by Village Committee (VC) and then through approval of the provincial Compensation Committee.

The community development plan is established for Nong Thuam and Nam Touad as affected villages. Beside those villages, parts of the plan will be implemented in Nong Hin village as some villagers will be affected by land acquisition.

Vocational training is targeting about 10 villagers per year for 10 years from commencement of the Project, with total of 100 villagers. Vulnerable and women will be given priority at the selection of trainees. Detailed training programs and target income level after the Project will be determined by provincial Compensation Committee through consultations with PAPs. Examples of vocational trainings in other projects are handicraft, small scale husbandry, marketing of agricultural products and livestock, accounting, electrician and mechanic.

Table 6.11-3 Community Development Plan

No.	Plan	Summary	Village
1	Education Service Support	・One primary school reconstruction with 3 rooms and toilet at Nong Thuam	Nong Thuam *GOL is planning to reconstruct the primary school at Nam Touad.
		・Provision of teaching materials such as textbooks and teaching tools during construction and operation ・Support to vocational training scholarships (ten persons per year) during construction and operation	Nong Thuam, Nam Touad, Nong Hin
2	Health Service Support	・Training of Village Health Volunteer (VHV) during construction ・Provision of medical products during construction	Nong Thuam, Nam Touad
		・Supply of household toilets ・Prevention measures of Malaria and other diseases: education, distribution of mosquito-net and medicines for two years during construction	Nong Thuam, Nam Touad, Nong Hin (to all families)
3	Fishery and Aquaculture Development	・Development of fishery regulations for sustainable management and use of fishery resources ・Development of fishery management organization in fish ponds and intake weir pond ・Development of breeding control and establishment of fish ponds for stable supply during construction and operation	Nong Thuam, Nam Touad
4	Training	・Training of management capacity development for four years during construction	Nong Thuam, Nam Touad, Nong Hin (for village's management organization)
		・Vocational training to improve incomes for gender and vulnerable group for four years during construction	Nong Thuam, Nam Touad, Nong Hin (for vulnerable group and women)

(2) Ethnic People Development Plan

Affected people in Zone 1 are categorized as the ethnic minority or indigeouous people, Nyaheun, according to World Bank OP 4.10. The impact analysis and mitigation measures were studied in consideration with the character of Nyaheun based on the survey result. The result of study is shown in Table 6.11-4.

Table 6.11-4 Impact on Ethnic Group and Mitigation Measures

No.	Survey results of Nyaheun	Potential Impact	Mitigation and Management Measures and Programs
1	Some women cannot speak Lao language.	Misunderstanding due to language barrier	Literacy training program by specialists
2	Animism is common. Nyaheun has the custom that they devote cows, pigs and chickens as sacrificial victim for good crop, disease, natural disaster.	Impact on the terrestrial sprits	Facilities were designed to minimize disturbance to or loss of Ethnic People's (EP) territorial spirits. But if the impact of territorial spirits is found, agreement with ritual leaders and villagers about ritual arrangements is necessary as well as support to conduct rituals.
3	There are cemeteries around the project site.	Damage of cemeteries	Though cemeteries were not found in affected area, the detailed survey is necessary to confirm whether there are cemeteries before construction. If replacement of cemeteries is unavoidable, the countermeasure should be determined through consultation with the ethnic group chief and related parties.
4	There are sacred places around the project site.	Damage of sacred places	Facilities were designed to minimize disturbance to or loss of EP's sacred places. But if the damage of sacred places is unavoidable, consultation is conducted for proper countermeasure including design change.
5	Nyaheun has their own history and culture.	Impact on their history and culture	Regular consultation (once per month) will be held with ethnic leaders to arrange the construction and operation schedule.

(3) Vulnerable Group Development Plan

The project company will engage a gender/community specialist to review the vulnerable group situation, develop specific plans for improvement of their living standard and implement the plans in consideration with the followings;

1) Provision of supplemental food supply during the livelihood restoration period for 1-2 years.
2) Provision of medical checks, medicine and mosquito nets.
3) Disabled receive some training in handicrafts if necessary.
4) Priority and special attention are given in vocational training and material support, for example, handicraft, small livestock, small fish or frog ponds, and NTFP gardens.
5) Development of awareness and access to markets and prices with particular attention to the low levels of numeracy and literacy.

(4) Gender Development Plan

The interviews revealed that women have disadvantage on lives as followings;

The proportion of females completing primary and secondary schools is lower than males.
Women's health in the Project area is often affected by daily workloads and maternity.

For improvement of woman's life, the project company will engage a gender/community specialist and prepare a detailed plan with the following considerations;

1) The livelihood restoration and community development plans are implemented by specialists from the inception phase. Specialist visit to follow up with regular 2 - 3 months.
2) Women of every household participate fully in all planning and making decisions and surely understand the livelihood development plan.
3) Encouragement of attendance to schools
4) Women in every household can obtain information to choose adequate training and the livelihood development options.

6.12 Monitoring Plan

The negative impact items by the Project will be monitored during construction and during operation.

6.12.1 Evaluation System of Monitoring Result

The project company conducts monitoring, regularly reports the result to GOL and takes corrective measures if the outcome is above the standard.

Table 6.12-1 Government Compliance and Liaison

Activity/ Frequency	Monitoring Item	Indicator
Progress meetings / 3 months XKHC/Province/ District	Quarterly reports XKHC's responses or instructions	Minutes of meetings and reports
CC and DWG/ XKHC monthly meeting	Resettlement and Compensation monthly progress reports	Minutes of meetings and reports
EC and DWG/XKHC monthly meeting	Physical-Biological monthly monitoring reports.	Meeting of minutes and reports

XKHC: Xe Katam Hydropower Company、CC: Compensation Committee、DWG: District Working Group

6.12.2 Natural Environmental Monitoring

Natural environmental monitoring plan is shown in Table 6.12-2.

Table 6.12-2 Natural Environmental Monitoring Plan

No.	Item	Frequency	No. Location	Implementing Agency	Responsible Agency
1	Air quality: TSP, PM_{10}, So_2, NO_2	2/year	2	HC	HC
2	Noise	1/month	4	HC	HC
3	Water quality: Surface water	Described in Table 6.12-3	4	XKHC	XKHC
4	Waste water	1/week (during construction)	3	XKHC	XKHC
5	Water quality: Aquatic biota	2/year (rainy and dry season)	4	XKHC	XKHC
6	River bank erosion and sedimentation: cross section survey	1/year	3	XKHC	XKHC
	Water flow (depth, width, velocity)	3/year (in rainy season)			

Table 6.12-3 Water Quality Monitoring Items (Drinking Water)

Parameter	Symbol	Frequency	Locations
Temp Air	T air	1/Month during Construction 1/Quarterly during Operation	**Surface Water**
Temp Water	T water		4 sites
pH	pH		
Dissolved Oxygen	DO		
Total Coliform			
Biological Oxygen Demand	BOD		
Chemical Oxygen Demand	COD		
Total nitrogen	Tot –N		
Total phosphate	Tot P		
Total suspended solids	TSS		
Chlorophyll	Ch-a		
Nitrate – nitrogen	NO3		
Conductivity	Ec		
Ammonia-nitrogen	NH3=N		
Alkalinity	Ca CO_3		
Hardness		1/Quarterly	
Fecal Coliform			
Phenols	C_6H_3OH		
Copper	Cu		
Nickel	Ni		
Manganese	Mn		
Zinc	Zn		
Cadmium	Cd		
Chromium	Cr6		
Lead	Pb		
Mercury	Hg		
Arsenic	As		
Cyanide	Cn		

Table 6.12-4 Waste Water Monitoring Items

Parameter	Frequency	Locations
Potential of Hydrogen(pH)	1 × week During Construction	2
Biological Oxygen Demand (BOD)		1 × Main camp/office
Chemical Oxygen Demand (COD)		2 work sites
Total Nitrogen (T-N)		
Total Phosphorous (T-P)		
Oil and Grease		
Total Suspended Solid (TSS)		
Total Coliform Bacteria		

Table 6.12-5 Water Quality Monitoring Items (Aquatic Biota)

Parameter	Unit	Frequency	Av. Value	Max Val	Lao Std	No. Locations
Temperature	°C	2/year - start rainy season & dry season			6-9	4
pH					30	
Conductivity	Cm				125	
Alkalinity	Mg/liter				10	
Hardness	Mg/liter				2	
Dissolved Oxygen	Mg/liter				10	
Ammonia	Mg/liter				50	
Nitrate	Mg/liter				400	
Nitrite	Mg/liter				6-9	
Free CO_2	Mg/liter				30	
Phosphate - phosphorus	Mg/liter				125	

Table 6.12-6 Cross Section Survey Items

Parameter	Unit	Frequency	Av. Value	Max Val	No. Locations
X – Section Surveys	Profile	1/year	Profile Change Analysis		3
Water Flows					
- Flow Depth		3 × rainy season × 3 days			
- Flow Width					
- Flow Velocity					

6.12.3 Social Environment Monitoring

Social Environment Monitoring Plan is shown in Table 6.12-7. Note that the period of monitoring etc. will be determined by consultation with relevant governmental agencies at the implementation stage.

Table 6.12-7 Social Environment Monitoring Plan

Monitoring Items - Parameters	Monitoring Results for Period	Responsible Authority
Permanent Loss & Relocation at Zone 1 & 2 –	• ECO with assistance of DWG and VC summarize compensation status monthly and report to CC and GOL (if necessary) quarterly. • GRC reports cases and settlement records to CC and GOL (if necessary) quarterly.	XKHC
Temporary Losses of Land & Crops at Zone 1 & 2	• ECO with assistance of DWG and VC summarize compensation status monthly and report to CC quarterly.	
Compensation and Community (Ethnic People) Development Plan	• ECO with assistance of DWG and VC summarize actual activities in reports below and report to CC quarterly. • Education support reports • Health and sanitary support reports • Fishery program reports • Training reports	
Vulnerable Group	• ECO with assistance of DWG and VC summarize actual activities in reports below and report to CC quarterly. • Nutrition and shelter security report • Health security assistance report • Work plans for vulnerable households • Employment/ income generation assistance report	
Gender Development	• ECO with assistance of DWG and VC summarize actual activities and report to CC quarterly.	
Communication - Language	• Language training report of ECO to submit to CC quarterly	
Cultural Heritage • Sacred Places • Spirit Territories • Cemeteries • Cultural Activities • Historic /Natural Structures • Archeological Sites	Monthly checks summarized in quarterly reports to GOL and Developer. Confirmation that: • All sites of spiritual significance avoided or appropriate arrangements made to respect EP concerns. • Cultural activities respected in construction activities. • Archeology site discoveries notified to GOL	

XKHC: Xe Katam Hydropower Company, CC: Compensation Committee, VC: Village Committee, DWG: District Working Group, ECO: Environment and Compensation Office

6.13 Grievance Redress Mechanism

After the Project has been approved by GOL, the project company requests to GOL establishment of a Grievance Resolution Committee (GRC) in Pakxong District. Members of the committee are;

1) A local government representative
2) Village head(s)
3) Representatives of the affected households, other than village heads
4) Village elders or local level representatives of mass organizations or other relevant agencies
5) Project company's representatives

Grievance redress procedure is as below;

1) Project authorities should make every effort to find amicable settlement to the complaints or grievances brought up by PAPs at the project level. If the PAPs are not satisfied with the decision of the project authorities within 15 days from the filing of the complaint, the complaints can then be forwarded to the GRC.

2) If the GRC cannot resolve the problem within 20 days of filing the complaint, or PAPs cannot receive any response from the GRC, PAPs will submit the complaint to the head office of the project owners and MONRE.

3) If the matter still remains unresolved within 20 days of filing the complaint to the project owner and MONRE, PAPs will forward the complaint to the court.

6.14 Implementing System and Schedule

6.14.1 Implementing System

Implementing organizations and their role in land acquisition and resettlement are explained in Table 6.14-1, implementing structure is depicted in Figure 6.14-1

Table 6.14-1 Implementing Organizations and Role

Organization	Role
GOL	
Compensation Committee (CC)	CC works on policy, determine compensation standard and approvals of Compensation.
Environmental Committee (EC)	EC conducts monitoring of environmental impacts by the Project and approves necessary corrective actions.
District Working Group (DWG)	DWG works with ECO to implement compensation, resettlement and mitigation measures.
Village Development Committees (VC)	VC works with ECO and DWG to implement compensation and resettlement work and resolve grievances from PAPs.
Grievance Resolution Committees (GRC)	GRC resolves grievance from PAPs through a process set forth in Government guideline regulations.
Project company	
Environment Community Office (ECO)	ECO are set up by the project company (XKHC), and implements Natural and Social Environmental Management and Monitoring Plan (NSEMMP) and to co-ordinate with GOL.
Contractor	
Head Contractor (HC)	HC prepares Contractor's Environmental Management and Monitoring Plan (CEMMP) and makes an effort to avoid and mitigate the negative impact on natural and social environment.
Sub-Contractors	Sub-Contractors implements CEMMP.

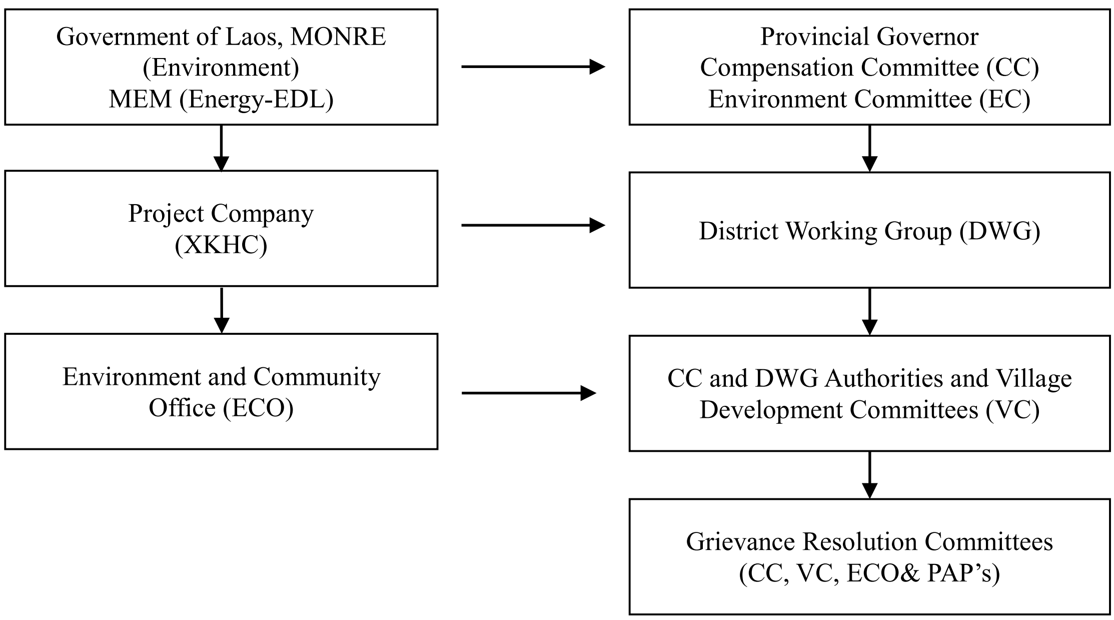


Figure 6.14-1 Implementing Structure

6.14.2 Implementing Schedule

Implementing schedule of compensation and the environmental and social management plan is shown in Table 6.14-2.

Table 6.14-2 Implementing Schedule

Plan Activity	Year 1				Year 2				Year 3				Year 4				Year 5			
	Construction start ▼												COD ▼							
Province establishes CC and EC.	■																			
Work Timetables / Budgets reviewed.	■	■			■	■			■	■										
Asset survey for compensation.		■	■																	
Valuation lost assets completed.		■	■	■																
Compensation explained to PAPs.				■																
PAP cash compensation approved and paid.				■	■	■														
PAP land/crop restoration values approval.				■	■	■	■													
GRC formed					■	■														
PAP work plans/budgets completed.							■													
Community Development Plan approval.									■	■	■									
1 new Primary schools with toilets						■	■	■	■	■	■									
2 fish ponds built and weir pond vegetation clearance						■	■	■	■	■	■									
Toilet upgrade.						■	■	■	■	■	■									
HIV/AIDS/STD training.	■	■	■	■	■	■	■	■	■	■	■	■								
School materials support					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gender Vulnerable group support plans.									■	■	■	■	■	■	■	■	■	■	■	■

6.15 Public Consultation Meeting and Stakeholder Meeting

6.15.1 Implementing Measures of Public Consultation Meeting and Stakeholder Meeting

Decree on Environmental Impact Assessment (Decree 112/PM, 2010) requires project developer to hold Stakeholder Consultation Meeting (SCM) before implementing the project and public participation in planning the environmental and social impact mitigating plan. The Decree 112 requires at least four (4) SCMs before the permission of Environmental Compliance Certificate.

1) Village Dissemination Meeting: for introducing project to PAPs and obtaining PAPs' opinion.

2) Village Level Consultation Meeting: for explaining 1st draft of EIA documents to PAPs and obtaining PAPs' opinion.

3) District Level Consultation Meeting: The project developer reflects PAPs' opinion at the Village Level Consultation Meeting to revised EIA documents (2nd draft EIA documents) and explain them at the SCM and obtain opinions.

4) Province Level Consultation Meeting: The project developer reflects opinions at the District Level Consultation Meeting to revised EIA documents (3rd draft EIA documents) and submit them to MONRE. After receiving review result and comments from MONRE and relevant governmental agencies, the project developer revise the EIA document (final draft EIA document). Final draft is explained at the Provincial Level Consultation Meeting and obtain opinions from PAPs and governmental officers of both provincial and central level.

Village Dissemination Meetings were held in June 2013. Taking this meeting as an example, actual procedures of SCM are explained below. Note that a SCM implementation plan is established before the SCM, which include meeting schedule, place, objectives, expected attendants, explanation manner, meeting procedure. Further note that SCM are organized in a manner that participants feel free to speak including wider range of years and females.

1) Developer, through engaged environmental consultant, request Provincial Office of Environment and Natural Resources (PONRE) to hold a SCM.

2) PONRE instruct holding SCM to District Office of Environment and Natural Resources (DONRE). DONRE requests village leader and village authorities to hold a SCM and announcement to public.

3) Village leader and/or village authorities announce all villagers about date and venue through verbal communication and/or village communication board.

4) SCMs are held with participation of officers from PONRE and DONRE with procedure below;
   a) Registration of participants
   b) Explanation of the Project and expected positive/negative impacts on environment and social aspect by the developer or engaged environmental consultant using flip chart and handout.
   c) Participants then are divided into three groups and group discussion takes place. Contents of groups are basically i) male and female group, ii) female group and iii) vulnerable group. A presenter of environmental consultant joins each group.
   d) A selected representative of each group presents result of group discussion to other groups.

e) Wrap up and finalization of meeting minutes. Meeting minutes is confirmed and signed by usually District Officer and Village Leader.

5) The explanation is made by Lao standard language. An interpreter is attended.

Figure 6.15-1 shows SCM held in June 2013.

Figure 6.15-1 Stakeholder Consultation Meeting at Nong Mek Village

These SCMs were held for the original project plan with the dam type design and the Provincial Level Consultation Meeting was held in November 2014 as the final step. Then the design was revised to the run-of-river type. The Provincial Level Consultation Meeting was held again for the revised design in May 2015.

6.15.2 SCM Records in Power Plant Area

Eleven (11) SCMs were held including Technical Workshop with MONRE. Five (5) meetings were for villagers impacted by dam, power generation facilities and access road. Others were a village officer meeting with JICA and consultation meetings at district and provincial level.

Table 6.15-1 SCM Records

No.	Date	SHM
1	11-16/Jun/2013	1st village level consultation meeting
2	20-21/Dec/2013	2nd village level consultation meeting
3	12-13/Feb/2014	3rd village level consultation meeting
4	09/May/2014	4th village level consultation meeting
5	12/Jun/2014	District level consultation meeting
6	27/Aug/2014	Technical workshop
7	30/Aug/2014	Village officer meeting
8	15/Oct/2014	Additional village level consultation meeting
9	21/Nov/2014	Provincial level consultation meeting
10	19/May/2015	Provincial level consultation meeting for the revised design
11	15/July/2015	PCM Follow-up meeting for the revised design

(1) 1st Stakeholder Meeting at Village Level

The first SCM in June 2013 with five villages expected to be affected by the dam, power generation facilities and access road construction resulted in no serious objections. Participants were provincial and district governmental authorities, village leaders and villagers. The concerns that were expressed related to compensation being fair and adequate. The record of meeting attendance and summary of proceedings is given in Table 6.15-2 below:

Table 6.15-2 First Meeting June 2013 Power Generation and Road Construction Zone

Village	Day, Time	Participants (Total/ Female)	Summary of Requests and Concerns.	Responses/Remarks
Nong Mek	June 11	40/19	1) Request of appropriate compensation for affected land, property and crop. 2) Request to supply rice during new rice plantation period (3 to 5 years) 3) Request to develop infrastructure (school, hospital and clean water system) 4) Request to support vocational training 5) Request to develop land for compensation 3 to 5 years in advance to ensure productivity 6) Request to check the details of affected lands and properties.	1) accepted 2) to 5) Requests will be considered and compensation policy will be explained at the next meeting 6) accepted
Nam Houng	June 13, 10:00 am	39/8	1) Affirmative response to the Project. 2) Request of appropriate compensation for affected land. 3) Request to supply rice during livelihood restoration period. 4) Request to develop infrastructure (road, school, clinic and clean water system) 5) Request to support vocational training (agriculture, animal raising, health service, handicrafts, etc.) 6) Request to supply experts to support livelihood restoration. 7) Proposal of land resettlement site (old Non Hin Village)	2) accepted 3) to 6) Requests will be considered and compensation policy will be explained at the next meeting 7) proposed land will be investigated
Nong Hin	June 14, 9:00 am	36/16	1) Request to compensate affected land and develop new land. 2) Request to supply rice during livelihood restoration period. 3) Request to develop infrastructures (road, school, clinic and clean water system) 4) Request to support vocational training (agriculture, animal raising, health service, handicraft etc.) 5) Request to supply experts to support livelihood restoration. 6) Proposal of land resettlement site (8km east of Non Hin, now belonging to Nam Houng)	1) accepted 2) to 5) Requests will be considered and compensation policy will be explained at the next meeting 6) proposed land will be investigated.
Nong Thuam	June 15	32/5	1) Request of appropriate compensation for losses and to develop new land. 2) Request to supply rice during livelihood restoration period (3 to 5 years) 3) Request to develop infrastructures (road, electricity and clean water system). 4) Request to provide fund to support education (renovation or built school) and scholarship. 5) to explore and develop land, located in the state conservative forest. This area has plenty of water from streams.	1) to 4) Requests will be considered and compensation policy will be explained at the next meeting 5) proposed land will be investigated.
Nam Touad	June 16, 10:00 am	16/6	1) Affirmative response to the Project. 2) Request of support infrastructure (school, clinic, village office and clean water system) 3) Request to supply electricity if possible 4) Request to supply scholarship for vocational training if possible 5) Request of appropriate compensation for affected land, property and crop. 6) Request to develop new land	2) to 5) Requests will be considered and compensation policy will be explained at the next meeting 6) proposed land will be investigated.

(2) 2nd Stakeholder Meeting at Village Level

The second SCM presented the Project and its impacts in more detail including explanation of assessment results with compensation package and the livelihood restoration proposals. Participants were provincial and district governmental authorities, village leaders and villagers. Two of the four villages which participated in the meeting had no objection to the Project proceeding but two villages, Nam Houng and Nong Mek, totally opposed to the Project. The record of attendance at these meetings and issues discussed is shown in Table 6.15-3.

After the second SCM, Pakxong District assembled village representatives in January 2014 to hear their opinions and discuss further steps. At the meeting, the Project owner explained to fairly implement compensation in accordance with laws. The local government addressed the importance of the Project.

Table 6.15-3 Second Meeting December 2013 Power Generation and Road Construction Zone

Village	Day, Time	Participants (Total/ Female)	Summary of Requests and Concerns.	Response/Remarks
Nong Mek	Dec 20 pm	57/15	1) They object to the Project proceeding because they have never been properly compensated by previous projects. 2) The land for livelihood restoration is already occupied by other persons. 3) If Project proceeds, all social obligations must be met 3 years before Project proceeds. 4) The Project should provide jobs to local people for 5 years before construction starts. 5) Vocational training and scholarships should be provided to 5 persons per year. 6) Replacement land provided must be good quality and at least the same size. 7) The company must inform and compensate for losses appropriately in advance.	2) Proposed land has enough vacant area for land replacement. 3) Social obligation of the developer strictly follow Lao regulations. 4) The Project will bring job opportunities, but starting with construction works. 5) Vocational training is included in the Community Development Plan together with education support plan. 6) accepted 7) accepted
Nam Houng	Dec 20 pm	50/11	1) They disagreed with the Project due to reservoir formation. Replacement land proposed is already being occupied. 2) If the Project proceeds it must respond to their 15 requests given in writing on 15 August 2013 that included: - Replacement all houses with cement/brick structures - Infrastructure must include electricity, water supply, access road and bridge. - Develop pasture and fish ponds and purchase livestock and fish for ponds - Supply agriculture production equipment. - During development new land supply food, household utilities and clothing. - Support medicine supply fund for the Project life. - Support 6 scholarships per year for secondary education.	2) The compensation and livelihood restoration plan will follow the Lao regulations. Some of the requests are beyond the regulations and will not be accepted.
Nong Hin	Dec 21 am	26/6	1) No objection to June meeting proposals and specific proposals presented for livelihood development on replacement land and community health and education improvement at the meeting. 2) Development of production land must be in parallel with Project development. 3) If mitigations change, the mitigations must provide benefits of equivalent or higher value.	2) accepted 3) accepted
Nong Thuam	Dec 21 pm	18/3	1) No objection to June meeting proposals and specific proposals presented for livelihood development on replacement land and community health and education improvement 2) Development of production land must be in parallel with Project development.	2) accepted

(3) 3rd Stakeholder Meeting at Village Level

The 3rd SCM was held in February 2014. Participants were provincial and district governmental authorities, village leaders and villagers. All affected villages including Nong Mek and Nam Houng accepted the Project proposal. Village head of Nong Mek presented his concern about condition of the proposed resettlement site (Old Nong Hin). The discussion of the meeting is summarized in Table 6.15-4.

Site reconnaissance was held at Old Nong Hin in April 2014 responding villagers' concern about the resettlement area, which was headed by Pakxong District. Representatives of Nong Mek and Nam Houng villages participated in the site reconnaissance. Representatives of Pakxong District explained the suitability of soil based on the soil test. KANSAI expressed immediate action to implement a pilot farm. Villagers were satisfied with the resettlement site and village head of Nong Mek signed the minutes of the meeting of the 2nd village level consultation meeting.

Table 6.15-4 Third Meeting February 2014 Power Generation and Road Construction Zone

Village	Day, Time	Participants (Total/ Female)	Summary of Requests and Concerns.	Response/Remarks
Nong Mek	Feb. 12	/	• Participating villagers agreed to develop the Project but it must be built in accordance with Lao Law. • Head of Village denied signing the official meeting minutes because he has concerns about the availability and productivity of the resettled land (Old Nong Hin)	After the visit of the resettled land and input about the productive soil conditions from the District Officers, the Head of Village agreed and signed the official meeting minutes of in April 2014
Nam Houng & Nong Hin	Feb. 13	13/2	Combined meeting of the 2 Villages • They agree to the company to develop the Project but it must be built in accordance with Lao Law. • Compensation must be fair. • Developer must help with food and other basic needs while the new land is being developed until they can support themselves with better income from their new land. • Developer to support purchase household items like tools, mosquito nets, cooking utensils.	• All plans have to be approved by Government who will follow up to check work is done correctly. • Compensation according to Lao Law and complaints settled according to Government regulations. • Food and other support included in livelihood restoration plan and community development plan to be approved by Government. • Development plan will consider the support of very poor people.
Nong Thuam	Feb. 13	17/6	• They agree to construction of Project by developer and require compensation to be fair. • They want the developer to prepare the replacement land and make ready for permanent agricultural production. • They want developer to help them with food and other basic necessities to survive until they can support themselves with better income from their new land.	• All compensation will be according to Lao law. • Proposed agriculture development plan to be submitted to Government for approval. • Food and other temporary support will be included in the compensation package and be submitted to Government for approval.

(4) 4th Stakeholder Meeting at Village Level

The 4th SCM was held on 9th May, 2014. Participants were provincial and district governmental authorities, village leaders and villagers. At the meeting, entitlement matrix and community development plans were explained to villagers, including resettlement and compensation for 384 hectares of lost land, provision of 4 schools, enhancement of agriculture production, improvement of village health and sanitation, support of medicines to each village and upgrade of road and bridges. Villagers requested fair compensation of KANSAI according to the Decree 192/PM.

Table 6.15-5 4th Village Level Consultation Meetings

Date	Purpose	Venue	Attended Villages	Participants /Female
May 9	Power and Road Construction Zone (Zone 1 and 2)	Nong Mek	Nong Mek, Nam Houng, Nong Hin, Nong Thuam, Nam Touad	65/18

(5) Stakeholder Meeting at District Level

The District Level Consultation Meeting was held on 12th June 2014 involving all parties affected or involved in all the Project components with 75 participants. Parties included representatives of the concerned central, provincial and district governmental authorities and the village leaders representing the PAPs.

The developer and the consultant presented a detailed summary of the Project, its impacts and mitigation measures that were designed to improve the livelihoods of the local communities.

The main comments or concerns related to the presentation were:

- Governmental authorities requested to identify Project area, forest are and forest type more clearly and with more detail, and to provide enough budget for monitoring and support for government.
- The District authority would like to see more support to the Lao Women's Union (LWU) to promote income opportunities for women.
- Village representatives advised they supported the Project, requested working closely with authorities in developing Project, consider households with developed land in area and development of alternative land for impacted families, and requested lists of assets to be rechecked.

The responses of the developer to issues raised in summary were:

- All compensation and livelihood procedures follow Lao Law and concerns on asset registration will be rechecked in the implementation of the compensation process.
- Concerning the role of the LWU, ethnic people, gender and vulnerable group development plans are to be provided with budget support that will provide a role for the LWU in the Project.
- Replacement land for families who will lose assets by reservoir formation has been soil tested, is similar to lost land quality, and suitable for improvement, agriculture and irrigation development.
- The surveys of forest and aquatic habitat diversity were completed in detail with assistance from

the National University, the Agriculture and Forestry Research Institute and Living Aquatic Resource Research Center (LARREC).

- The developer wanted to be sure that all affected persons and concerned authorities receive accurate information on the Project. The Project will not be developed if the local people do not receive a benefit and better life. Therefore the developer will follow the objectives of the Lao Government regulations and co-operate closely with local people and authorities to ensure compensation, livelihood and community development plans successful.

In closing the meeting the Chairman stressed the need to improve water supplies, local infrastructure, opportunities for women and community support as indicated in development plans.

(6) Technical Workshop

The joint technical workshop was organized on 27th August 2014 at office of MONRE. The objective of this workshop is discussion of technical issues about ESIA with related authorities. MONRE, Ministry of Health, Ministry of Agriculture and Fishery, and Lao Front for National Construction participated in the Technical Workshop.

(7) Village Officer Meeting

The meeting between affected villages' officials and JICA was organized on 30th August 2014. JICA aimed at hearing of villagers' opinions about the Project, entitlement, compensation policy, community development plan and so on. 11 requests were raised as a consensus of the Nong Mek villagers.

- Requests of Nong Mek village
  1) Allocate enough production land
  2) Provide water and electricity
  3) Provide a good road
  4) Improve livelihood of the villagers to be better
  5) Provide permanent school and clinic
  6) Provide scholarship for kids of affected people
  7) Provide village development fund and education fund
  8) Establish production and marketing group for selling products
  9) Provide good technique, methodology and equipment for farming
  10) New layout of the village
  11) Promotion to reserve ethnic culture, respect on ethnic culture (e.g., do not touch sacred places)

(8) Additional Village Level Consultation Meeting

The consultation meeting about Nong Mek village's requests was organized with Pakxong District Office and PAPs (Nong Mek, Nam Houng, Nong Hin, and Nong Thuam) on 5th October 2014. The number of participants was 52, 10 of them were females.

(9) 1st Provincial Level Consultation Meeting

Provincial Level Consultation Meeting chaired by the Deputy Governor of Champasak Province was held on 21st November, 2014 with 54 participants from governmental agencies, impacted villages and JICA. After the presentation of the ESIA reports, discussions were made among the participants, which are summarized below;

- Request to the developer to continue discussion with affected people

- The Project should have a committee in the implementation phase and the committee re-survey the impact and determine details.
- Livelihood restoration and community development plans shall be further studied and determined during the implementation stage.

(10) 2nd Provincial Level Consultation Meeting

As the Project design had been revised, the second Provincial Level Consultation Meeting chaired by the Director General of ESIA Department in MONRE was held on 19th May, 2015 with 22 participants from governmental agencies and impacted villages. The purpose of this meeting is disclosure about differences of affected area, compensation and mitigation measures due to change of the design from reservoir type to run-of-river type. The opinions at the meeting are summarized below;

- In general the meeting accepts principal and request to implement the Project as soon as possible;
- Request the consultant to cooperate with the Project owner to revise and update the unclear issues in the report and resubmit to MONRE again;
- The water use plan of the Project should make as minor impact as possible to downstream project. If it is necessary, the discussion is recommended to be continued;
- Before the implementation of compensation the Project in cooperation with local authorities should recollect the precise data of impacted assets and adopt the compensation plan and then submit to governmental authorities or compensation committee to review and approve;
- Request the developer to set up the environmental and social obligation into the contract with sub-contractors in order that all sub-constructors have obligation on environment care and to do not avoid the responsibility when problem occurred;
- Request the developer to publish the Project development to the affected people including other development projects at downstream in order to have good understanding and the avoidance of conflict;
- The Project should pay attention to the liaison with especially provincial, district level to have discussion and co-operation in community development in order to have the involvement of the government and community in the implementation process;
- The Project should actively establish its own responsible unit to take care of the monitoring and management with co-operation with GOL unit in the construction and operation periods;
- To solve the problem when occurred by the amicable way and negotiation base on real situation.

An officer of the Department of Energy and Mines of Champasak Province questioned to KANSAI about the impact on a small hydropower construction utilizing the Xe Katam River in between the intake and powerhouse of the Project. KANSAI responded that he already discussed with the developer of the small hydropower project, the Ministry of Energy and Mines informed its conclusion of precedential preference being held by KANSAI due to the Project Development Agreement (PDA) in 2007 and that the revised design from dam type to run-of-river type could provide more water flow to the small hydropower project than the design in the PDA.

(11) PCM Follow-up Meeting

As some villages had not been able to participate in the 2nd Provincial Level Consultation Meeting (PCM) due to sudden rain on that day. A follow-up meetings were held for those villages on 15th July, 2015. Villages for the follow-up meeting are shown in Table 6.15-6.

Table 6.15-6 Villages for PCM Follow-up Meeting

Village	Affected Village		Follow-up Meeting	
	Reservoir Type	Run-of-river Type	Village	Remark
Nong Mek	✓			Participate in PCM on 19th May, 2015
Nong Hin	✓		✓	
Nam Houng	✓		✓	
Nong Thuam	✓	✓	✓	
Nam Touad	✓	✓	✓	

- Affected Village by Run-of-river Type (Nong Thuam and Nam Touad)

  A PCM Follow-up Meeting was held for Nong Thuam and Nam Touad as affected villages by the run-of-river type with 15 participants from Paxsong District officers, village heads of Nong Thuam and Nam Touad villages and villagers of those. After KANSAI explained outline of the run-of-river type and compensation for the impact by the new design, participants of affected villages presented requests as indicated in Table 6.15-7.

Table 6.15-7 Request from PAPs by Run-of-river Type

Question and Request		Response	
Nong Thuam	・If the Project will affect the land (such as coffee garden), aquaculture and livestock should be supported as livelihood restoration measures. ・Request one new school with 6 classrooms ・Request scholarship for 15 children per year ・Request one well per 10 household for clean water ・Request support of 50% installation cost of electricity	XKHC	・Requests will be reviewed. ・Support for 50% cost of electricity installation cost will be studied at a certain time in the future.

- Affected Villages by Reservoir Type (Nong Hin and Nam Houng)

  Another 2nd PCM Follow-up Meeting was held for previously affected villages by the reservoir type with 7 participants from Paxsong District officers, village heads of Nong Hin and Nam Houng villages, and villagers of those. After KANSAI explained outline of the run-of-river type and compensation for the impact by the new design, villagers presented their opinions and requests indicated in Table 6.15-8.

Table 6.15-8 Request from PAPs by Reservoir Type

Opinion and Request		Response	
Villager	・Compensation is not required. ・Request development of road as a community development support.	XKHC	・The request was acknowledged.

6.15.3 SCM Records in Transmission Line Area

Tow (2) public stakeholders consultation meetings (SCM) in transmission line area were held.

Table 6.15-9 SCM Records for Zone 2

No.	Date	SHM
1	26-30/Aug/2013 29/Sep/2013 01-03/Oct/2013	1st village level consultation meeting
2	08-11/May/2014	2nd village level consultation meeting

In the meetings in transmission line area, PAPs did not mention concern about the impact on health by low-frequency electromagnetic field.

(1) 1st Stakeholder Meeting at Village Level (Zone 2)

1st Village level stakeholder consultation meeting with 14 villages was held in August 2013 as a Village Dissemination Meeting. Two of the villages were in the Zone 1 and 12 villages are located outside of the catchment area of the Xe Katam River. Participants were provincial and district governmental authorities, village leaders and villagers. There were no objections to the Project regarding transmission line construction. In general, no objection against the Project was raised and participants of all meetings requested assurances that compensation to be fair and in accordance with GOL guidelines and regulations.

Table 6.15-10 1st Stakeholder Meeting Attendance Record in Transmission Line Area

Transmission Line Zone – First meeting				
Village	Date	No families	No at Meeting	No Women Present
Nam Touad		31	No family land impacted. GOL only	
Nong Tuang	27/08/2013	86	33	12
Nong Thuam	26/08/2013	48	15	6
Lasasin	28/08/2013	87	9	1
Houaykong	30/08/2013	252	30	7
Nam Tang	30/08/2013	154	30	7
Nong Keuang Yai	02/10/2013	252	26	7
Nam Pod	01/10/2013	84	14	6
Nong Kin	29/09/2013	64	22	2
Chan Sa vang	01/10/2013	228	12	4
Km15	01/10/2013	174	20	6
Km 12	03/10/2013	136	48	8
Km 11	03/10/2013	85	20	6
Nong Chan	03/10/2013	101	11	3
Bangliang	03/10/2013	377	9	1
Total		**2159**	**299**	**76**

(2) 2nd Stakeholder Meeting at Village Level (Zone 2)

The 2nd village level stakeholder meetings were held in May 2014 as shown in Table 6.15-11. Participants were provincial and district governmental authorities, village leaders and villagers. Villagers requested fair compensation to KANSAI according to the Decree 192/PM.

Table 6.15-11 Village Level Consultation Meetings

Date	Venue	Attended Villages	Participants /Female
May 8	Nong Thuam	Nong Thuam, Nongtouang, Lalasin	27/5
May 10	Houaykong	Houaykong, Nam Tang	35/5
May 11	Chansavang	Nongkin, Nam Pot, Nongheuang Gnai, Chansavang, Lak 15, Lak 12, Lak 11, Nonhchan	[72/14]

APPENDIX

STUDY OF DAM WATERWAY TYPE

Appendix：Study of Dam Waterway Type

1. Main Dam

(1) Outline of Comparison of Dam Types

Suitable dam type for the Xe Katam site is selected in following studies. Power generation scheme of this project is classified into the reservoir type with an annual regulation reservoir. The reservoir is located at a depression area along the tributary of Xe Katam River to mitigate environmental impacts. Surrounding area of the dam site is a flat plain. Therefore the main dam and the saddle dam are required to ensure the necessary reservoir capacity. Height and crest length of the main dam are approximately 40m and 450m and those of the saddle dam are approximately 15m and 1,300m respectively. Rockfill with center core was applied to the main dam and earthfill dam was applied to the saddle dam in existing studies.

At first, feasible dam types at Xe Katam site are screened in the desk study based on results of existing studies and topographic maps. Considering the components of geological and material investigations for each dam type, technically and financially unfeasible types will be rejected in the first screening. The most feasible type will be selected from the technical and financial aspects in the further screening according to the results of additional geological investigations in this study. Basic design, quantity estimation, cost estimation and construction schedule planning are prepared for comparison studies.

(2) 1st Screening

Generally, dam types are classified into concrete dams and fill dams. Concrete dams are concluded as an unfavorable one by following reasons and fill dams are recommended in existing studies.

- Weathered layer of the rock foundation is thick and excavation volume is large
- As the suitable sand and gravel for concrete aggregates are not found near the project site, it is necessary to transport or produce them at the site.
- Compared with dam height, the crest length is long and the dam volume is large.

There are several types of fill dam, such as earthfill dam, Rockfill dam with center core (hereinafter referred to as “Rockfill”) and CFRD (Concrete Face Rockfill Dam). The earthfill dam type is proposed for the saddle dam because the dam height is low, the crest length is long and embankment materials are easily procured at the site. Meanwhile, the earthfill dam is not suitable for the main dam with the height of approximately 40m due to low stability against earthquakes, seepage and overflow.

In addition, CSG (Cement Sand and Gravel) dam, which is embanked by rock materials consolidated by cement are adaptable for the main dam.

Therefore the comparison study to select the dam type will be implemented among Rockfill with the center core, CFRD and CSG.

(a) Outline of Proposed Dam Types

(i) Rockfill with Center Core

Rockfill dam with the center core is composed of three (3) zones, pervious zone (Rock), semi pervious zone (Filter) and impervious zone (Core) which perform the sealing and stability. Design of the dam body layout is implemented considering the prevention of movement of materials between each zone by seepage flow which cause the escalatory destruction of dam body.

(ii) CFRD (Concrete Face Rockfill Dam)

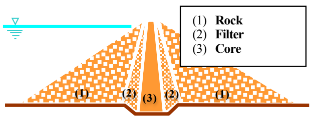
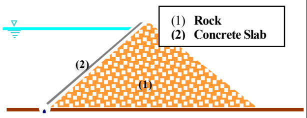
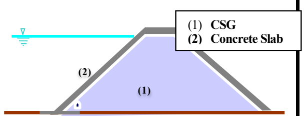
CFRD is composed of the concrete slab at the upper face of dam body which cut the seepage and pervious materials such as rock and gravels. Generally, embankment volume and construction cost of CFRD is smaller than Rockfill dam because of steeper slope gradient of dam body. Although it is relatively new dam type, there are a lot of CFRDs with over 100m in the world.

(iii) Trapezoid CSG (Cement Sand and Gravel) Dam

Trapezoid CSG (Cement Sand and Gravel) dam is recently developed dam type in Japan. The trapezoidal CSG dam combines the characteristics of a trapezoidal dam and the CSG method to simultaneously rationalize the materials, design, and execution of dam construction. CSG materials are prepared using simple facilities to mix cement and water with materials easily obtainable from the dam construction such as the river gravels and excavation debris.

Rationalization of Design	Stability against earthquakes is improved and required strength for materials is smaller to apply the trapezoid shape for the dam body.
Rationalization of Materials	As low quality materials are used due to less required strength, materials selection can be selected widely.
Rationalization of Construction	Construction works can be implemented quickly by simple construction equipment.

Table 1-1 General Concept of Dam Types

Dam Type		Rockfill Dam with the Center Core	CFRD (Concrete Face Rockfill Dam	Trapezoid CSG (Cement Sand and Gravel) Dam
Layout		 	 	 
Features	Material	Rock (pervious), Filter (semi pervious) and Core (Impervious) materials which are available around the dam site.	Rock materials which are available around the dam site and concrete slabs	CSG materials (composed of base materials such as river gravels and excavation debris, cement and water) and concrete slabs
	Dam Body	Rock zone gives the stability against the slide of dam body and core zone gives the sealing function.	Concrete slab gives the sealing function and rock zone gives the stability against the slide of dam body.	Concrete slab gives the sealing function and CSG material gives the stability against the slide of dam body.
	Construction	It is necessary to procure and construct more than three different materials simultaneously.	After Rock materials are embanked, concrete slabs are placed. Embankment of rock materials is easy and can be constructed during the rainy season.	After CSG materials are embanked, concrete slabs are placed.
	Past Performance	Applicable to high dam	Applicable to high dam	Mainly planned in medium and small dams in Japan

(b) Results of 1st Screening

Table 1-2 Results of 1st Screening

Item	Rockfill Dam	CFRD	Trapezoid CSG Dam
Topography and Geology	Good Foundation rock is strong enough to meet the design criteria	Good	Good
Fill Materials	Fair Core materials can be procured at the site, but filter materials will be produced at the site or be transported from other areas	Fair Aggregates for concrete slabs and rock and filter materials will be produced at the site or be transported from other areas.	Poor Aggregates for CSG materials, which are usually procured from river bed or excavated materials, will be produced at the site or be transported from other areas.
Stability	Good Stability is ensured due to the moderate high of around 40m	Good	Good
Construction Plan	Fair Grouting works cannot be conducted in parallel to dam embankment and then the construction schedule will be tight.	Good	Fair It will be difficult to procure aggregates for CSG, of which maximum size is around 80mm.
Construction Cost	Good (100%)	Fair (156%)	Poor (214%)
Conclusion	**Applicable** **Applicable to the Xe Katam Site**	**Applicable** **Applicable to the Xe Katam Site**	**Not applicable** **due to high cost and difficulty on procurement of CSG materials**

Results of the 1st screening are shown in Table 1-2. Trapezoid CSG dam is aimed to rationalize the materials, design, and execution of dam construction using base materials around the site. However, as the result of geological studies, it is difficult to procure gravels for filter or concrete aggregate at Xe Katam site. Therefore CSG is judged that it is not applicable to Xe Katam site because of the disadvantage in material procurement.

As a conclusion, Rockfill and CFRD are selected for candidates of further studies.

(3) Study of Design Conditions

(a) Design Seismic Coefficient

Although dissected valleys by differential erosion has been developed in Boloven Plateau at where Xe Katam site is located, liner topographies which is features of active faults are not recognized. Annamite Range with 1,100km length is aligned on the north-northwest and south southeast direction where is western part of Boloven Plateau and the borderline between Laos and Vietnam Although it is a big faults in Laos, there is no evidence of activities after the Quaternary period. As Xe Katam site is located at 50km eastern part from this fault, it is judged that there is less negative affect by this fault.

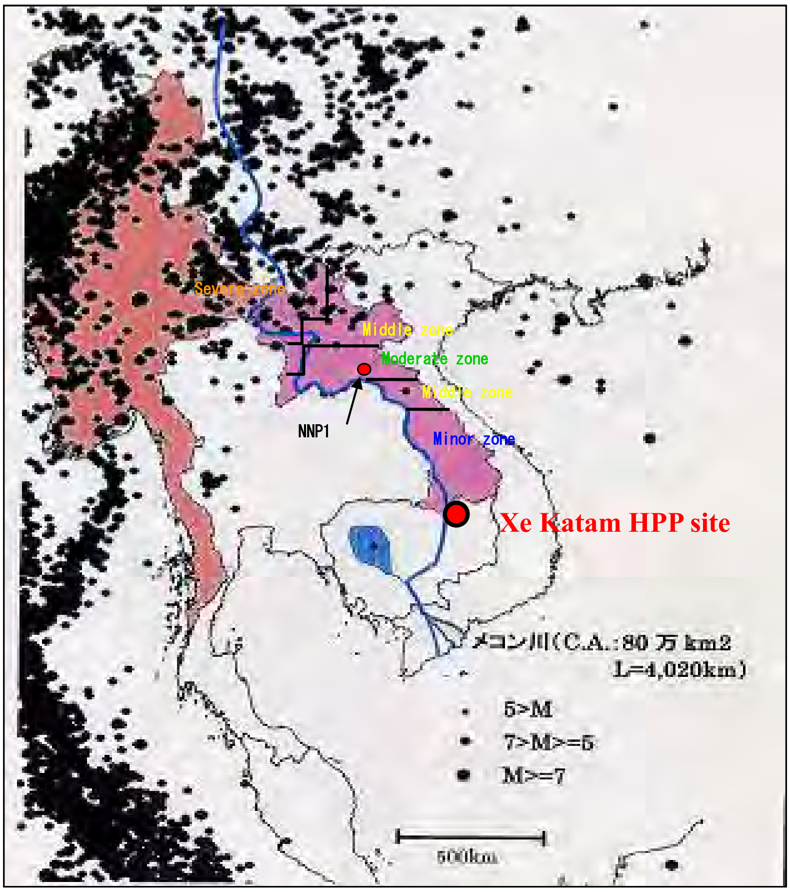


Figure 1-1 Distribution Map of Earthquake Occurrence in Laos (1904 – 1996)

Source: Seismic Zoning: Laotian Electric Power Technical Standard, Ministry of Industry and Handicrafts, 23 April, 2002

According to earthquake records of Laos in past a hundred (100) year, there is no earthquake occurrence at the south part of Laos and Xe Katam site is categorized in Minor Zone which is ranked in the lowest risk of earthquakes. Thresholds of the design seismic coefficients in Minor Zone are not defined in the guideline published by Ministry of Industry. In neighbor projects, g=0.07 is applied to Xe Set 1 (Gravity concrete dam) and g=0.10 is applied to Houay Ho (Earthfill dam).

In this study, g=0.07 which is also used in the neighboring project is applied.

Table 1-3 Zoning of Earthquake Risk by Design Horizontal Seismic Coefficients

Zone	Gravity Dam	Arch Dam	Fill Dam	
			Earth	Zoned Rock Fill
Severe	0.12	0.24	0.15	0.15
Middle	0.12 (Theum Hinboune: 0.12)	0.24	0.15	0.12
Moderate	0.10 (Nam Ngum: 0.03)	0.20	0.12	0.10 (Nam Leuk: 0.10)
Minor	(Xe Set: 0.07)	-	(Houay Ho: 0.10)	-

Source: Seismic Zoning: Laotian Electric Power Technical Standard, Ministry of Industry and Handicrafts, 23 April, 2002

(b) Evaluation of Base Foundation Rock and Excavation Line

Geology of the main dam site is composed of basalt lava which forms the flat layer on the bottom of valley and of sandstone and mudstone which exist in both banks above the flat basalt layer. According to the boring result of RB02 drilled at the center of flat area at the bottom of valley, there is a fresh basalt layer below the weathered rock layer (surface of unconformity) of thickness 10m -12m. Regarding the right bank, there are fresh foundations of sandstone and mudstone below the overburden and weathered soften sandstone layer of thickness 15.2m.

Table 1-4 Base Rock Conditions of Foundation

Zoning	Rock Class	Strength and Deformation	Permeability
Rockfill Dam			
Core and Filter Materials	CL class base rock	- no shear failure - no significant deformation	- required permeability is obtained by the grouting (3 – 5 Lu) - no seepage failure
Rock Material	D class base rock with removal of surface soil	- Shear strength as same as rock materials - no shear failure - no significant deformation	
CFRD			
Plinth	CL class base rock	- no shear failure - no significant deformation	- required permeability is obtained by the grouting (3 – 5 Lu)
Transition Materials	CL class base rock	- no shear failure - no significant deformation	- required permeability is obtained by the grouting (3 – 5 Lu)
Rock Materials	D class base rock with removal of surface soil	- Shear strength as same as rock materials - no shear failure - no significant deformation	

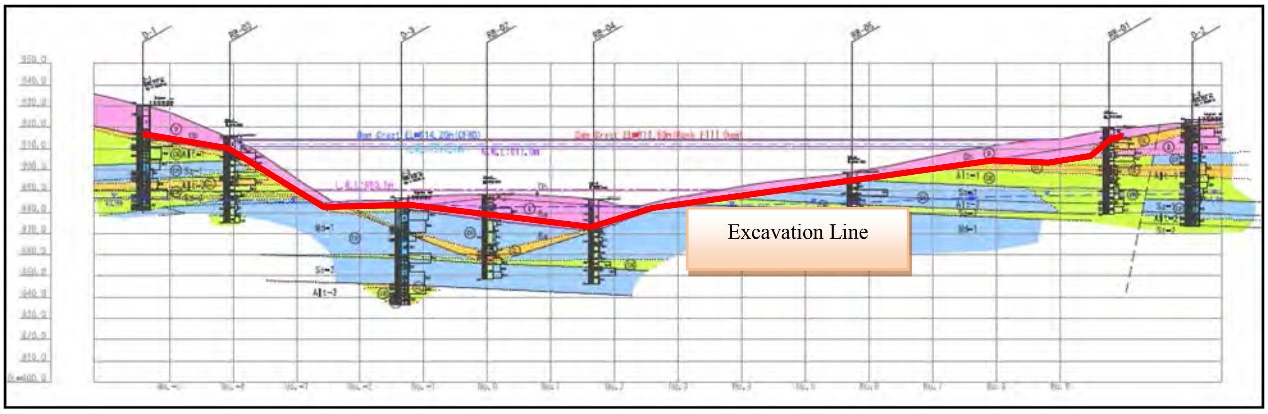


Figure 1-2 Excavation Line of Dam Axis

(c) Determination of Dam Crest Elevation

Elevation of non overflow section of the reservoir is estimated in accordance with FREEBOARD CRITERIA AND GUIDELINES FOR COMPUTING FREEBOARD ALLOWANCES FOR STORAGE DAMS (U.S.DEPARTMENT OF THE INTERIOR Bureau of Reclamation, 1981) established by USBR. This method is to estimate the H1 and H2 shown below formulas and to select the higher elevation among them as the minimum elevation of non overflow section. HWL of 912.2m of flood discharge 350m^3/s (1,000-yr and 48 hour) is used.

H1 = Minimum Freeboard + Hd
H2 = Normal Freeboard + Hn

Here, a) Minimum Freeboard = Wind Run-up + Wind Set-up + Settlement (Static)

b) Normal Freeboard = Maximum (Comb.-1, Comb.-2)
Comb.-1 = a) Wind Run-up + b) Wind Set-up + c) Settlement (Static)
Comb.-2 = a) Settlement (Static) + b) Settlement (Earthquake)
Hd: NWL. 911.0m + surcharge depth = EL 912.2m
Hn: NWL. 911.0m

Results of calculation for Rockfill dam and CFRD are shown in Table 1-5 Results of Freeboard Calculation (Rockfill Dam) and Table 1-6 respectively.

Table 1-5 Results of Freeboard Calculation (Rockfill Dam)

Rockfill Dam		Normal freeboard		Minimum freeboard
		Comb.-1	Comb.-2	
Wind	Hs (m)	1.34	-	0.49
	T (s)	3.78	-	2.48
	Run-up (m)	1.78	-	0.57
	Set-up	0.03	-	0.01
Settlement	Static	0.30	0.30	0.30
	Earthquake	-	1.27	-
Total		2.12	1.57	0.88
		2.12		
Non overflow section		913.20		913.10

Table 1-6 Results of Freeboard Calculation (CFRD)

CFRD		Normal freeboard		Minimum freeboard
		Comb.-1	Comb.-2	
Wind	Hs (m)	1.34	-	0.49
	T (s)	3.78	-	2.48
	Run-up (m)	2.82	-	0.89
	Set-up	0.03	-	0.01
Settlement	Static	0.30	0.30	0.30
	Earthquake	-	1.24	-
Total		3.15	1.55	1.20
		3.15		
Non overflow section		914.20		913.50

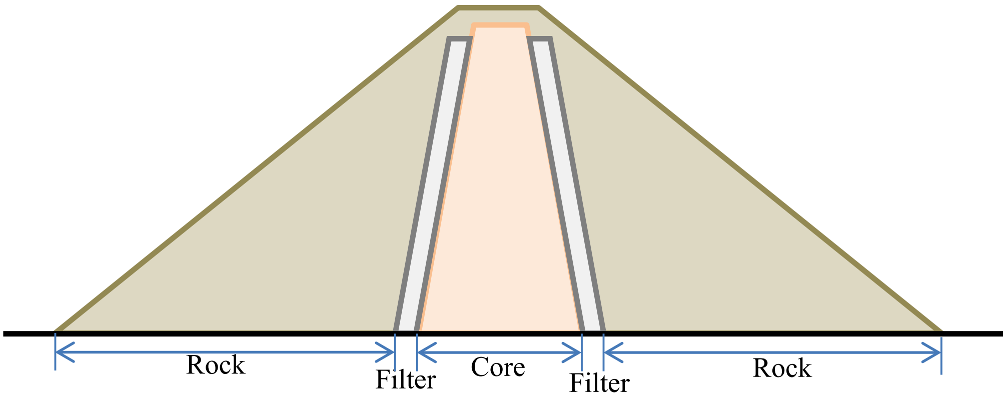
Based on this calculation, required elevation for the non overflow section of Rockfill dam is EL. 913.2m of H2 Normal Freeboard. Meanwhile the water level in PMF is EL. 913.5m in the flood analysis. Therefore EL. 913.5m is applied to the elevation for non overflow section of Rockfill dam considering PMF. The crest elevation is EL. 913.9m including 0.40m of the protection layer.

Required elevation for the non overflow section of CFRD is set as EL. 914.2m of H2 Normal Freeboard which is higher than EL. 913.5m of PMF. EL. 914.2m with the concrete parapet wall at the upstream face is determined as the crest elevation.

(4) Basic Design of Rockfill Dam

(a) Embankment Materials

Rockfill dam is composed of impervious zone (Core) at the center, Semi-pervious zone (Filter) outside of impervious zone and pervious zone (Rock) at outside of Semi-pervious zone as shown in Figure 1-3. Each zone is designed to have function to obtain the required permeability and stability and to prevent the movement of each material which causes the escalatory destruction by the seepage flow between each zone.



Material (Grain Size Distribution)	Coarse ←	Fine	→ Coarse
Permeability	High ← > $1x10^{-3}$cm/s $1x10^{-3}$ to $1x10^{-4}$cm/s	**Low** $1x10^{-5}$cm/s	→ High > $1x10^{-3}$cm/s $1x10^{-3}$ to $1x10^{-4}$cm/s
Strength	**High** ←	Low	→ **High**

Figure 1-3 Zoning of Rockfill Dam

(i) Core Material

Core material is prepared considering the impermeability, stability against piping, uneven settlement and thickness of zone. As mentioned in Chapter 2, most of soil materials at Xe Katam site are too fine to use as core materials according to results of the laboratory test. However, test pit TC-6 which is obtained at the downstream of right bank of main dam is applicable. Grading curves of test pits obtained around TC-6 are shown in Figure 1-4 and suitability of TC-6 for core material is shown in Table 1-7.

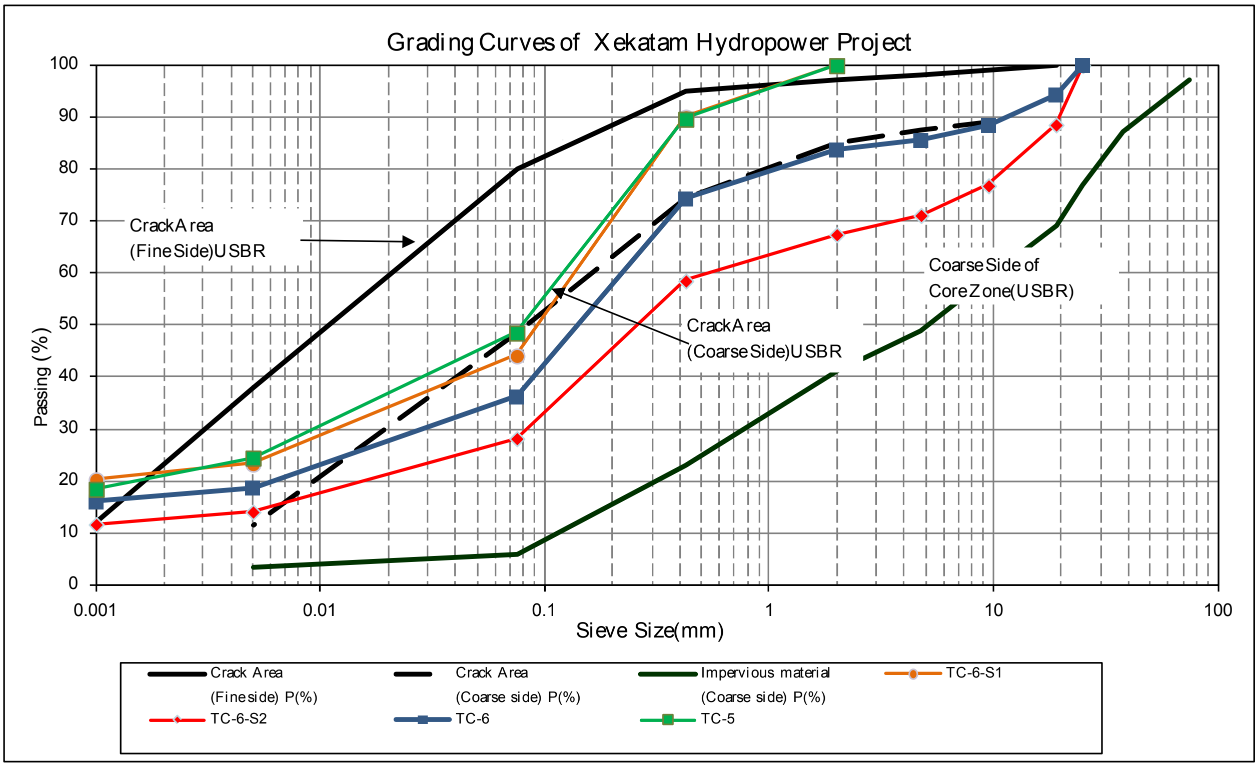


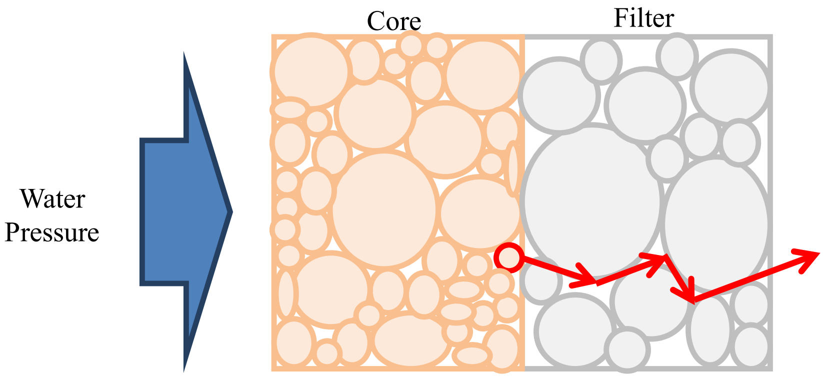
Figure 1-4 Grading Curves of Test Pits around TC-6

Table 1-7 Suitability of TC-6 for Core Material

Items	Target		Test Results	Evaluation
Impermeability	Permeability coefficient	About **<u>1×10^{-5}cm/s order at site</u>** Less than about **<u>1×10^{-6}cm/s order in laboratory</u>**	1.013×10^{-6}cm/sec at the Optimum Water Content	Possibly OK
Stability against piping	Compaction	Easily compacted	Expected to be easily compacter	OK
	Plastic Index (PI)	(Trafficability) **Less than 25 of IP**	IP=13.8	OK
		Greater than 10 to 15 of IP		OK
Uneven settlement	Material	Lower fluctuation of quality of materials	Lower fluctuation in Grading Curve	OK
Pore pressure	Grain size distribution	**Not too fine** to avoid excess pore pressure	Large amount of fine particle of less than 0.05mm	Possibly OK

(ii) Filter Material

Semi-pervious zone (Filter) is arranged between impervious (Core) and pervious zone (Rock). This zone has function to buffer the difference of material components such as particle size between both zones, transition of stress and affect of deformation. This zone is composed of Filter materials which particle sizes distribution are designed to prevent the outflow of pervious zone and to release the seepage safely. As Filter materials are hardly procured around Xe Katam site, it will be produced to satisfy required conditions at the site.



- No way to pass a particle of core materials through a filter zone.
- Only water is discharged through a filter zone.

Figure 1-5 Concept of Filter Materials

(iii) Rock Material

As pervious zone is significantly affected to the stability of dam body, it should be composed of materials with high shear strength such as rock and gravels. Materials with good size distribution including large size particles, easiness of compaction and high durability are expected to be arranged especially at surface and top of the dam body. This zone is required to release seepage from the impervious zone and pore water led by the rainfall and sudden lowering of reservoir water level.

As mentioned in Chapter 2, Sandstone (Ss) and Alternation of Strata of sandstone and mudstone (Alt) is obtained at the proposed quarry which is located at the downstream ridge of main dam left bank. In addition, basalt lava which is widely distributed at riverbed level is expected to be obtained from the ground excavation. Because basalt is more expensive due to many explosives for excavation, materials obtained from the quarry should be utilized for cost reduction. However available amount of materials at the quarry is not sufficient to the required volume including Filter, Rock and concrete aggregates.

Therefore two zones of rock materials are arranged for Rockfill dam body. Outer rock zone is composed of Ss which is relatively stronger materials and inner rock zone is composed of Alt.

(b) Basic Design of Rockfill Dam

Core and filter foundations are placed on CL class base rock and rock foundation is placed on D class base rock with removal of surface soil. Crest elevation is EL. 913.9m (non – overflow section EL. 913.5m + freeboard 0.40m). Features of the dam body are crest width W=8.0m, dam height H=41.6m and crest length L=449.8m. Rock zones are divided into two (2) zones, outer rock of Ss and inner rock of Alt which is relatively less quality. Dam slope gradient is 1:2.0 at the upper face and 1:1.7 at the lower face determined by the stability analysis of circular slip.

Typical cross section across No. 1 +20.0m is shown in Figure 1-6 and layout plan of Rockfill dam is shown in Figure 1-7.

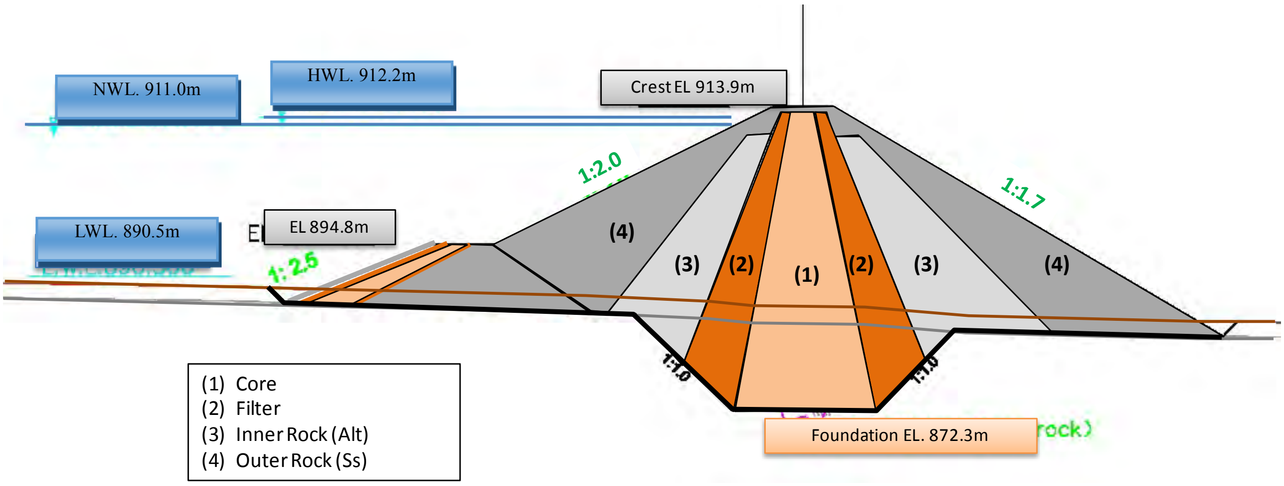


Figure 1-6 Typical Cross Section of Rockfill Dam (H=41.6m, No. 1 +20.0m)

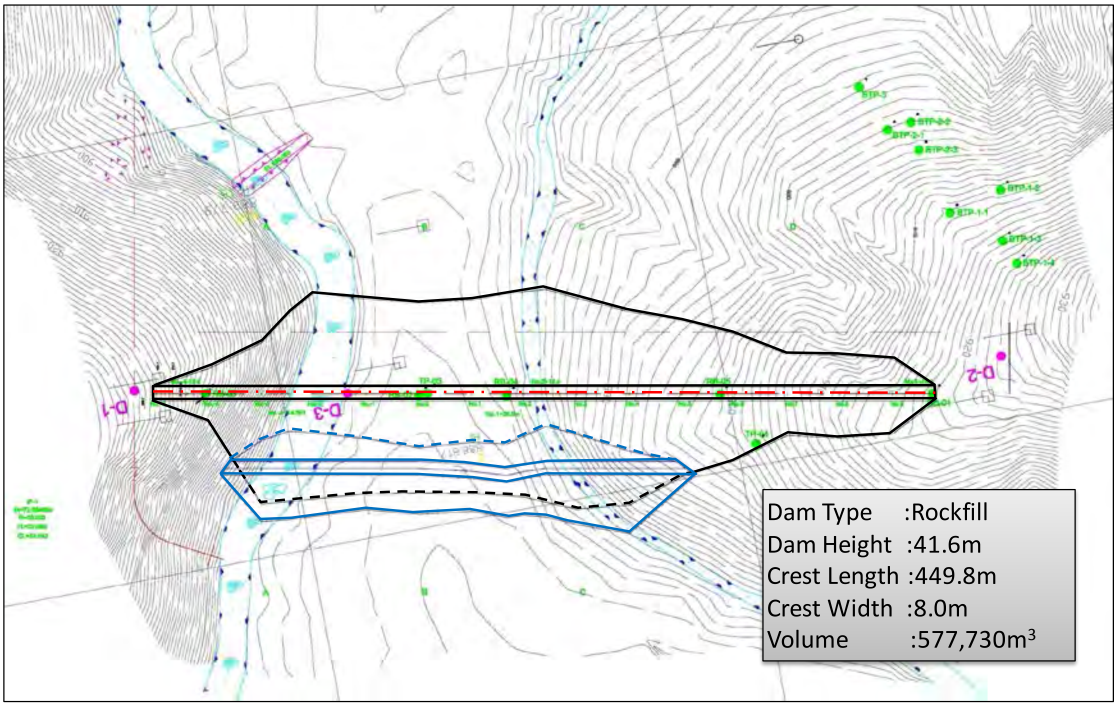


Figure 1-7 Layout Plan of Rockfill Dam

Comparison of Rockfill dam features between existing studies and this study is shown in Table 1-8.

Table 1-8 Comparison of Rockfill Dam Features

Item		Unit	Existing Study (TR2009)	This Study	Remarks
Crest Elevation		EL. m	913.7	913.9	Determined by USBR Freeboard Criteria considering the update of flood analysis (1,000-yr Probable Flood) and slope gradients
Foundation Rock Elevation		EL. m	872.3	872.3	Determined by CL foundation rock of core materials based on the updated Rock Class Map
Dam Height		m	41.4	41.6	
Crest Width		m	8.0	8.0	
Crest Length		m	420.5	449.8	
Slope Gradient	Upper Face	-	1.8	2.0	Determined by the stability analysis considering modification of the friction angle of rock materials (φ40 to 38) and the seismic factor (kh= 0.05 to 0.07)
	Lower Face	-	1.6	1.7	
Embankment Volume (including Coffer Dam)		m^3	550,000	577,730	Although slope gradient becomes milder, increase of 27,730m^3 in dam embankment volume is small by the omission of berm.
Excavation	Soil	m^3	80,063	83,776	Excavation volume of rock is decreased by the modification of excavation gradient of the core trench (1:1.5 to 1:1.0)
	Rock	m^3	79,202	66,043	

(5) CFRD

(a) Embankment Materials

Typical layout of CFRD and explanation of each zone are shown in Figure 1-8 and Table 1-9.

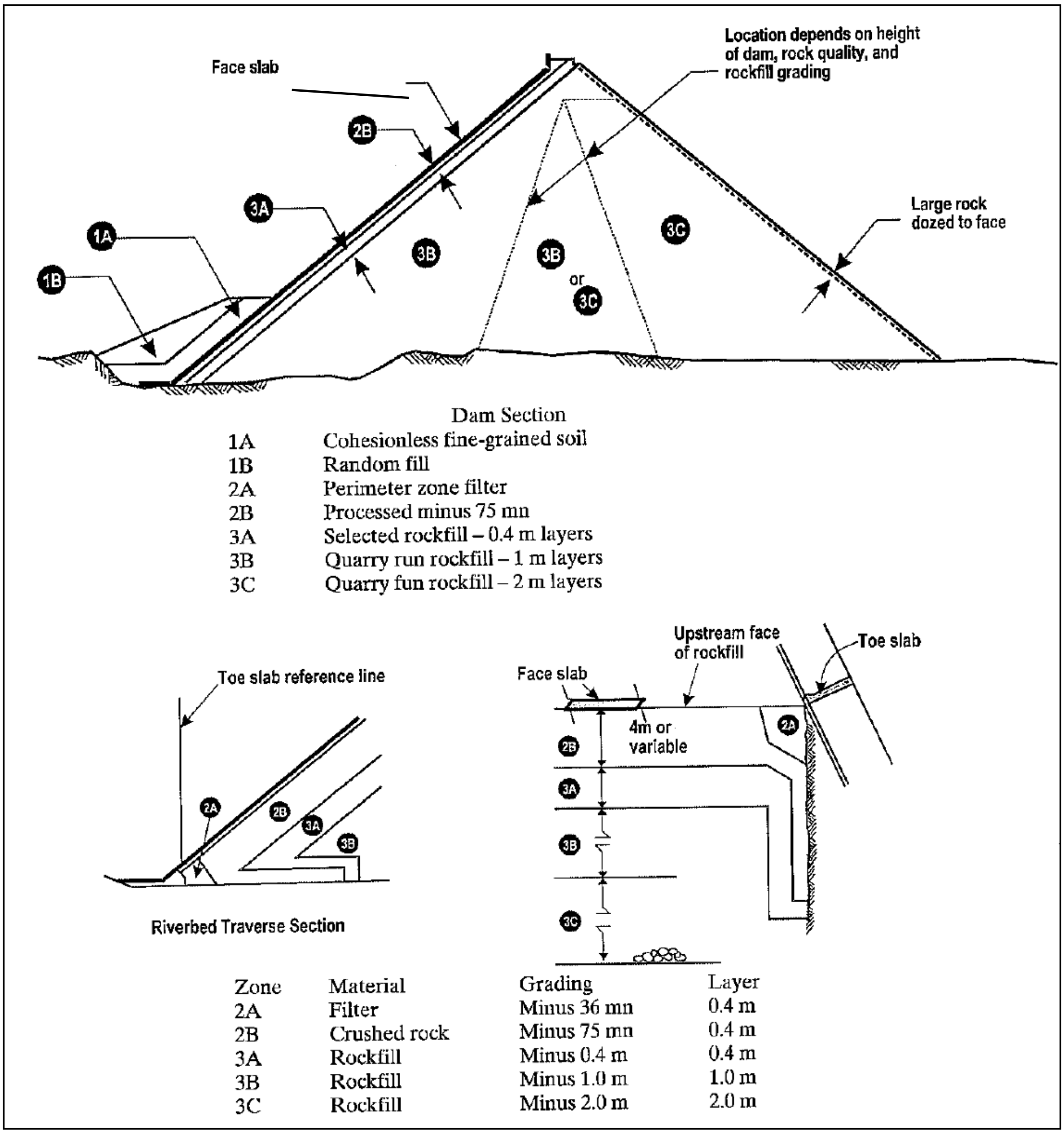


Figure 1-8 Typical Layout of CFRD

Table 1-9 Explanation of CFRD Zoning

Zone		Function	Material Feature	Focused Issue	Application to Xe Katam
1A	Blanket (Impervious materials)	It is arranged at the upstream side of face slab to cover the plinth and horizontal joint. If cracks happen at the face slab after impounding of the reservoir, cracks are blocked by blanket materials naturally. 1A zone is expected to protect the seepage to plinth and joints.	It should be fine materials which can be moved with high water pressure and to microscopic cracks. Although Non-Plastic Silt and Silty Sand are often used, clay materials cannot be applied.	Particle size Consistency	✓
1B	Blanket (Semi pervious materials)	It is expected to be the transition and counter weight embankment against 1A.	It is required to protect 1A material from the outflow caused by the lowering of water level and to give necessary strength as counter weight embankment.	Permeability Impermeability Strength	✓
2A	Filter Zone	It is arranged at the back side of connection point between the plinth and face slab to control the deformation of the slab and seepage from cracks and joints.	(1) Density (2) Permeability	Deformation Permeability	✓
2B	Transition (Semi pervious materials)	It is a thin layer arranged below the face slab to support it by bearing of stress from the dam body and leveling the surface of slab. It is also aimed to control the seepage from cracks and joints.	(1) Bearing capacity (2) Particle size to level the connection point of face slab smoothly (3) Permeability	Strength Deformation Construction	✓
3A		It is arranged between Zone 2B and Zone 3B to be the transition and to control the seepage as filter materials.	Medium particle size between Zone 2B and Zone 3B	Permeability Strength	✓
3B	Rock Zone	It forms a main rock zone of the dam body to resist against water pressure from the face slab.	Strength for the dam stability and low compressibility are required.	Strength Deformation	✓
3C		It also compose the dam body as same as 3B. Compared with 3B, materials with less strength can be applicable.	It is similar to Zone 3B. However relatively less quality materials can be applicable.	Strength Deformation	✓
3E	Riprap Zone	It is arranged at the downstream face for the slope stability and protection of the slope surface.	It has durability against climate conditions such as erosion and weathering and slope stability.	Particle size Rock Kind	✓
5	Drain	It is arranged to release water inside the dam body such as spring water, rainfall, seepage from cracks and joints. If embankment materials are low permeable, it can be arranged in vertical direction.	Particle size to obtain required permeability and protection from piping.	Permeability	-

(b) Concrete Structures

In CFRD, water is cut off by the concrete face slab arranged at the upstream face of dam body. Main concrete structures of CFRD are shown in Table 1-10.

Table 1-10 Concrete Structures of CFRD

Item	Description	Function
Plinth	It is the concrete block arranged along the upstream toe of dam body to connect the face slab and base rock foundation. Foundation treatment such as grouting is also implemented from the plinth.	- to obtain sufficient water tightness against base rock foundation - to obtain required creep length to control hydraulic gradient - to be the cover concrete during the grouting works
Face Slab	It is the concrete wall arranged along the upstream face of dam body to cut off water.	- to be stable against the upstream water pressure - to absorb deformation of the dam body - to minimize cracks by shrinking of the face slab itself

(c) Basic Design of CFRD

Regarding the CFRD foundation, plinth, Zone 2A, 2B, 3A are placed on CL class base rock and zone 3B and 3C are placed on D class base rock with removal of surface soil. Crest elevation is EL. 914.2m and the parapet is installed at top of the concrete face slab. Features of the dam body are crest width W=8.0m, dam height H=41.9m and crest length L=423.4m. Rock zones are divided into two (2) zones, 3B (Ss) and 3C (Alt). Dam slope gradient is 1:1.6 at the upper and lower face determined by the stability analysis of circular slip. Blanket zones are placed on the plinth. As it is possible to repair the crack of plinth above the water level during dry season, elevation of top of blanket zones is EL. 890.5m as same as L.W.L.

Typical cross section is shown in Figure 1-9 and plan layout of CFRD is shown in Figure 1-10.

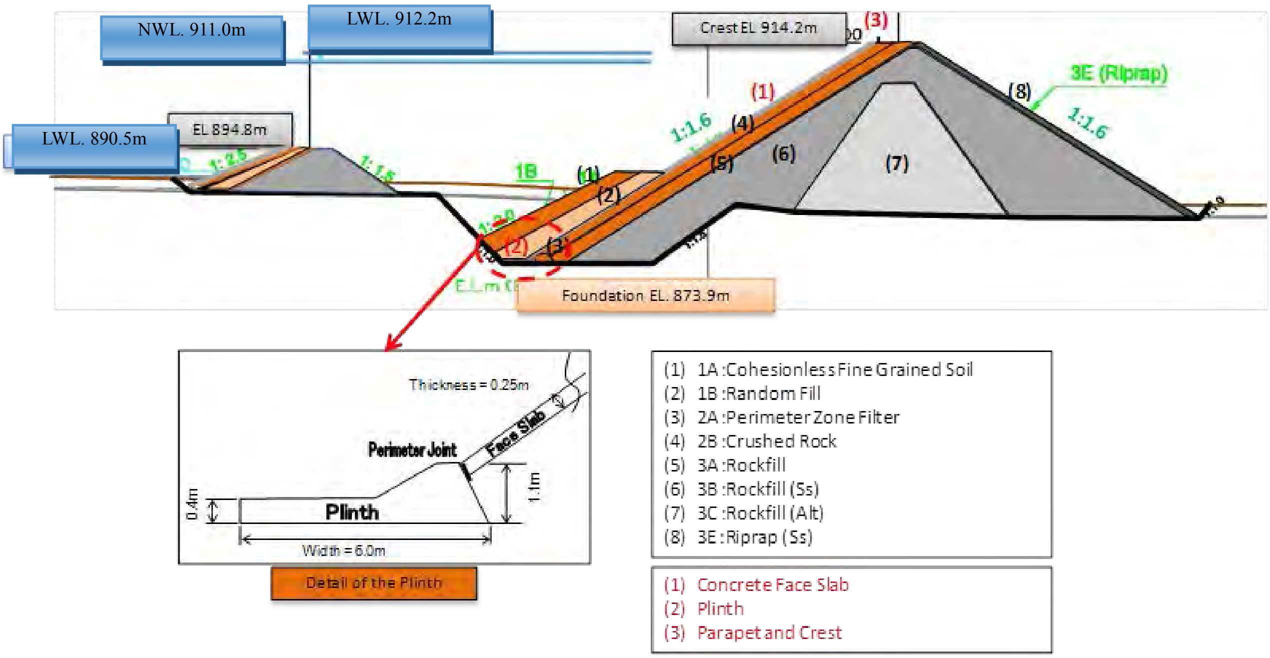


Figure 1-9 CFRD Typical Cross Section (H=41.9m, Section No1 +20.0m)

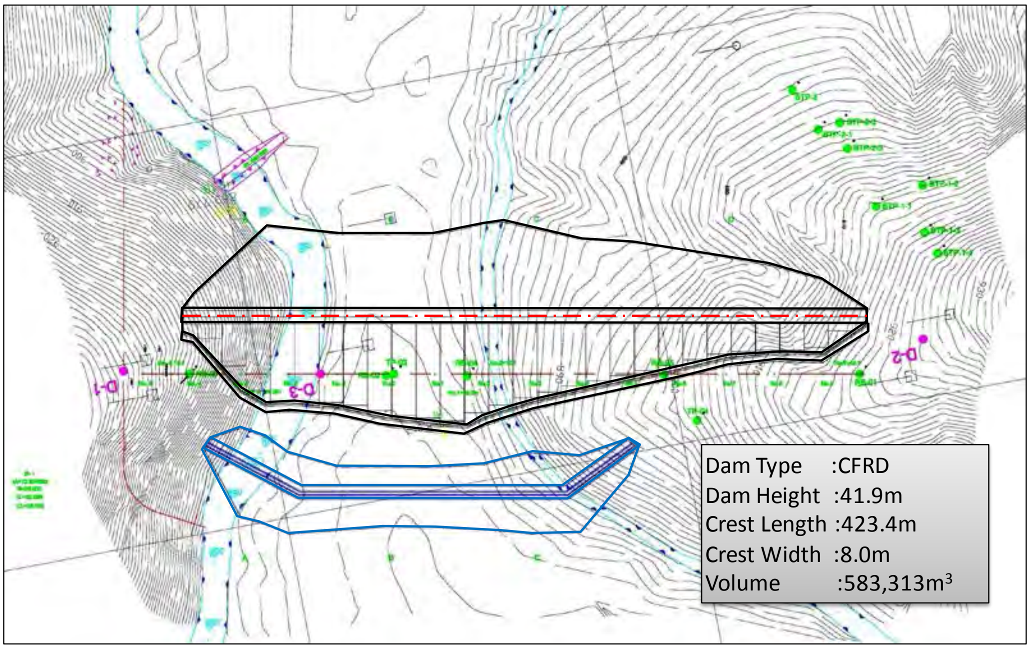


Figure 1-10 Plan Layout of CFRD

Main features of CFRD are shown in Table 1-11.

Table 1-11 Main Features of CFRD

Item		unit	This Study	Remark
Crest Elevation		EL. m	914.2	Determined by USBR Freeboard Criteria considering the update of flood analysis (1,000-yr Probable Flood) and slope gradients
Foundation Rock Elevation		EL. m	872.3	Plinth is placed on the CL base rock foundation based on the updated geological investigations. 2m of surface soil is removed at rim of both banks.
Dam Height		m	41.9	
Crest Width		m	8	
Crest Length		m	423.4	
Slope Gradient	Upper Face	-	1.6	Determined by the stability analysis considering modification of the friction angle of rock materials (φ40 to 38) and the seismic factor (kh= 0.05 to 0.07)
	Lower Face	-	1.6	
Embankment Volume (including Blanket and Coffer Dam)		m^3	583,313	Embankment volume was increased because of revision of excavation line and slope gradient.
Excavation	Soil	m^3	108,571	Excavation volume was increased because of revision of excavation line.
	Rock	m^3	67,569	

(6) Comparison Dam Types

(a) Estimation of Dam Embankment Materials

Embankment volume of main dam are 577,730m^3 of Rockfill dam and 583,313m^3 of CFRD. Regarding CFRD, the volume except blanket zone is approximately 3% smaller than Rockfill dam. Because the dam height of 41.9m is relatively lower than other dams, it is difficult to take advantage of CFRD to reduce the embankment volume by steeper slope gradient at Xe Katam site. Comparison of embankment volume of for each dam type is shown in Table 1-12.

Table 1-12 Comparison of Embankment Volume

Item	Source	Rockfill	CFRD	Remark
Soil	Borrow Area	100,327	8,824	Disposal soil is allocated to zone 1A in CFRD.
	Disposal		13,106	Possibility of allocation of disposal sand of quarry for the core material of Rockfill dam will be studied.
Rock	Sand Stone	244,892	278,605	Embankment volume of 42,379m^3 is allocated inside the main dam body in Rockfill dam.
	Alternation of Strata	119,991	122,210	Inner rock and Zone 3C
	Disposal		57,173	Disposal rock is allocated to zone 1B and rock of coffer dam in CFRD
Riprap	Sand Stone	28,780	20,463	
Crushed Stone	Sand Stone	83,741	76,044	Rockfill Dam :Filter CFRD :Zone 1B, 2A, 2B and 3A, Filter of coffer dam
Excavation	Soil	83,776	108,571	
	Rock	66,043	67,569	
Concrete	-	-	6,889	

(b) Determination of Dam Type

Comparison of main dam features is shown in Table 1-13 and results of comparison are shown in Table 1-14.

As a conclusion, Rockfill dam is applied to the main dam type at Xe Katam site considering the construction cost and schedule.

Table 1-13 Comparison of Main Dam Features

Item		Unit	Rockfill	CFRD
Crest Elevation		EL. m	913.9	914.2
Base Rock Elevation			872.3	872.3
Dam Height		m	41.6	41.9
Crest Width		m	8.0	8.0
Crest Length		m	449.8	423.4
Slope Gradient	Upper	-	2.0	1.6
	Lower	-	1.7	1.6
Dam Embankment Volume (including Coffer Dam)		m^3	577,730	583,313
Excavation	Soil	m^3	83,776	108,571
	Rock	m^3	66,043	67,569
Construction Schedule		month	22.0	22.0
Construction Cost *Rockfill is set as 100%		%	100%	156%

Table 1-14 Comparison of Each Dam Type

Item	Rockfill	CFRD
Embankment Materials	Fair - Although filter materials must be produced at the site or procured from outside suppliers, required volume is relatively small. - It is necessary to procure core materials	Fair - Although filter materials and concrete aggregates must be produced at the site or procured from outside suppliers, required volume is relatively small.
Seepage Treatment	Good - Gallery is installed considering the construction period of grouting works on the riverbed section.	Good - Construction time for grouting can be obtained until the reservoir filling. - After impounding, additional grouting works are impossible on the riverbed section.
Construction Schedule	Good (22 month)	Good (22 month)
Construction Works	Good - Core material is planned to be placed during rainy season	Good - Slip form is required to construct the concrete face slab
Cost	Good (100%)	Poor (156%)
Conclusion	Adopt	Reject

2. Saddle Dam

(1) Location and Layout

In order to reduce dam volume, the dam axis is chosen to be arc line which passes through a higher ground. Layout plan of the Saddle dam is shown in Figure 2-1.

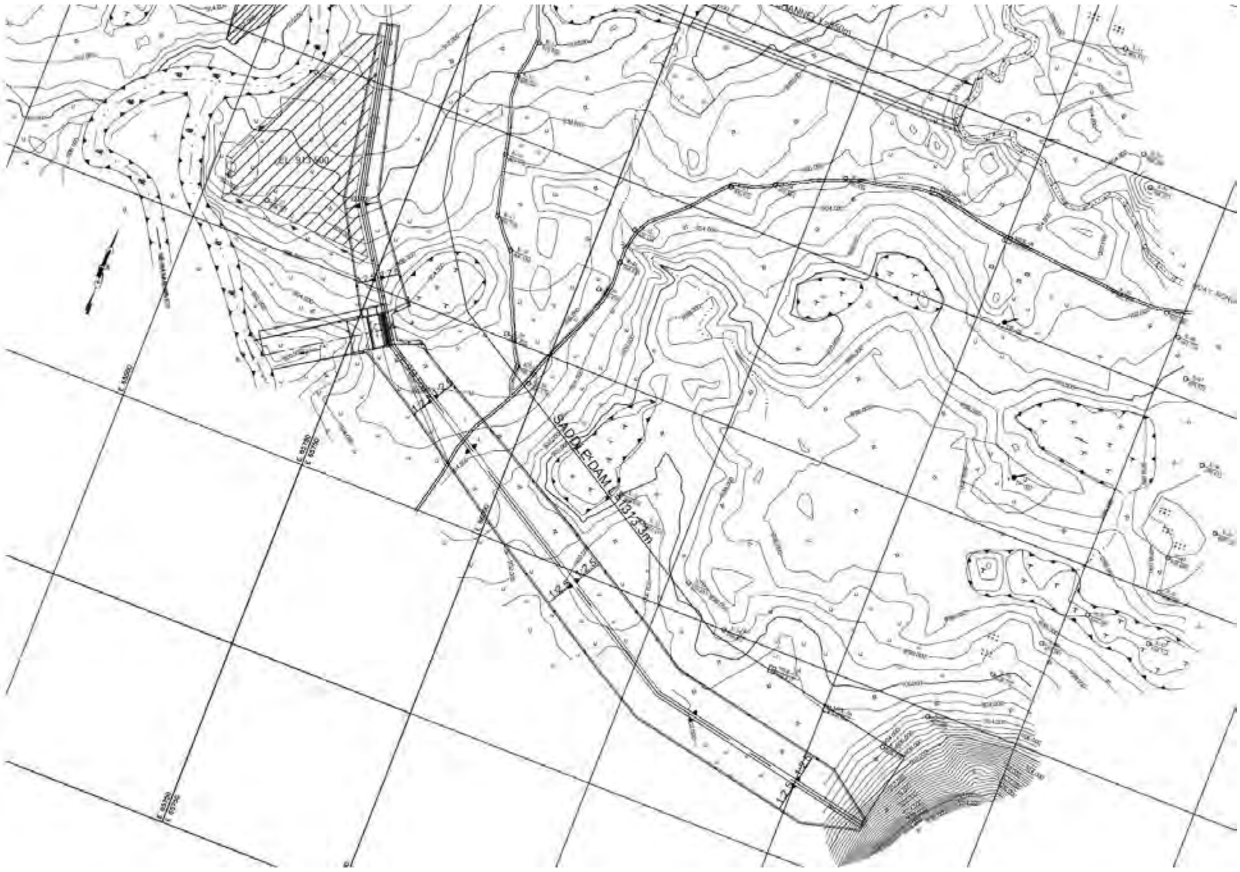


Figure 2-1 Layout Plan of the Saddle Dam

(2) Dam Type

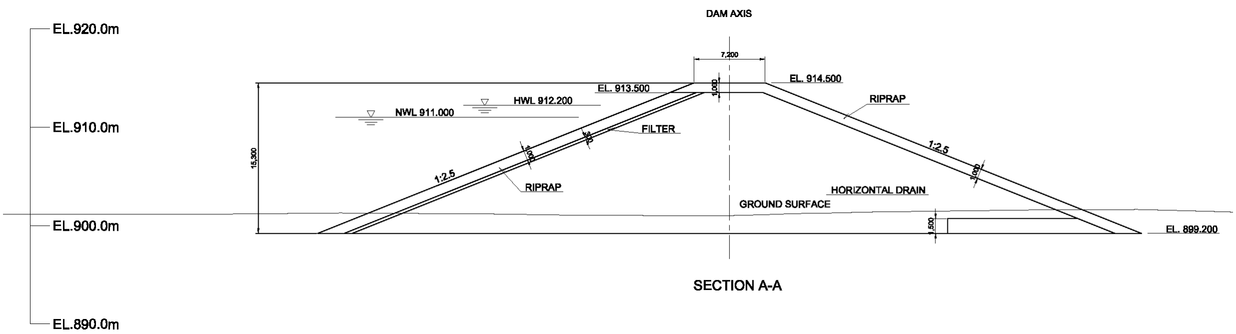


Figure 2-2 Typical Cross Section of the Saddle Dam

Since the large amount of embankment material is required due to long dam crest in spite of dam height, a homogenous earthfill dam is selected in aspects of construction efficiency and economy. Typical cross section of the saddle dam is shown in Figure 2-2.

(3) Basic Design of the Saddle Dam

(a) Rock Surface and Excavation Line

According to the test pits at two (2) places carried out in the vicinity of the saddle dam, the basalt plateau is covered with 1 ~ 2 m thick overburden soil and a strongly weathered layer with progressed clay formation.

By removing the overburden soil of around 2 m from the ground surface containing organic matter, the weathered layer of basalt (D class) is planned to be the foundation rock.

(b) Dam Slopes

By using results of the laboratory test of embankment materials, stability analysis of the dam body is conducted, which determines the dam slopes for both upstream and downstream to satisfy the specified safety factor. Design conditions are as same as the analysis of main dam. As a result, the dam slope is determined to be 1:2.5 for both upstream and downstream.

(c) Embankment Material

Approximately 550,000 m^3 is required for earthfill materials. It is obtained from the borrow areas in the vicinity of the main dam. In addition, disposal soil of the quarry is also expected to be utilized for embankment materials with adequate laboratory tests.

(d) Foundation Treatment

Permeability of the saddle dam foundation is supposed to be high because there are cracks along horizontal direction. However, the dam height of 15.3m is low and creep length is adequate along the longitudinal direction of dam body.

Based on results of additional geological surveys, countermeasures against permeability such as key trench and blanket core are supposed to be necessary in order to secure the impermeability of the saddle dam.

3. Spillway

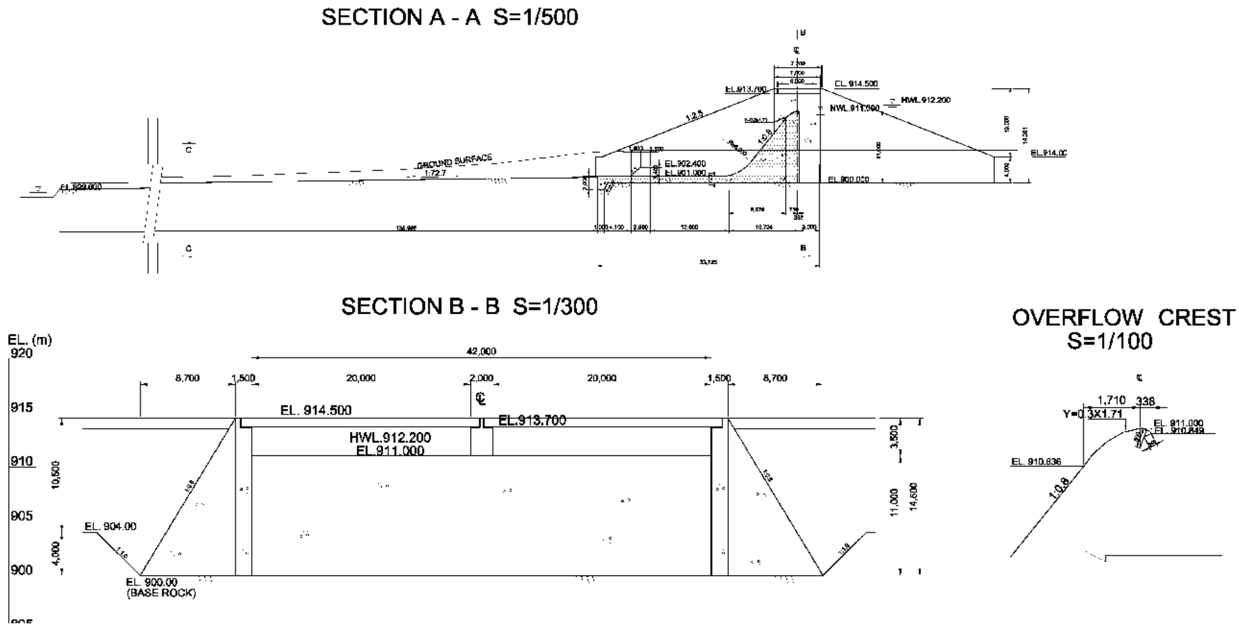


Figure 3-1 Cross Sections of the Spillway

The concrete gravity dam type of spillway is placed at the center of the saddle dam where the topography forms a valley at the downstream of the spillway and distance to Xe Katam River is the shortest. Height of spillway is 12 m and length of the overflow section is 42 m with a pier located at the center of section for the bridge of access road.

Design flood is estimated to be 350 m^3/s (1,000-year probable flood). Spillway shall be designed to discharge 110 m^3/s considering the reservoir storage function. Discharged water will be flown down into Xe Katam River. As for foundation of the spillway, outcrops of basalt are confirmed by site reconnaissance at the riverbed of Xe Katam River where is at 150 m downstream of the spillway. This basalt rock is expected to be as foundation rock. Excavation line is determined to be around 6 m from the ground surface which is almost same elevation with the riverbed mentioned above. Cross sections of the spillway are shown in Figure 3-1.

4. Discharge Facility (diversion tunnel and discharge tunnel)

(1) Location of Discharge Facility

It is necessary to divert the river flow of Nam Hong River and Makka River during the construction period of foundation excavation, foundation treatment and embankment for the main dam.

An inlet is constructed at 30 m upstream of the main dam on the left bank and the outlet is constructed at 150 m downstream from the inlet. A diversion tunnel is constructed across the mountain of left bank, which is below 35 m depth from the assumed foundation rock of the main dam.

At both of the inlet and outlet sites, there are outcrops of sandstone and the geology of the foundation ground is sound. However, top of the tunnel may pass the alternation strata of sandstone and mudstone.

(2) Basic Design of the Discharge Facility

(a) General

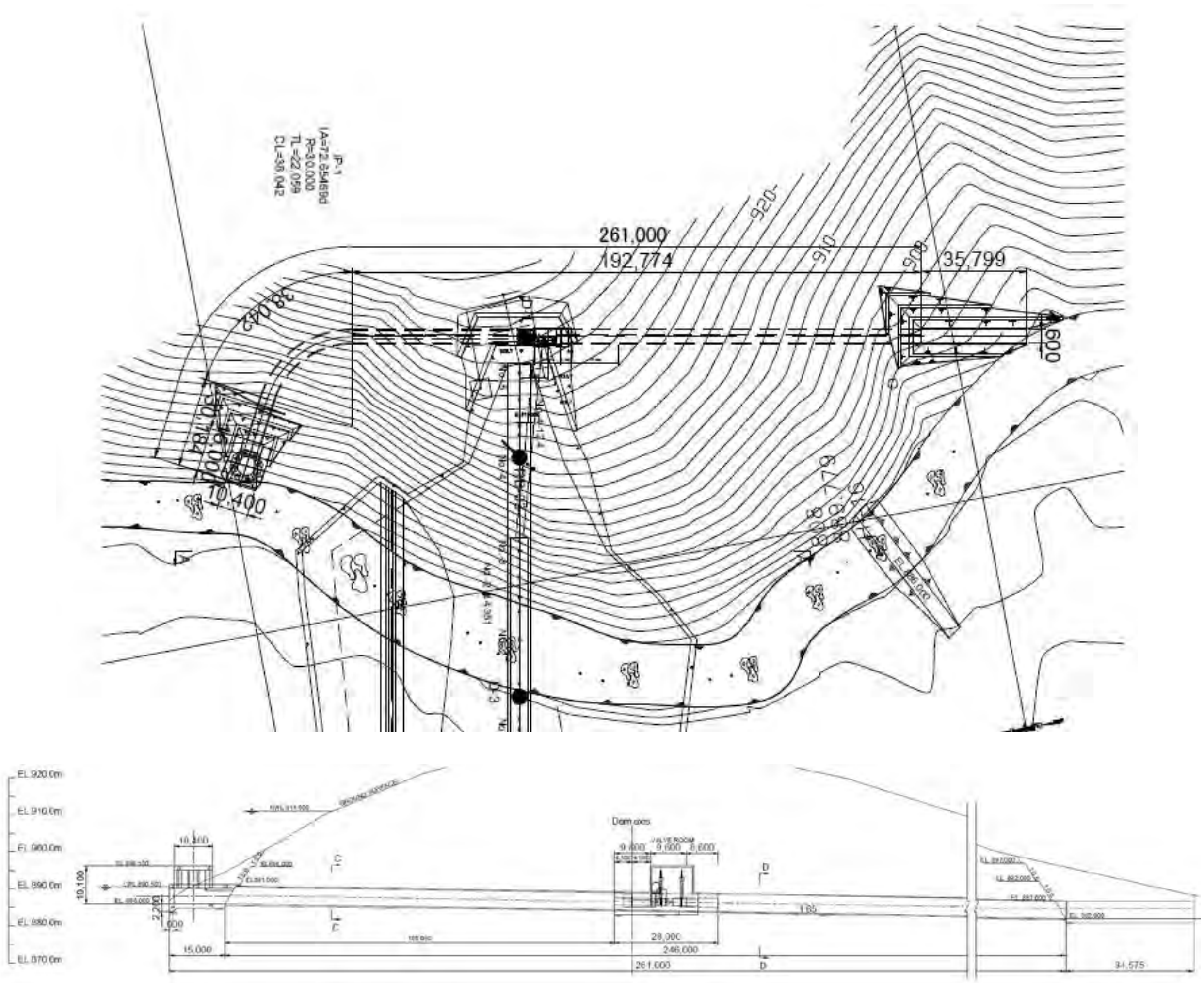


Figure 4-1 Layout Plan and Cross Section of Discharge Facility

Structure of the discharge facility is shown in Figure 4-1. At first, it is designed as a discharge tunnel to divert river flows during the dam construction. After completion, it will be used as the discharge facility to release discharge for the power generation by plugging the part of the tunnel and installing an outlet pipe and a jetflow gate.

By constructing a partition wall along the downstream tunnel from the gate chamber, the right side is planned to be the discharge waterway and the left side to be the access road for inspection. A vertical shaft is constructed at the inlet of the diversion tunnel. It is used for the intake tower after completion of the main dam construction by plugging the inlet. The sill level of the water intake is set at EL. 890.0m or above which is equal to the 50-year sedimentation level.

(b) Diversion Tunnel

(i) Design Flood

According to existing examples of diversion tunnels for Rockfill dams, 10 to 20-year probable flood discharge is selected as design flood during the construction period. In the Study, 10-year probable flood discharge of Q = 150 m^3/s is selected in consideration of the construction period and basin scale.

(ii) Tunnel Design

Tunnel inner diameter is determined as 4.5 ~ 4.6 m with a "D" shape cross section which can discharge the design flood of Q = 150 m^3/s safely. After completion, the diversion tunnel will be used as a discharge tunnel. Upper section from the inlet to valve room is used as the pressure tunnel and downstream section from the valve room to outlet is used as the non pressure open channel.

In the upstream pressure tunnel section, the tunnel is designed to be concrete-lined and in the downstream non-pressure tunnel section, only the invert and side wall to be concrete-lined. Salient features of the diversion tunnel are as follows.

1) Number of tunnels: 1
2) Upstream cofferdam elevation: EL. 894.8 m
3) Tunnel length: L = 246 m
4) Tunnel gradient: I = 1/65
5) Intake ~ Valve chamber: L = 53 m, inner diameter 4.5 m
6) Valve chamber ~ Outlet: L = 193 m, inner diameter 4.6 m

(c) Discharge Tunnel

(i) Discharge valve

Discharge valve has functions to release the water for power supply, to control the water level change at the initial impoundment of the reservoir, and to discharge the environmental flow to downstream and emergency release in the case of flood. Two discharge pipes of Φ1.9m are installed at the plugging point of diversion tunnel and gate chamber. A jet flow gate and a high pressure slide gate of Φ1.9m are also installed. A valve of the downstream side is used for the normal operation and the one of upstream is for the spare.

The discharge valve is designed to release maximum plant discharge of 20 m^3/s for power generation by means of the jetflow gate even in the lowest water level (LW.L. 890.5 m).

The structure of the valve room and the specifications of the valve are shown in Figure 4-2 and Table 4-1 respectively.

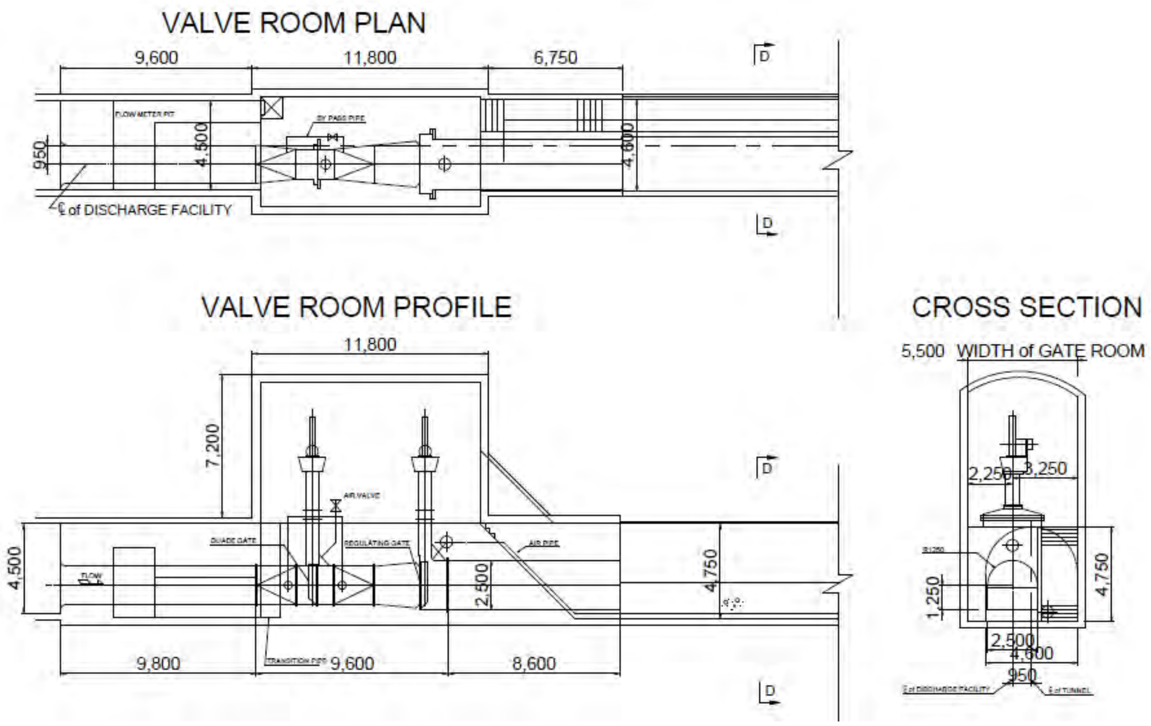


Figure 4-2 Structure of the Valve Room

Table 4-1 Specification of Valves

Item		Specifications	
Valve		Main discharge valve (downstream)	Sub discharge valve (upstream)
Type		Jet flow gate	High pressure slide gate
Unit		1	1
Diameter		1.9m	1.9m
Maximum Design Water Depth		27.5m	27.5m
Capacity	HWL	51 m^3/s	—
	LWL	20 m^3/s	—

(ii) Intake Tower

Intake tower is the morning glory gate type with an inlet height of EL. 890.1 m. Inlet diameter is 10.4 m (octagonal) and height of tower is 10.1 m. Structure of the intake tower is shown in Figure 4-3.

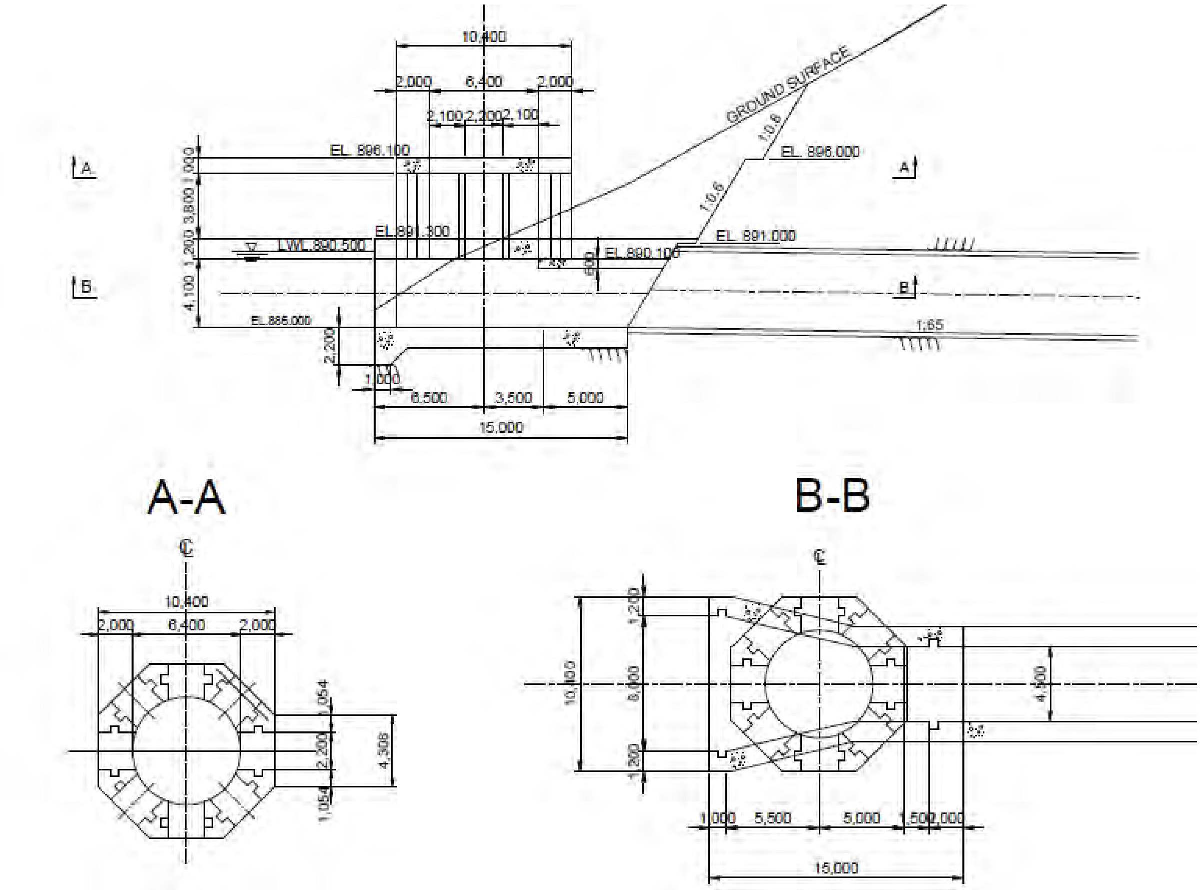


Figure 4-3 Structure of the Intake Tower

(iii) Downstream tunnel

By constructing a partition wall along the downstream tunnel from the gate chamber, the right side is planned to be the discharge waterway and the left side to be the access road for inspection as shown in Figure 4-4

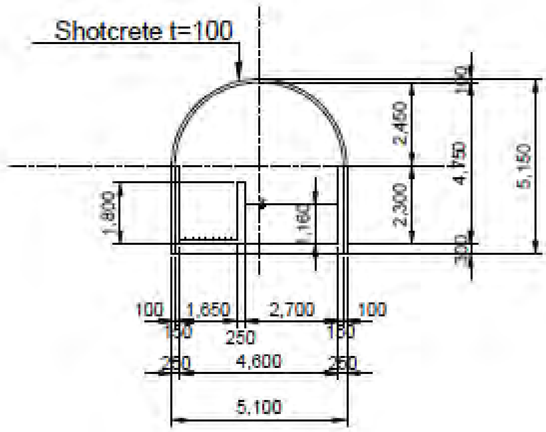


Figure 4-4 Cross Section of Downstream Tunnel

5. Diversion Weir

(1) Location

The diversion weir will be placed at right side of the saddle dam considering following matters.

- At the narrow point of the Xe Katam River at where the right bank has a small hill
- At the point that enables diversion even when the reservoir is at the Normal Water Level (N.W.L. 911 m)
- To shorten the distance from the weir to the reservoir

Layout plan of the diversion weir and connecting channel is shown in Figure 5-1.

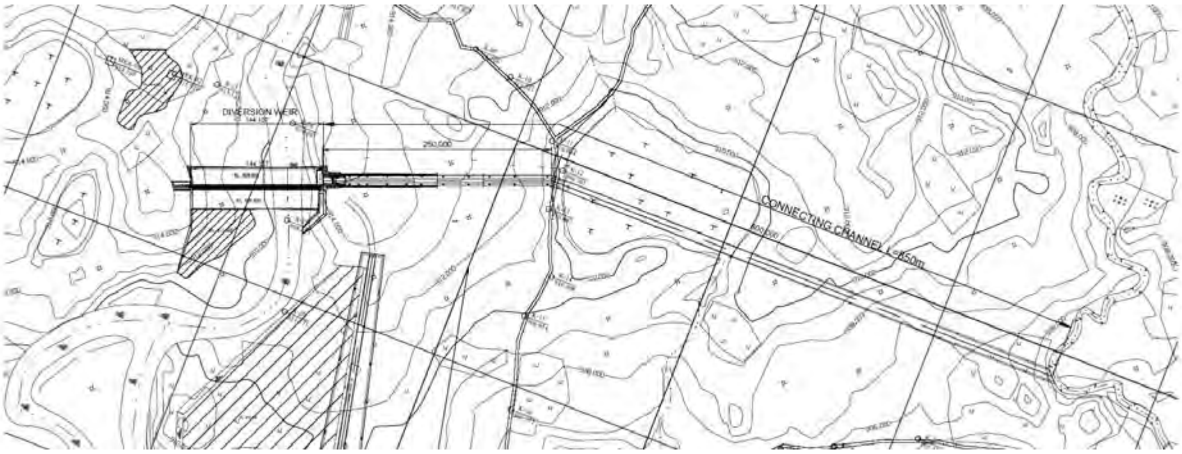


Figure 5-1 Layout Plan of the Diversion Weir and Connecting Channel

(2) Type of the Diversion Weir

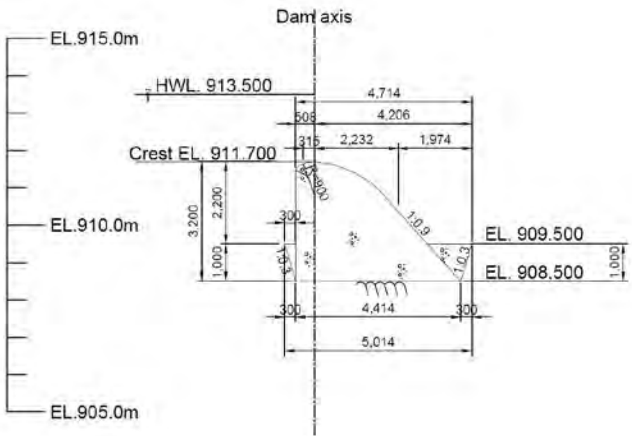


Figure 5-2 Typical Cross Section of the Diversion Weir

Since the diversion weir is a very small-scale one with a weir height of 3.2 m, the concrete gravity dam type is selected allowing flood water to overflow above the weir during floods. Outcrops of basalt are found around the riverbed, which will become a good foundation for the concrete type of weir.

(3) Basic Design of the Diversion Weir

Diversion weir has a long crest length of 144.2 m, while its weir height is small being 3.2 m. Although basalt is exposed on the riverbed, both abutments are covered with thick overburden soils and soil-like weathered rocks without outcrops. Both abutments shall be excavated by around 6 m down to the riverbed elevation to contact with the foundation rock. Crest elevation of the diversion weir is EL. 911.7 m, and HWL on the diversion weir with the 1,000-year probable flood discharge (750 m^3/s) is EL. 913.5 m. Flood discharge is overflowed on the diversion weir.

(4) Appurtenant Facility

In order to discharge sediment accumulated in front of the connecting channel for avoidance of any influence on the diversion to the reservoir, a flushing gate of 2.4 m in width and 4.9 m in height shall be installed. The sill level of the flushing gate is planned to be 1 m lower than of the connecting channel. This gate is also used for the release of environmental flow of approximately 0.35m^3/s.

6. Connecting Channel

(1) Alignment of Channel

Side overflow type is adopted as an intake method for easy maintenance. Alignment of the connecting channel is selected to make the shortest distance between the diversion point and reservoir. End of the channel is extended to the small tributary of EL. 905 m equivalent to LWL of the reservoir to avoid ground erosion along the connecting channel.

(2) Capacity of Channel

Capacity of the connecting channel is determined to maximize the diversion based on the actual river discharge.

As mentioned in the hydrological study, daily discharge records during 1991-1994 and 2005 – 2012 and hourly flood discharge records observed several times during 2005 – 2012 are obtained. Based on these data, capacity of the connecting channel is studied as shown below.

- The maximum daily mean inflow from 1991 to 1994 (4 years) and from 2005 to 2012 is 88 m^3/s in August 9th, 2005.
- In the rainy season from 2005 to 2010, thirteen (13) hydrographs in hours are observed. Peak discharge over 100 m^3/s are 121 m^3/s in October 2nd 2006, 15:00 and 120.7m^3/s in September 30rd 2009, 20:00. Others did not exceed 100 m^3/s.

Based on the above, capacity of the connecting channel is planned to be 100 m^3/s, which mostly enables divert the inflow even in the flood during observation period.

(3) Basic Design of the Connecting Channel

While the area around the connecting channel is covered by thick overburden soil and soil-like weathered rocks, there are outcrops of the bedrock of basalt around the riverbed of the Xe Katam River. In a section of about 250 m from the diversion weir to the height of NWL. 911 m, where foundation rock is not found at the ground, an open channel of concrete lining is built to prevent surface excavation by scouring.

(4) Appurtenant Facility

It is planned that one (1) gate with automatic discharge control device of 5.4 m in width and 4.2 m in height be installed.

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