LAO PEOPLE'S DEMOCRATIC REPUBLIC
DEPARTMENT OF WATER SUPPLY (DWS)
OF MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)
DEPARTMENT OF PUBLIC WORKS AND TRANSPORT
OF LUANG PRABANG PROVINCE (DPWT-LPB)
LUANG PRABANG WATER SUPPLY STATE ENTERPRISE (WSSE-LPB)

LAO PEOPLE'S DEMOCRATIC REPUBLIC

PREPARATORY SURVEY
ON
THE PROJECT FOR
EXPANSION OF THE WATER SUPPLY SYSTEM
IN LUANG PRABANG CITY

FINAL REPORT

JANUARY 2019

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIHON SUIDO CONSULTANTS CO., LTD.
ExeIdea LTD.

GE
JR
19-002

Exchange Ratio (June 2018)

US$ 1.00 = JPY 108.75

LAK 1.00 = JPY0.0132

SUMMARY

(1) Overview of Lao PDR

The Lao People's Democratic Republic (Lao PDR) is a landlocked country bordered by Myanmar and China to the north, Thailand to the west, Vietnam to the east, and Cambodia to the south. The country occupies 237,000 km^2. The population was estimated to be approximately 6.5 million in 2013 and 6.9 million in 2017. The population growth in recent years has been 1.3 to 1.5% per year.

The population of Luang Prabang Province (16,875 km^2) located in the northern part of Lao PDR is approximately 430 thousand. Luang Prabang city is the most populated area in Luang Prabang Province, with the total population of approximately 90,000 (about 21% of Luang Prabang Province).

Lao PDR has a tropical monsoon climate. The rainy season is from May to September and the dry season is from October to April. It is hot especially during March to May, and the daytime temperature can be 35 - 40 °C. The average annual precipitation during 1995 to 2015 was 1,834 mm.

The gross domestic product (GDP) per capita at nominal value was 2,542 USD in 2017, with growth of 6 to 8% over the last 10 years. 16.2% of the GDP is coming from the agricultural sector, 30.9% and 41.5% from the industrial and service sectors respectively. Supported by continued expansion in the mining, manufacturing, and service industries, the economic growth in 2017 was 6.89%. Significant Chinese and Vietnamese investments have been coming on stream in the recent years.

Export in 2017 was about 4.9 billion USD, and import was about 4.8 billion USD (Ministry of Industry and Commerce). The main exports are copper products and electric power, and the main imports are electrical and mechanical products and fuel. Thailand is the top trading partner in both export and import, but in recent years the increase in trade with China has been remarkable.

(2) Background of the Project

The "8th Five-Year National Socio-economic Development Plan" (NSEDP) (2016) states that the goal of water supply coverage is to achieve 90% in the central part of each city by 2020.

The "Water supply and sewerage sector development plan " (2016) prepared by the Ministry of Public Works and Transport (MPWT) states the coverage target for the central part of each city as 80, 85 and 90% for 2020, 2025 and 2030 respectively.

The water supply coverage of 95.3% in Luang Prabang city in 2017 has surpassed the target. The coverage including the expansion area, at 90.2% in 2017 has also achieved this target.

The "Luang Prabang Province Seventh Social Economic Development Five-Year Plan" has the goal to have water supply systems in all 12 districts in Luang Prabang Province by 2020. There are 6 districts with water supply systems. Water supply systems are under construction in 2 districts and the

remaining 4 districts do not have water supply systems.

The water supply coverage ratio in Luang Prabang city exceeds 90%. However, there are problems with high turbidity of treated water, leakage and lack of water pressure because of aged reservoir and pipelines. The current water supply service must be improved to meet the goal identified in the Water Supply Planning Technical Guidelines developed with the support of the MaWaSU[1] project (see below).

Water Supply Planning Technical Guidelines under the support of MaWaSU Project	
Overall Goal	The water supply service will provide customers with safe, stable and sustainable water supply, thereby improving public health and the living environment.

Improvement to the Namkhan WTP and renewal of aged distribution pipelines are urgently needed for improved water supply in Luang Prabang city including the World Heritage Site.

In August 2018, Lao PDR made a request to the Government of Japan (GOJ) for Grant Aid for the Project for Expansion of Water Supply System in Luang Prabang City.

The details of the request are as follows:

Category		Items
Facilities	Namkhan WTP	Rehabilitation/ improvement of the existing Namkhan WTP including replacement of booster pumps (7 units), intake pumps (4 units), and backwash system. Construction of sludge lagoon for Namkhan WTP.
	Phouphueng WTP	Repair of deteriorated parts related to treatment operations, maintenance of facilities and water meters related to water hardness, recommendations for future operation.
	Distribution facilities	Construction of new distribution tank with 1,500 m^3 capacity Installation of flow meters in WTP and elevated tank (5 units)
	Replacement of aged pipe	Replacement of aged pipe 19.8 km
	Fire hydrant	Installation of fire hydrant 120 locations
	Expansion of pipe network	Installation of new HDPE pipelines 13.25 km
	Monitoring systems	Monitoring systems for volume of water treated, water level in reservoirs, water distribution and water pressure in service area.
Soft components		For WSSE staff in monitoring volume of water treated and water distribution
		For villagers to be aware of causes of fire, fire protection and equipment used for firefighting

The Japan International Cooperation Agency (JICA) implemented the preparatory survey to determine if Grant Aid can be used to support this project. The preparatory survey developed the project scope and an outline design to estimate project cost.

[1] The JICA technical cooperation for "Capacity Development Project for Improvement of Management Ability of Water Supply Authorities (MaWaSU)", 2012-2017

(3) Results of the Preparatory Survey and Scope of Project

1) Results of the Preparatory Survey

JICA dispatched the preparatory survey team to Lao PDR on the dates shown below:

First assignment in Lao PDR : April 22th to July 3rd , 2018

Second assignment* in Lao PDR : November 25th to December 1st, 2018

* The first assignment includes the inception meeting and the second assignment includes the meeting for explanation on Draft Outline Design.

The survey team investigated the conditions of the existing water supply systems, social situation, topographic and soil conditions, water quality, and water pressure in Luang Prabang city.

The both side agreed on the contents of outline design as well as each other's respective obligations.

The major project components are: improvements to Namkhan WTP, construction of a new reservoir, renewal of aged pipelines, expansion of service area, installation of fire hydrants, introduction of a monitoring system, and implementation of soft component (technical assistance). Both sides agreed that treatment for water hardness in Phouphueng WTP will not be implemented and customer water meter maintenance will continue as before.

2) Scope of the Project

A) Construction of Water Supply Facilities

The water supply facilities to be constructed by the project are as follows:

Components			Contents
Facility	Distribution pipelines		Total length: approx. 60.2 km Outlet from new reservoir : 1.6 km (OD 400) Renewal of existing pipes : 44.3 km (OD 80-225) New pipelines for expansion area : 14.3 km (OD 80-225) Fire hydrants : 45
	Service Connections		Replace: 2,400 connections
	Service Reservoir		Capacity: 1,500 m^3
	Treated water transmission pipelines		Total length: approx. 5.0 km ・ From Phouphueng WTP to Khouthinieng Reservoir: 3.4 km (OD 225) ・ From existing transmission pipe to new reservoir: 1.6 km (OD 400)
	Namkhan WTP	Intake	・ Intake pumps (total 6: 3 large (2 for regular operation, 1 on standby), 3 small (2 for regular operations, 1 on standby) ・ Pipes and electrical equipment for intake pump facility

Components			Contents
		Treatment	・ Receiving well and mixing chamber ・ Flocculation and sedimentation basin (6,000 m^3/day) ・ Renewal of existing facilities and equipment
		Treated Water Transmission	・ Transmission pumps (6,000 m^3/day x total 2 units: 1 for regular operation and 1 on standby) ・ Pipes and electrical equipment for transmission pump facility
		Waste wash water treatment	・ 2 wastewater basins and 1 sludge basin ・ 1 lagoon
	Monitoring system		・ One set (computers with monitor, software, data loggers, flow meters, water level gauges, etc.)

B) Procurement of Equipment

Wastewater treatment facilities will be constructed in Namkhan WTP. To convey sludge treated by the wastewater treatment facilities, the following equipment will be procured under Japanese Grant Aid:

Item	Details	Use	Amount
Belt conveyor	Length 7 m, Width 350 mm	Carry out sludge	1

C) Soft Component (Technical Assistance)

Training will focus on the technical operations which will be changed by the implementation of the project, specifically in the following 2 areas:

1. Water Quality Management and O&M of the Namkhan WTP
   - Control of intake flow and setting chemical injection rate based on the intake volume
   - Wastewater treatment operation
2. Distribution Control Using the Monitoring System
   - Recording and organizing the data on intake, transmission and distribution flow; and utilizing the data for water supply management
   - Operation method based on monitored water level

(4) Project Implementation Schedule and Cost Estimate

The project will be implemented for multi years. The detailed design will be carried out over 5.0 months during the first fiscal year, followed by the tendering process, which will take about 5.0 months. Procurement of equipment and construction will take 26 months.

The project cost borne by the Lao side will be about 3,045 million Lao Kip (LAK).

(5) Project Evaluation

1) Relevance

A) Project Beneficiaries

The project will expand the water supply area and residents in the expansion area will be able to connect to the water supply system. About 600 new households are expected to connect to the water supply system in the expanded service area by 2025.

The coverage will increase from 90.2 % in 2017 to 96.2 % in 2025. The served population will increase by 12,000, from 59,000 in 2017 to 71,000 in 2025. The project will carry out improvements to Namkhan WTP, renewal of aged pipelines and construction of a new reservoir. These efforts will contribute to stabilization of supply volume, better water quality and water pressure. The overall improvement to the water supply system will benefit an estimated 71,000 people in 2025.

Luang Prabang city received approximately 650,000 tourists in 2017, since Luang Prabang city has a World Heritage Site (WHS). The improved water supply service will also benefit these tourists.

Fire hydrants will be installed to enhance the firefighting capability for better protection of Luang Prabang city including the World Heritage Site.

B) Urgency of Project Implementation

Although the coverage in the existing service area is high, there are problems with treated water quality caused by insufficient capacity of the sedimentation basin, and leakage and lack of water pressure because of aged reservoir and pipelines. The renewal of 50-year old pipelines will reduce leakage and increase water supply pressure. Improvements are urgently needed to upgrade the service to supply safe water with adequate pressure.

The two critical issues to be resolved: turbidity of treated water and aged pipelines, are further explained below.

Although the rapid sand filter in Namkhan WTP has a capacity of 12,000 m^3/day, the capacity of the flocculation and sedimentation basin is only 6,000 m^3/day. The gap in capacity results in inadequate sedimentation and the floc flows to the filter. Sometimes turbidity exceeds the Lao water quality standard of 5NTU, making it difficult to deliver safe water supply. Stable supply is also compromised when raw water turbidity is high especially in the rainy season and intake flows must be reduced to achieve the required treated water quality. A flocculation and sedimentation basin with adequate capacity is urgently needed.

Old pipelines are the main reason for high leakage rates. In recent years, NRW has increased, by 10% over just a 5-year period. Large amounts of leakage contribute to the problem of poor water supply pressure. Renewal of old pipelines will reduce leakage significantly and improve supply pressure. The NRW and leakage ratio are expected to be increased considering the recent trend and the increases of NRW and leakage ratio have the adverse impacts including decrease of water supply pressure. Therefore, the renewal of the aged pipelines is also the urgent task.

C) Relevance to Lao National Plans

The 8th National Socio-Economic Development Five-Year Plan (2016) aims to increase the water supply coverage to 90% by 2020 for the central part of each city in Lao PDR. The coverage in the existing supply area in Luang Prabang city is 95.3%, i.e. the national target has already been achieved.

The current water supply service has to be improved to meet the goal in the Water Supply Planning Technical Guidelines developed with the support of MaWaSU project (see below). However, there are still problems with high turbidity of treated water caused by insufficient capacity of the sedimentation basin, leakage and lack of supply pressure because of aged reservoir and pipelines, and installation of the distribution pipelines in expansion area.

Water Supply Planning Technical Guidelines under the support of MaWaSU Project

Overall Goal	The water supply service should provide customers with safe, stable and sustainable water supply, and thereby improve public health and living environment.

The improvement of the WTP and the renewal of aged pipelines and installation of distribution pipelines in the expansion area by the project are consistent with the national plans.

D) Compliance with Japan's Assistance Policy for Lao PDR

"Development of Economic and Social Infrastructure" is a high priority in Japan's assistance policy for Lao PDR (2012). This includes the development of infrastructure including water supply in urban areas. JICA country analysis for Lao PDR (2015) shows that expansion of existing WTPs, construction of new WTPs and transmission/distribution pipelines, and renewal of aged pipelines have a high priority. Therefore, the project is consistent with Japan's assistance policies.

2) Effectiveness

A) Quantitative Effects

The project is expected to provide the following beneficial outcomes:

No.	Index	Baseline (2017)	Target (Year 2025)
1	Served population	58,760	70,812
2	Number of new house connections in the expanded service area	-	600 Connections
3	Maximum turbidity of treated water in Namkhan WTP	12 NTU (Maximum in last 5 years from 2013 to 2017)	< 5 NTU
4	Water pressure	0-10 m	> 10 m

B) Qualitative Effects

The qualitative effects are as follows:

- The renewal of aged pipelines and installation of new distribution pipelines will improve water supply pressure and reduce leakage in the supply area.
- Improvement to Namkhan WTP will strengthen the stability of water supply and improve water quality.
- Installation of fire hydrants will improve protection and firefighting capacity in the WHS.

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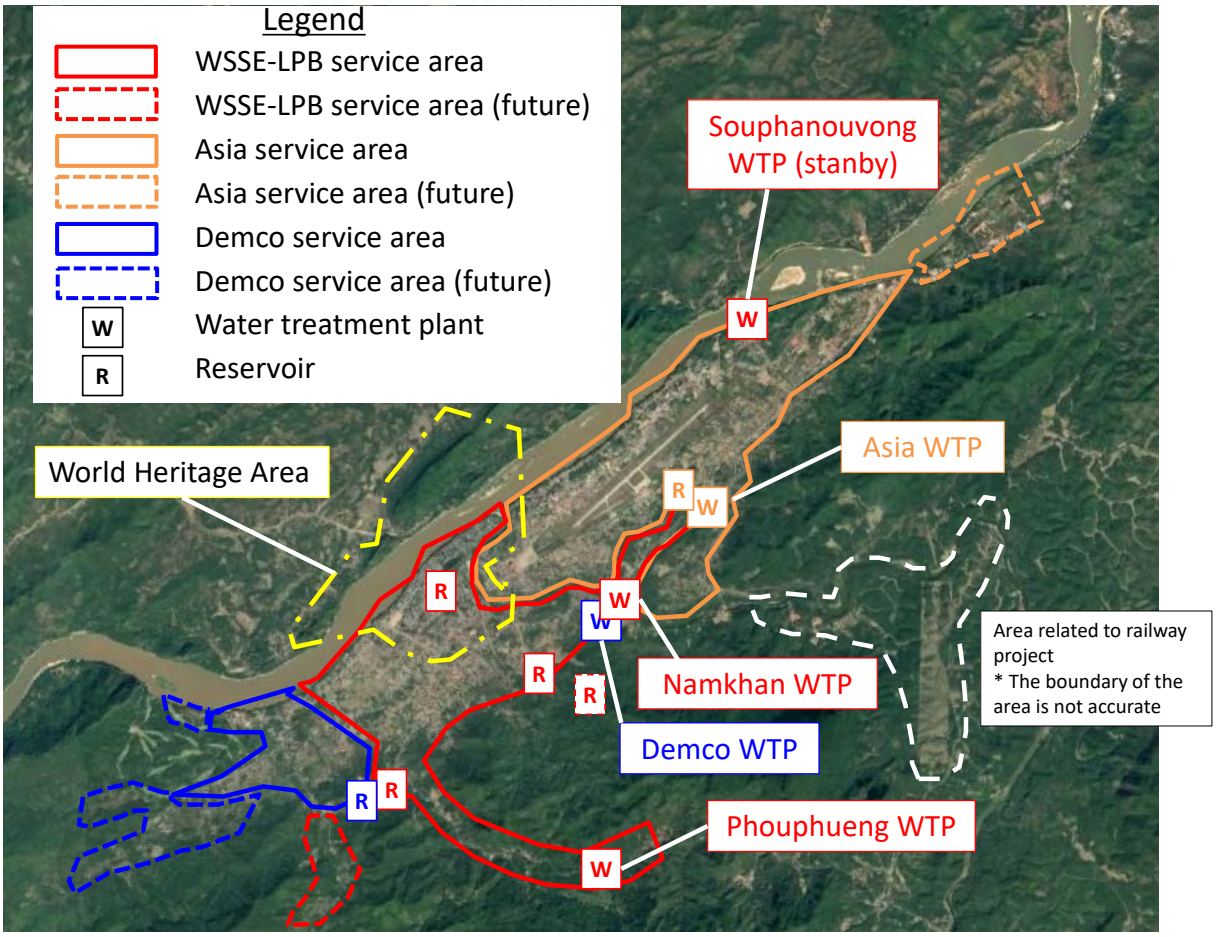
LOCATION MAP



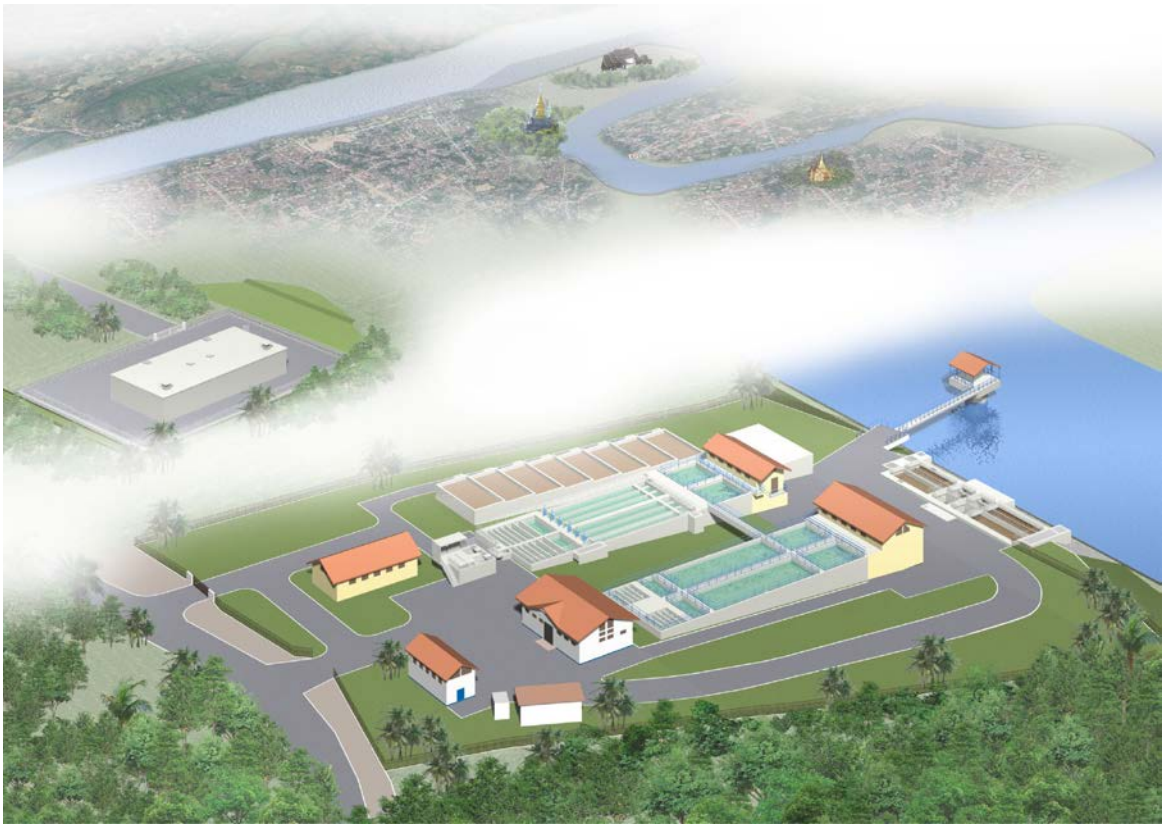
Map source: Google, DigitalGlobe

WSSE-LPB : Luang Prabang Water Supply State Enterprise

Asia : Asia Nampapa Luang Prabang Co., Ltd.

Demco : Demco De Lao Co., Ltd.

PERSPECTIVE



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ABBREVIATIONS

ADB	:	Asian Development Bank
Asia	:	Asia Nampapa Luang Prabang Co., Ltd.
BOT	:	Build Operate Transfer
Demco	:	Demco De Lao Co., Ltd.
DF	:	Department of Forestry of Luang Prabang Province
DIP	:	Ductile Iron Pipe
DOD	:	Draft Outline Design
DOF	:	Department of Finance of Luang Prabang Province
DOH	:	Department of Health of Luang Prabang Province
DONRE	:	Department of Natural Resources and Environment of Luang Prabang Province
DP	:	Department of Police of Luang Prabang Province
DPI	:	Department of Planning and Investment of Luang Prabang Province
DPWT	:	Department of Public Works and Transport
DPWT-LPB	:	Department of Public Works and Transport of Luang Prabang Province
DWS	:	Department of Water Supply
ECC	:	Environmental Compliance Certificate
EIA	:	Environmental Impact Assessment
ESMMP	:	Environmental and Social Management and Monitoring Plan
ESS	:	Environmental and Social Staff
FRP	:	Fiber-Reinforced Plastics
GDP	:	Gross Domestic Product
GOJ	:	Government of Japan
GSP	:	Galvanized Steel Pipe
HDPE	:	High Density Polyethylene Pipe
HIA	:	Heritage Impact Assessment
IEE	:	Initial Environmental Examination
JICA	:	Japan International Cooperation Agency
JIS	:	Japan International Standard
JPST	:	JICA Preparatory Survey Team
JWWA	:	Japan Water Works Association
KfW	:	Kreditanstalt für Wiederaufbau (German)
Lao PDR	:	Lao People’s Democratic Republic
LDB	:	Lao Development Bank
LPB	:	Luang Prabang Province
LPCD	:	Liters per Capita per Day
MaWaSU	:	Capacity Development Project for Improvement of Management Ability of Water Supply Authorities
MaWaSU2	:	The Project for Improvement of Management Capacity of Water Supply Sector
MOH	:	Ministry of Health
MPI	:	Ministry of Planning and Investment
MPWT	:	Ministry of Public Works and Transport
NPLP	:	Nam Papa Luang Prabang
NRW	:	Non-Revenue Water
PAC	:	Poly-Aluminum Chloride
PAP	:	Project Affected Person
PPP	:	Public–Private Partnership
PVC	:	Polyvinyl Chloride

SOP	:	Standard Operating Procedure
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UPS	:	Uninterruptible Power Supply
u-PVC	:	Un-plasticized Polyvinyl Chloride
UXO	:	Unexploded Ordnance
VAT	:	Value Added Tax
WHS	:	World Heritage Site
WSSE	:	Water Supply State Enterprise
WSSE-LPB	:	Luang Prabang Water Supply State Enterprise
WTP	:	Water Treatment Plant

1. Background of the Project

1.1 Background of the Project

The "8th Five-Year National Socio-economic Development Plan" (NSEDP) (2016) states that the goal of water supply coverage is to achieve 90% in the central part of each city by 2020.

The "Water supply and sewerage sector development plan " (2016) prepared by the Ministry of Public Works and Transport (MPWT) states the coverage target for the central part of each city as 80, 85 and 90% for 2020, 2025 and 2030 respectively.

The existing coverage (95.3% as of 2017) and the coverage with the expansion by the project (90.2% as of 2017), both surpass the target of 90% by 2020.

The "Luang Prabang Province Seventh Social Economic Development Five-Year Plan" has the goal to have water supply systems in all 12 districts in Luang Prabang Province by 2020. 6 districts already have water supply. Water supply systems are under construction in 2 districts and the remaining 4 districts do not have water supply systems.

Although the water supply coverage of Luang Prabang city exceeds 90%, the system still has deficiencies that impede its ability to meet the goal shown in Table 1.1.1. There are problems with high turbidity of treated water caused by insufficient capacity of the sedimentation basin, and leakage and lack of supply pressure because of aged reservoir and pipelines.

Table 1.1.1 Goal in Water Supply Planning Technical Guidelines under the support of MaWaSU Project

Overall Goal	The water supply service should provide customers with safe, stable and sustainable water supply, and thereby improve public health and living environment.

Although water supply coverage in Luang Prabang city is high, improvement is still urgently needed in the water supply service of Luang Prabang city including the World Heritage Site. This requires improvements to Namkhan WTP and renewal of distribution pipelines.

In August 2018, Lao PDR made a request to the GOJ (Government of Japan) for Grant Aid for the Project for Expansion of Water Supply System in Luang Prabang city.

The details of the request are as follows:

Category		Items
Facilities	Namkhan WTP	Rehabilitation/ improvement of the existing Namkhan WTP including replacement of booster pumps 7 units and intake pumps 4units, and backwash system Construction of sludge lagoon for Namkhan WTP
	Phouphueng WTP	Phouphueng WTP repair of degradation parts related to treatment function: maintenance of facilities and water meter related to water hardness, recommendation of future operation.

Category		Items
	Distribution facilities	Construction of new distribution tank capacity; 1,500m^3 Installation of flow meters in WTP and elevated tank 5 units
	Replacement of aged pipe	Replacement of aged pipe 19.8km
	Fire hydrant	Installation of fire hydrant 120 points
	Expansion of pipe network	Installation of new HDPE 13.25km
	Monitoring systems	Monitoring systems for water production of WTPs, water level in reservoirs, water distribution and water pressure in service area.
Soft components		Training WSSE staff for monitoring water production and water distribution
		Training villagers to be aware of causes of fire, fire protection and equipment usage of firefighting.

Japan International Cooperation Agency (JICA) implemented the preparatory survey to determine if Grant Aid can be used to support this project. The survey developed the appropriate project scope and outline design to estimate project cost.

The two sides discussed and agreed on the outline design as well as each other's respective obligations.

The major project components are: improvements to Namkhan WTP, construction of a new reservoir, renewal of aged pipelines, expansion of service area, installation of fire hydrants, introduction of a monitoring system, and implementation of soft component (technical assistance). Both sides agreed that treatment for water hardness in Phouphueng WTP will not be implemented and customer water meter maintenance will continue as before.

1.2 Natural Environmental Conditions

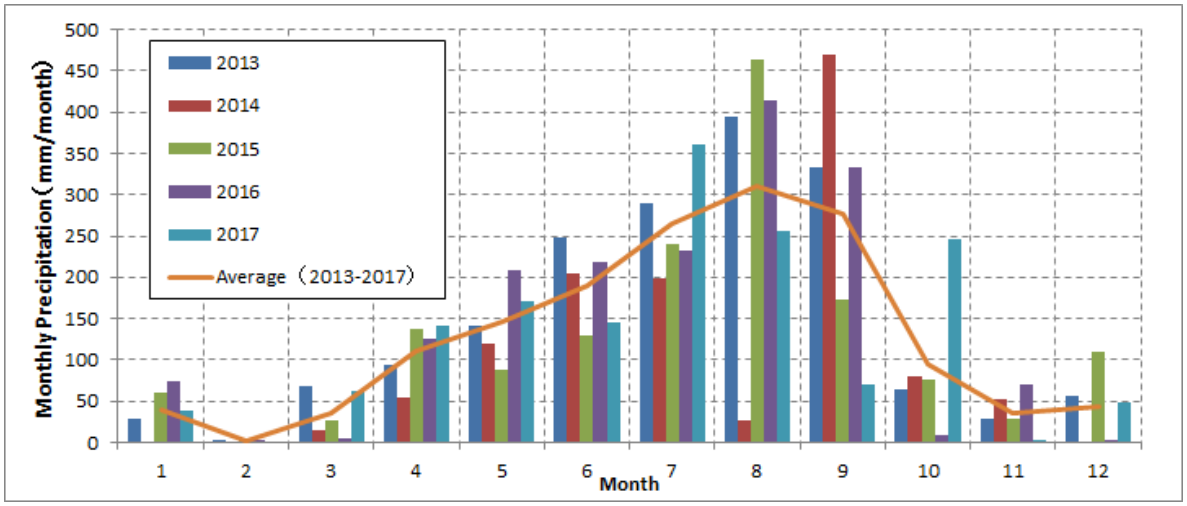
1.2.1 Precipitation

Table 1.2.1 and Figure 1.2.1 present the monthly precipitation of Luang Prabang city. Maximum daily precipitation by month is shown in Table 1.2.2 and Figure 1.2.2, and days with precipitation exceeding 10 mm is shown in Table 2.2.3 and Figure 1.2.3. Although precipitation is higher in the rainy season, there are only about 7 to 8 days with daily precipitation exceeding 10 mm. Construction can be carried out even in the rainy season.

Table 1.2.1 Monthly precipitation

Year	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	28	2	68	94	141	248	290	394	333	65	28	57	1,748
2014	0	0	15	55	119	205	198	27	470	80	52	0	1,221
2015	61	5	27	137	87	129	239	463	174	76	28	110	1,536
2016	74	3	4	126	209	218	232	414	333	9	71	4	1,697
2017	38	0	63	140	172	146	362	257	71	247	1	48	1,545
Average	40	2	35	110	146	189	264	311	276	95	36	44	1,548

(Unit : mm)



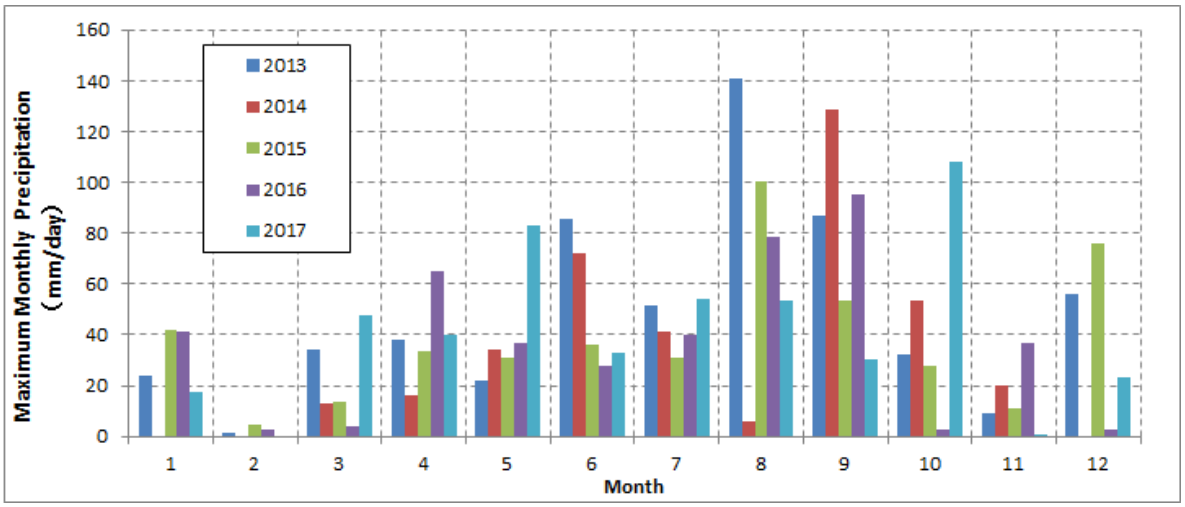
Source: JPST based on the weather data of Luang Prabang city

Figure 1.2.1 Monthly precipitation

Table 1.2.2 Maximum daily precipitation by month

Year	Month												Max.
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	24	2	35	38	22	86	52	141	87	33	9	56	141
2014	0	0	13	16	34	72	42	6	129	54	20	0	129
2015	42	5	14	34	31	36	31	100	54	28	11	76	100
2016	42	3	4	65	37	28	40	79	95	3	37	3	95
2017	17	0	48	40	83	33	54	53	31	108	1	23	108
Maximum	42	5	48	65	83	86	54	141	129	108	37	76	141

(Unit : mm)



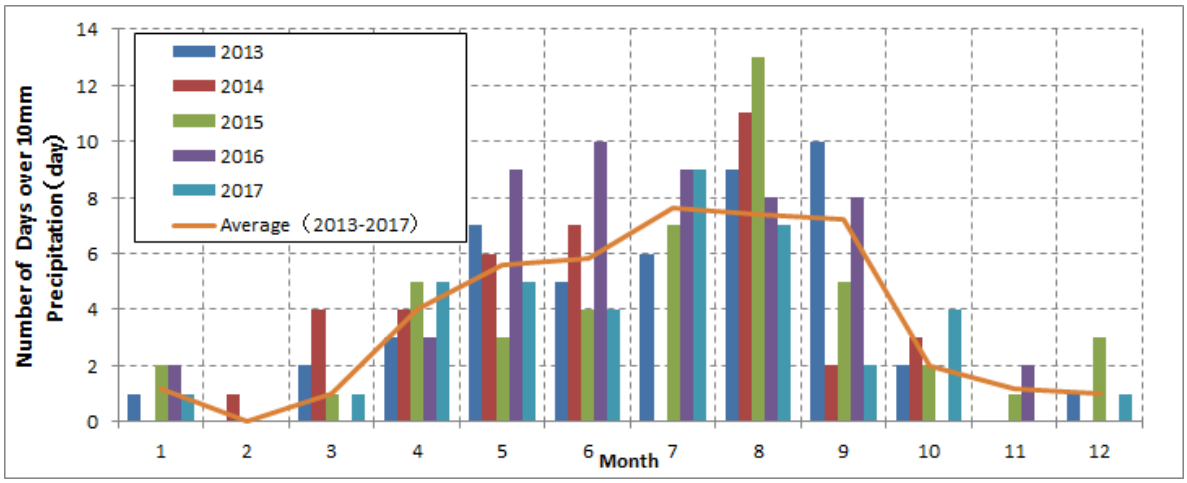
Source: JPST based on the weather data of Luang Prabang city

Figure 1.2.2 Maximum daily precipitation by month

Table 1.2.3 Days with precipitation exceeding 10 mm by month

Year	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	1	0	2	3	7	5	6	9	10	2	0	1	46
2014	0	0	1	4	4	6	7	0	11	2	3	0	38
2015	2	0	1	5	3	4	7	13	5	2	1	3	46
2016	2	0	0	3	9	10	9	8	8	0	2	0	51
2017	1	0	1	5	5	4	9	7	2	4	0	1	39
Average	1.2	0.0	1.0	4.0	5.6	5.8	7.6	7.4	7.2	2.0	1.2	1.0	44

(Unit : day)



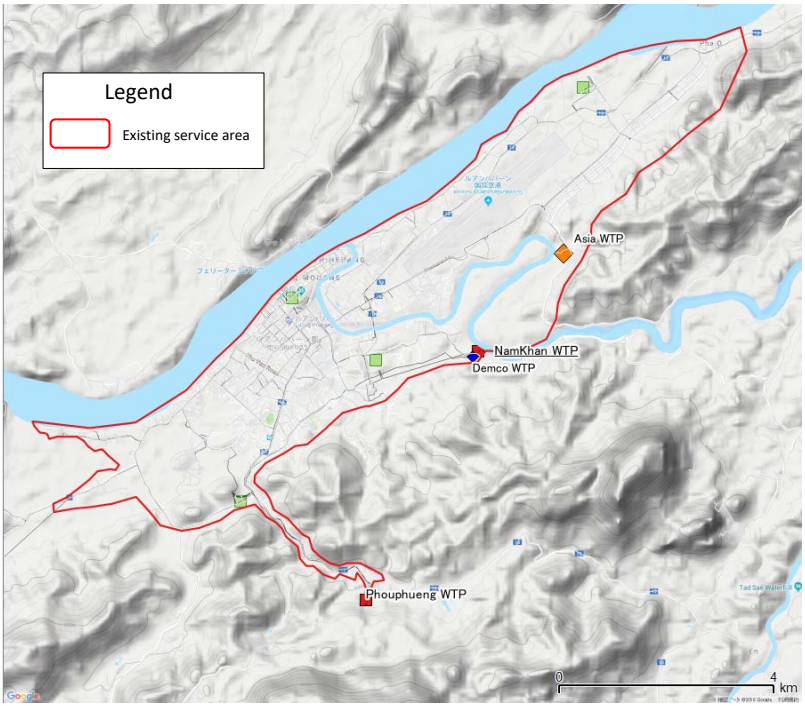
Source: JPST based on the weather data of Luang Prabang city

Figure 1.2.3 Days with precipitation exceeding 10 mm by month

1.2.2 Topography and Geography

The project area is in the plain between the Mekong River and the mountains as shown in Figure 1.2.4. House construction is spreading to the mountainous area from the plain.

The soil investigation at the Namkhan WTP shows cohesive soil with N values of more than 50, to the depth of 12 to 15 m. The ground is firm enough for the construction of WTP facilities and reservoir without the need for pile foundation.



Source: Google, DigitalGlobe

Figure 1.2.4 Topography of project area

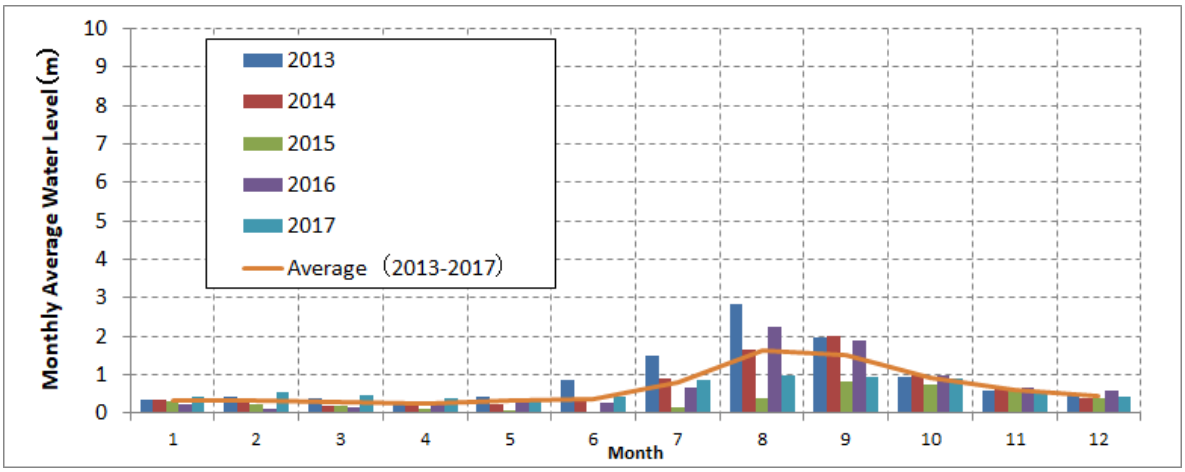
1.2.3 Water Level of Khan River

Khan River is the raw water source for the Namkhan WTP. Its average water level by month is shown in Table 1.2.4 and Figure 1.2.5. Maximum water level by month is shown in Table 1.2.5 and Figure 1.2.6.

Table 1.2.4 Average water level of Khan River by month

Year	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	0.34	0.44	0.37	0.31	0.44	0.84	1.49	2.83	1.95	0.92	0.60	0.49	0.92
2014	0.35	0.26	0.20	0.21	0.23	0.30	0.90	1.66	1.99	0.99	0.65	0.38	0.68
2015	0.31	0.21	0.18	0.13	0.06	0.05	0.17	0.41	0.81	0.75	0.59	0.39	0.34
2016	0.25	0.10	0.15	0.27	0.40	0.28	0.68	2.26	1.90	0.96	0.67	0.58	0.71
2017	0.43	0.53	0.48	0.39	0.41	0.41	0.85	0.98	0.96	0.90	0.60	0.43	0.62
Ave.	0.34	0.31	0.28	0.26	0.31	0.38	0.82	1.63	1.52	0.91	0.62	0.45	0.65

(Unit: m)



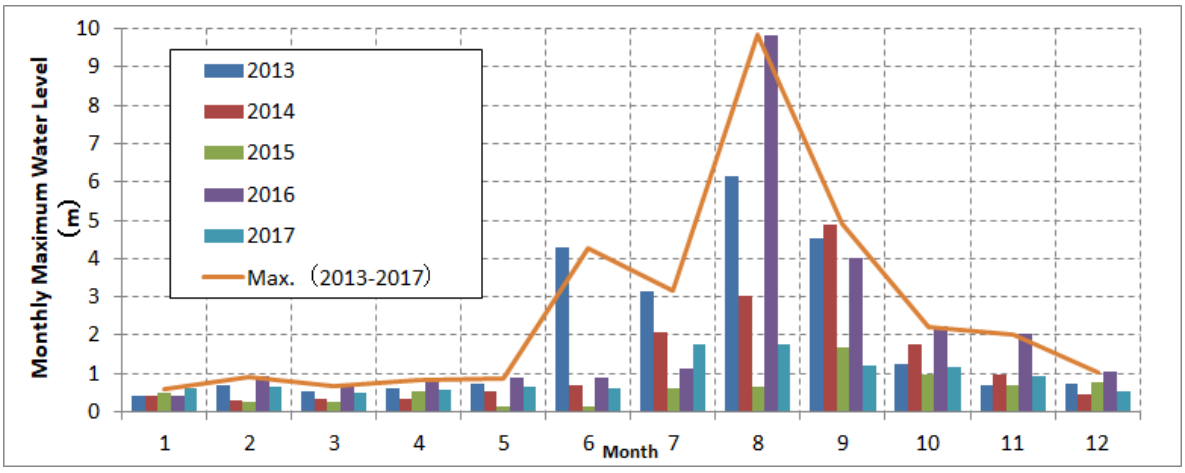
Source: JPST based on the weather data of Luang Prabang city

Figure 1.2.5 Average water level of Khan River by month

Table 1.2.5 Maximum water level of Khan River by month

Year	Month												Max.
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	0.40	0.69	0.55	0.61	0.75	4.29	3.15	6.15	4.54	1.26	0.71	0.72	6.15
2014	0.40	0.30	0.32	0.32	0.54	0.69	2.06	3.01	4.90	1.75	0.95	0.46	4.90
2015	0.49	0.24	0.25	0.55	0.12	0.12	0.60	0.65	1.67	0.95	0.69	0.76	1.67
2016	0.40	0.93	0.68	0.82	0.88	0.88	1.13	9.84	4.01	2.22	2.02	1.04	9.84
2017	0.61	0.64	0.50	0.58	0.66	0.62	1.75	1.75	1.23	1.16	0.92	0.55	1.75
Max.	0.61	0.93	0.68	0.82	0.88	4.29	3.15	9.84	4.90	2.22	2.02	1.04	9.84

(Unit: m)



Source: JPST based on the weather data of Luang Prabang city

Figure 1.2.6 Maximum water level of Khan River by month

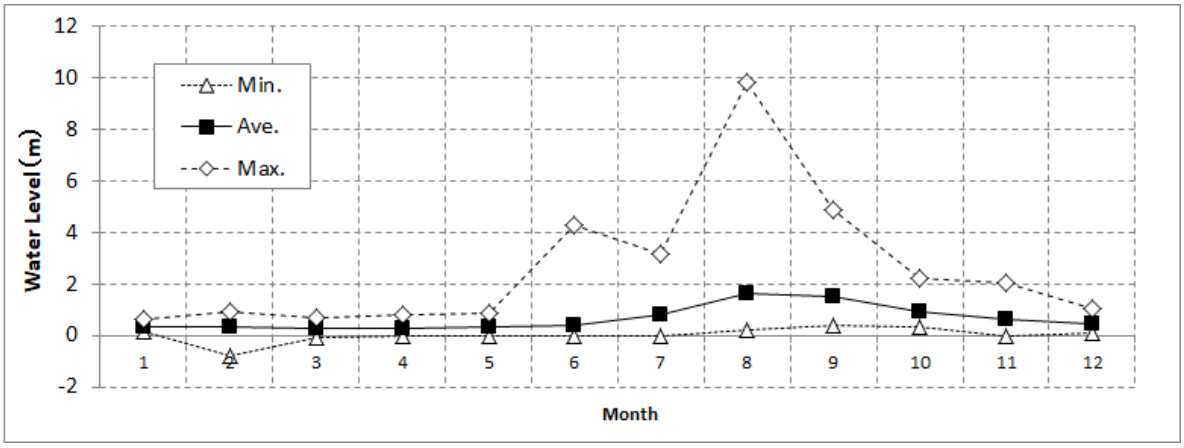


Figure 1.2.7 Average, maximum and minimum water level of Khan River by month (2013 to 2017)

As shown in Figure 1.2.7:

- The fluctuation of maximum water level is about 10 m each year (based on monthly maximum water level).
- The fluctuation of average water level is not big, at less than 2 m each year.

1.2.4 History of Precipitation and Flood Damage

The Namkhan WTP was damaged by flood water in 20 August, 2016. Figure 1.2.8 shows the history of precipitation and water level of the Khan River from 2013 to the end of 2017. A dam was constructed and put into operation in June 2016.

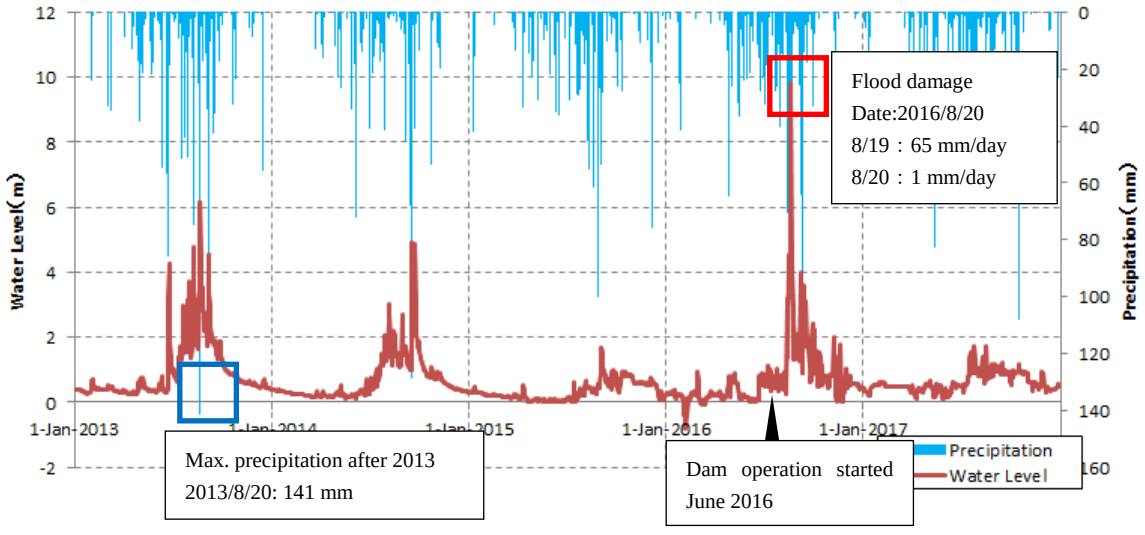


Figure 1.2.8 Precipitation and water level of Khan River

According to interviews with WSSE-LPB staff, the water level during the flood on August 20th, 2016 was 3 m higher than the estimated high-water level (HWL). All pump facilities were inundated. (Photo 1.2.1 and Figure 1.2.9)

Photo 1.2.1 Flood damage

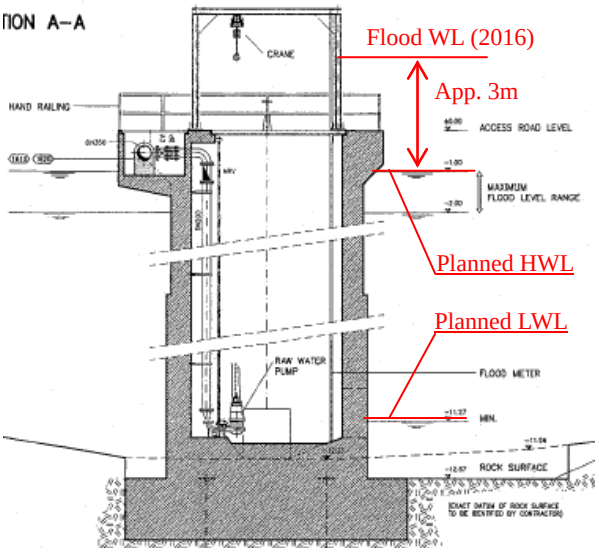


Figure 1.2.9 Section of intake tower

Usually measures are taken to prevent frequent damage to facilities from flooding caused by heavy rainfall. However, as shown in Figure 1.2.8, the flood damage did not occur on the day with the maximum precipitation (August 20th, 2013). The flooding of the facilities occurred on August 20th, 2016 when precipitation was lower than the maximum precipitation, after the dam was in operation.

Detailed data on precipitation and water level of the Khan River in August 2013 (maximum precipitation) and August 2016 (when flooding occurred) are shown in Figure 1.2.10 and Figure 1.2.11. In August 2013 (before dam construction) the water level was obviously affected by precipitation. After dam operation started, the relationship between precipitation and water level was like that of 2013 until August 14th, 2016. On August 15th, 2016 no correspondence between precipitation and water level was observed. Starting from August 19th, 2016 the water level showed an abnormal increase. The abnormal increase could be caused by the water discharge from the dam between August 15th and August 20th.

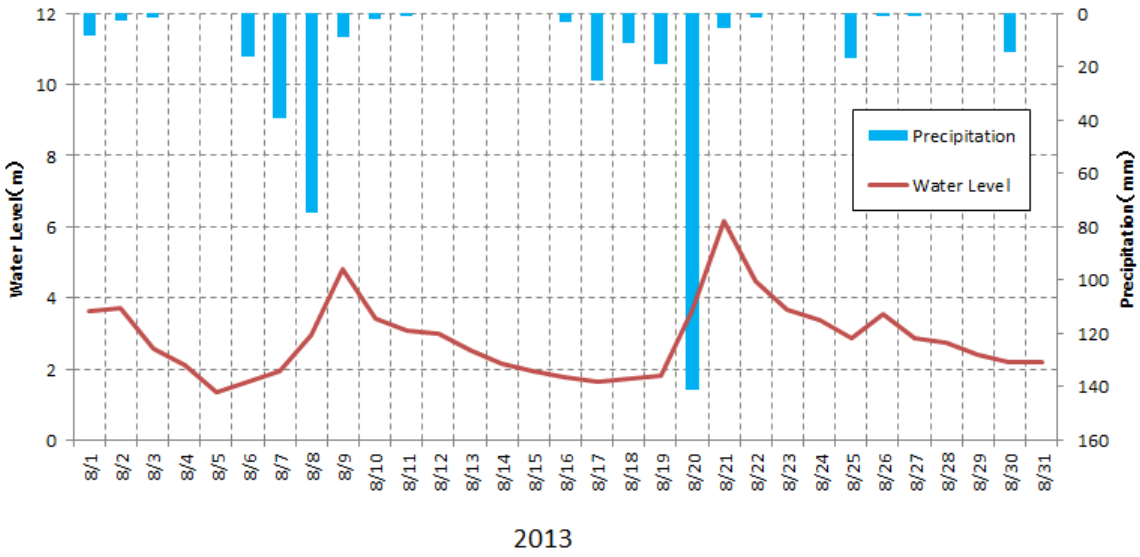


Figure 1.2.10 Precipitation and water level of Khan River (Aug. 2013)

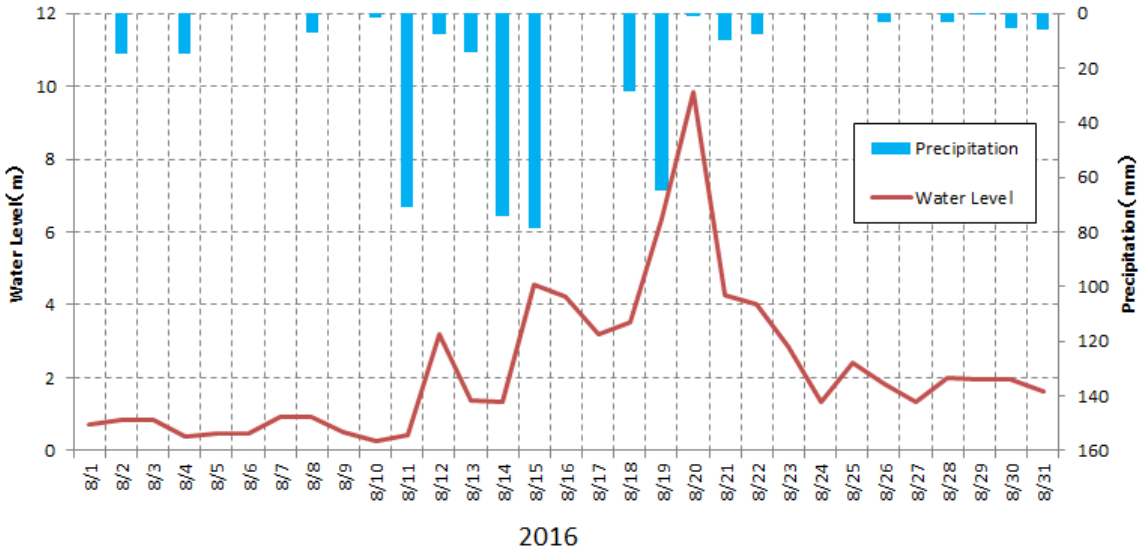


Figure 1.2.11 Precipitation and water level of Khan River (Aug. 2016)

Except for the flood on August 20th, 2016, in the past five years (from 2013 to 2017), the highest water level of about 6 m was recorded on August 21st, 2013. This is 4 m lower than the flood level (10 m) and 1 m lower than planned HWL set in 2001. The planned HWL set in 2001 is still valid.

The water level of the Khan River would be lower than the planned HWL if the dam can be operated properly. It is not necessary to take special flood prevention measures (such as embankment construction) to avoid excessive investment.

1.2.5 Raw Water Quality

Table 1.2.6 and Table 1.2.7 present the water quality results summarized in the WSSE-LPB Annual Report 2017 and measurements taken in the preparatory survey.

Table 1.2.6 Summary of raw water quality

Parameter	Unit	Standard Value	Frequency[1)]			WSSE-LPB Annual Report 2017		Water Quality Studies in the Preparatory Survey	
			W	M	Y	Raw Water of Namkhan WTP	Raw Water of Phouphueng WTP	Raw Water of Namkhan WTP (2018-4-25)	Raw Water of Phouphueng WTP (2018-4-25)
Bacteriological Parameter									
E. Coli	No./100ml	0		✔		-	-	Detected	ND
Chemical Parameter									
Aluminum (Al)	mg/l	<0.2		✔		0.015～0.03	0.012～0.023	-	-
Arsenic (As)	mg/l	<0.01			✔	-	-	ND (<0.005)	ND (<0.005)
Chloride (Cl^-)	mg/l	<250			✔	3.0～4.0	3.0～9.0	4.3	11.1
Residual Chlorine (Cl_2)	mg/l	0.1 - 2.0	✔			-	-	-	-
Copper (Cu)	mg/l	<2				-	-	-	-
Cyanide (CN^-)	mg/l	<0.5			✔	-	-	-	-
Fluoride (F^-)	mg/l	<1.5			✔	0.04	0.02 以下	0.13	ND (<0.05)
Iron (Fe)	mg/l	<0.3			✔	0.08	0.02	0.09	ND (<0.03)
Lead (Pb)	mg/l	<0.01			✔	-	-	-	-
Manganese (Mn)	mg/l	<0.1			✔	-	-	ND (<0.01)	ND (<0.01)
Mercury (Hg)	mg/l	<0.006			✔	-	-	-	-
Nitrate (NO_3^-)	mg/l	<50	✔			0.6～1.1	0.6～1.1	2.7	1.5
Nitrite (NO_2^-)	mg/l	<3	✔			0.005～0.006	0.005～0.007	ND (<0.05)	ND (<0.05)
Sodium (Na9	mg/l	<200			✔	-	-	-	-
Sulphate (SO_4^{2-})	mg/l	<250			✔	-	-	-	-
Zinc (Zn)	mg/l	<3			✔	0.05	0.07	-	-
Taste	-	Acceptable	✔			-	-	-	-
Physical Parameter									
Color	TCU	<5	✔			0	0	9.0	6.0
pH	-	6.5 - 8.5	✔			7.39-8.20 7.85	7.20-7.60 7.25	8.3	7.8
Electrical Conductivity (EC)	µS/cm	<1000			✔	208～276	448-554	485	193
Turbidity	NTU	<5	✔			6.5-928 49	0.85-76.0 2.13	6.6	0.7
Total Hardness	mg $CaCO_3$/l	<300			✔	112-168 128	122-290 162	124	304

ND: Not detected Upper: minimum value – maximum value Lower: average value
Source: JPST based on Minister's Decision on Water Quality Standard Management for Drinking and Domestic Use (MOH, March 2014)

Table 1.2.7 Water quality for the parameters not included in drinking water quality standard

Parameter	Unit	WSSE-LPB Annual Report 2017				Water Quality Studies in the Preparatory Survey	
		Raw Water of Namkhan WTP	Treated Water of Namkhan WTP	Raw Water of Phouphueng WTP	Treated Water of Phouphueng WTP	Raw Water of Namkhan WTP	Raw Water of Phouphueng WTP
Total Hardness	mg/l	101～130	91～125	261～312	268～307	44	292
Total Dissolved Solids (TDS)	mg/l	102～123	105～124	246～261	241～261	-	-
Odor	-	Normal	Normal	Normal	Normal	Normal	Normal
Ammonia	mg/l	-	-	-	-	0.49	0.23
Permanent Hardness	mg/l	-	-	-	-	52	77
Temporary Hardness	mg/l	-	-	-	-	72	227
Phosphates (PO_4^{3-})	mg/l	-	-	-	-	0.08	0.06
COD_{Mn}	mg/l	-	-	-	-	3.2	1.5

1.2.5.1 Namkhan WTP

The maximum turbidity of the raw water for Namkhan WTP in 2017 was 928 NTU. Turbidity increases during the rainy season. There are no abnormal values observed for other water quality parameters. The removal of turbidity is particularly important for the operation of the WTP.

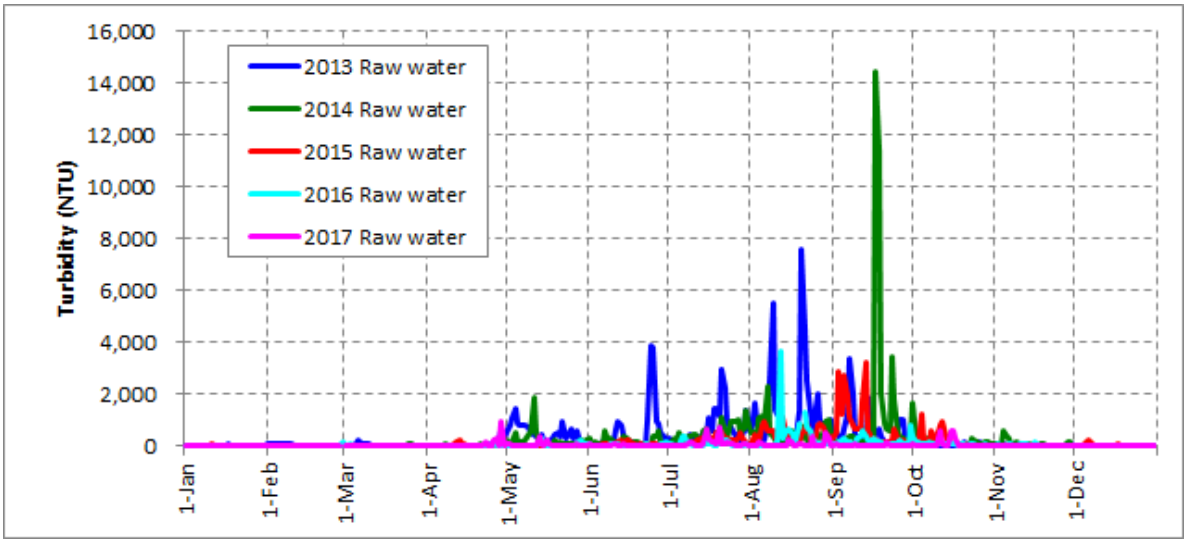
The monthly average turbidity and the maximum turbidity of the raw water for Namkhan WTP in the past five years are shown in Table 1.2.8, Table 1.2.9 and Figure 1.2.12.

Table 1.2.8 Average raw water turbidity by month

Year	Month (Ave.)												Ave.
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	44	53	49	77	527	559	683	1,432	632	70	46	–	379
2014	22	15	35	57	248	208	516	525	1,377	186	114	30	278
2015	26	15	18	49	33	91	219	490	772	226	46	57	170
2016	29	30	30	21	67	60	109	385	216	97	47	15	92
2017	14	11	13	79	56	44	121	86	34	96	14	18	49
Ave.	27	25	29	56	186	193	330	584	606	135	54	30	194

Table 1.2.9 Maximum raw water turbidity by month

Year	Month (Max.)												Max.
	1	2	3	4	5	6	7	8	9	10	11	12	
2013	64	111	262	694	1,480	3,882	2,945	7,575	3,385	159	99	–	7,575
2014	37	34	90	310	1,880	630	1,375	2,300	14,409	1,655	569	45	14,409
2015	68	25	47	209	65	253	560	1,125	3,201	1,265	56	255	3,201
2016	40	176	64	81	301	204	578	3,659	787	363	181	40	3,659
2017	22	27	28	928	411	87	742	531	186	628	24	42	928
Max.	68	176	262	928	1,880	3,882	2,945	7,575	14,409	1,655	569	255	14,409



Source: JPST based on the information provided by WSSE-LPB

Figure 1.2.12 Raw water turbidity 2013 to 2017

The following observations can be established on the turbidity of the raw water:

- Turbidity rises during the rainy season (May to October).
- Turbidity in the dry season is low and stable.

- Turbidity of the raw water in 2017 was low, and its maximum value was the lowest in the past five years. The low turbidity is assumed to be caused by the new dam.

When the turbidity of the raw water exceeds 1,500 NTU, the Namkhan WTP will stop water intake from the Khan River.

1.2.5.2 Phouphueng WTP

The average turbidity of the raw water at the Phouphueng WTP is low (2.13 NTU). The average turbidity of the treated water was 0.85 NTU in 2017. Although the total hardness of the raw water is lower than the drinking water standard (300 mg/l), the maximum value of total hardness is as high as 290 mg/l. The water quality survey conducted in the preparatory survey showed the total hardness reaching 304 mg/l. No abnormalities were identified for other parameters.

1.3 Environmental and Social Considerations

1.3.1 Project Components and Potential Environmental Impacts

The four construction components are: 1) improvement of facilities in the Namkhan WTP, 2) renewal of aged transmission/distribution pipes and extension of distribution pipes in Luang Prabang city, 3) construction of a new reservoir away from the center of Luang Prabang city, and 4) development of facilities in and around the WHS.

The environmental and social considerations for each construction component are as follows:

1.3.1.1 Improvement of Facilities in the Namkhan WTP

The Namkhan WTP is located in a forested area 3 km northwest of Luang Prabang city. There are some stockyards and water treatment plants owned by private companies near the site. The closest residential area is about 500 m to the west.

Two facilities, a sludge pond and backwash wastewater basins and lagoon, will be constructed to treat the high turbidity backwash wastewater. Currently, the backwash wastewater is discharged directly to the Khan River. Sludge in this wastewater will be separated by the new facilities and only the low turbidity supernatant will be discharged to the river, minimizing the negative impact to the natural environment.

New receiving and mixing wells, and flocculation and sedimentation basins will be constructed next to the existing facilities. No land acquisition will be needed for new facilities or access road.

The location of the existing WTP and new facilities is shown in Figure 1.3.1.

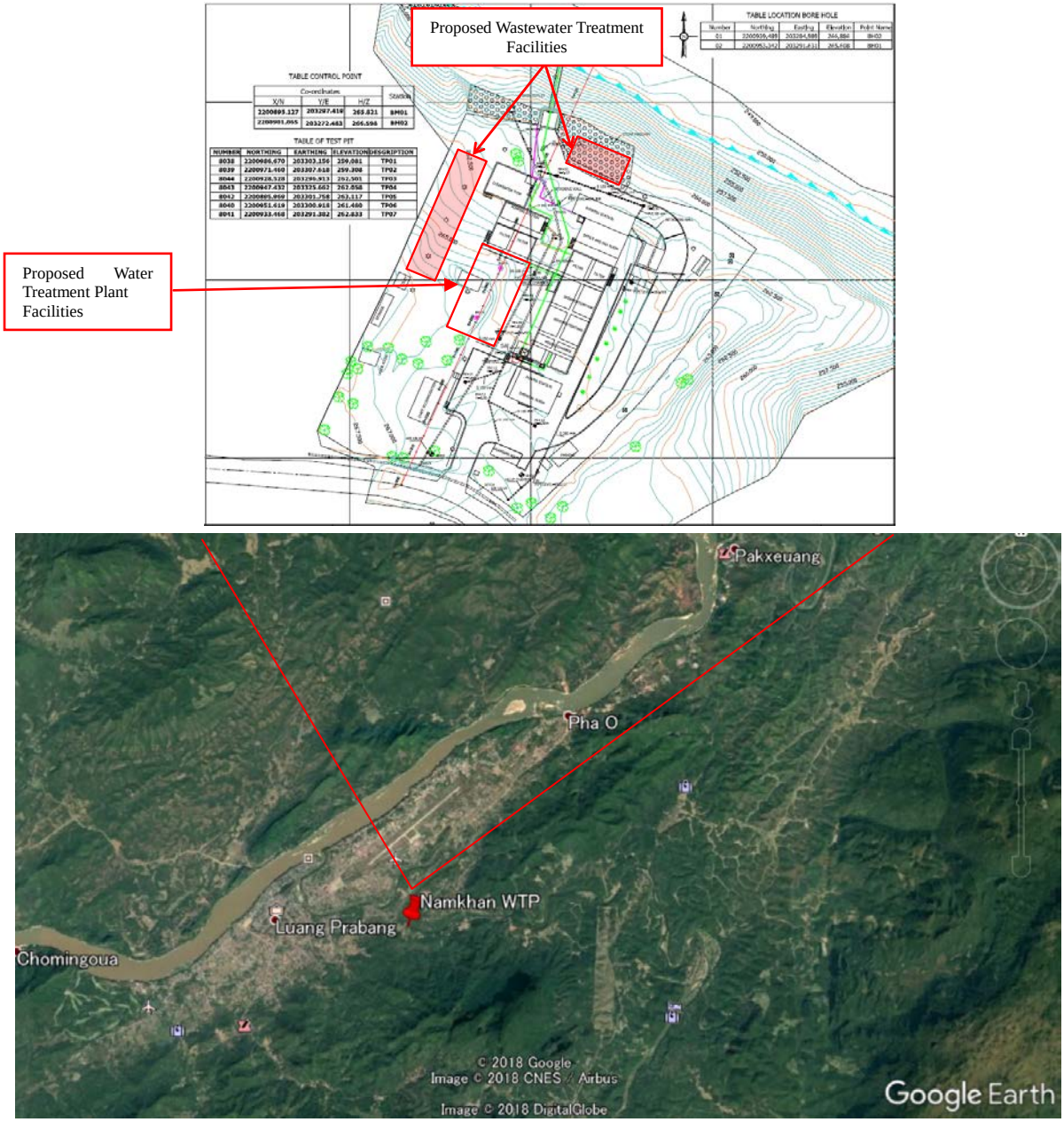


Figure 1.3.1 Namkhan WTP and new facilities to be constructed

1.3.1.2 Renewal of Aged Transmission/Distribution Pipes and Extension of Distribution Pipes in Luang Prabang City

Land acquisition is not required for this component. All transmission and distribution pipes will be installed under public roads.

The location of the existing distribution pipes, transmission/distribution pipes to be renewed, and planned extensions are shown in Figure 1.3.2.

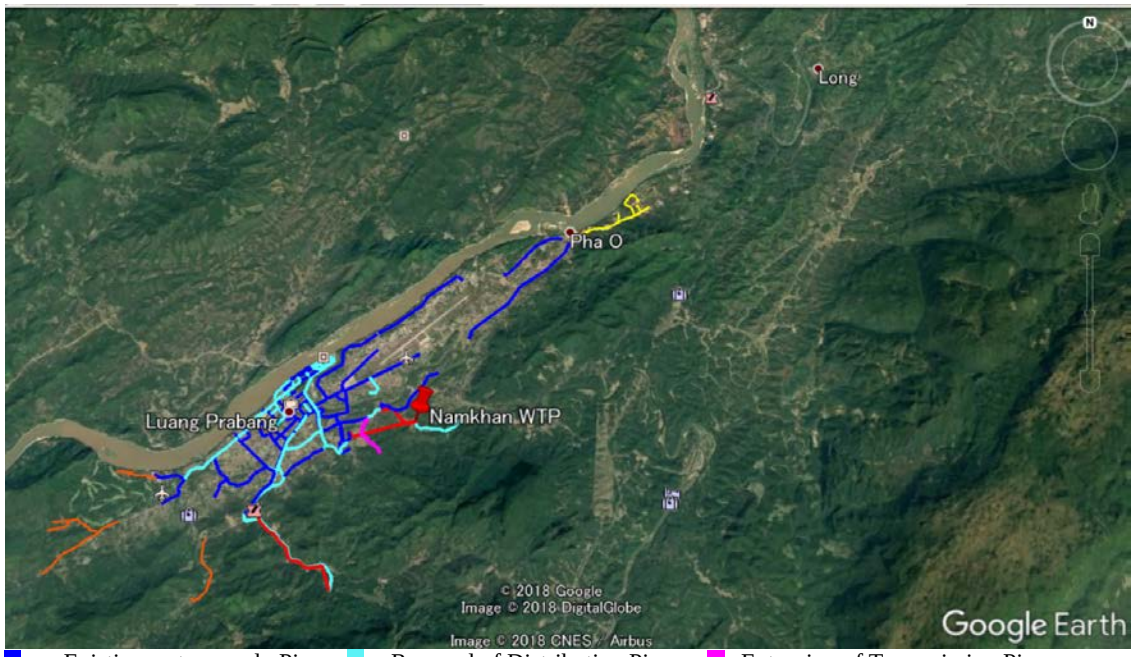


Figure 1.3.2 Location of existing pipes and planned extensions

1.3.1.3 Construction of A New Reservoir

A new reservoir will be constructed 1.2 km southeast of the Namkhan WTP to replace the existing Phousi Reservoir. The new reservoir requires a foot print of 27 m x 10 m. However, total land area of 50 m x 100 m is needed to accommodate construction activities. Although the planned construction site is located wholly on government owned land, approximately 30 m^2 is utilized by a villager from Phanom Village. Compensation will be paid to this villager for loss of land use. The land is forested and there are no houses in the area. No resettlement will be necessary.

The final 100 meters of the road leading up to the planned construction site is not public road. However, due to residential development taking place in the area, this section is expected to become public road in the near future. WSSE-LPB will confirm the road development status during the detailed design phase and secure the area for the access road at that time.

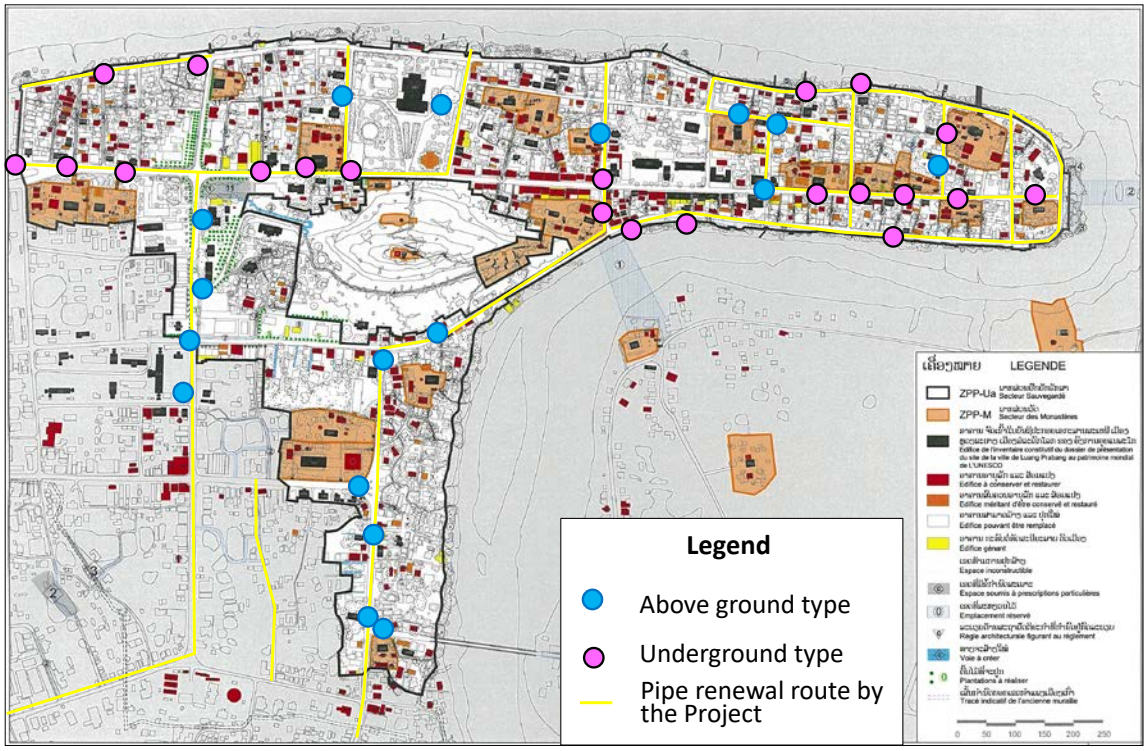
The location of the new reservoir is shown in Figure 1.3.3.

Figure 1.3.3 Location of new reservoir

1.3.1.4 Development of Facilities in the WHS (Renewal of Aged Pipes and Installation of Fire Hydrants)

Historical structures in the WHS will not be disturbed by this project. The project will install distribution pipes and fire hydrants under or on public roads.

The locations for installation of distribution pipes and fire hydrants in the WHS are shown in Figure 1.3.4.



Source: Prepared by JICA Preparatory Survey Team (JPST) based on Plan de Sauvegarde et de mise en Valeur（2001）

Figure 1.3.4 Locations of new fire hydrants and renewal of distribution pipes in WHS

1.3.2 Conditions of the Survey Area

1.3.2.1 Natural Environment

Precipitation, topography, geology, water level, and water quality of the Khan River are described in Section 1.2 Natural Environmental Conditions. Information regarding protected areas, and endangered species and vegetation in and around the project area are described below.

(1) Protected Areas, Endangered Species and Vegetation

Most of the construction sites are in urban areas except for the new reservoir. There are no protected areas or endangered species in any of these sites. The proposed land for the new reservoir has been logged for many years and is not a primary forest. The closest protected forest about 2 km south of Luang Prabang city, is as shown in Figure 1.3.5.

Proposed New Reservoir City Protected Forest Urban Area

Source: Forestry Map in Luang Prabang Province (Department of Agriculture and Forestry, Luang Prabang Province, 2012

Figure 1.3.5 Protected area in Luang Prabang city

1.3.2.2 Social Environment

(1) Ethnicity

In 2017 the population in Luang Prabang city was made up of Lao (Lowland Lao[2] 28.7%), Kamou (Middle Land Lao 47.3%), Hmon (Highland Lao 17.8%), and other ethnic groups (6.2%)[3]. Kamou and Hmon, which make up the largest ethnic groups, often reside in mountainous areas and their mother tongue is not the national language, Lao. However, these ethnic groups have successfully integrated into the local community since long ago, including into the well-developed network of primary and secondary schools. Therefore, there seems to be no compelling motivation for special consideration. Nevertheless, it is advisable to pay attention to the possibility of impacts specific to households

[2] It is not the official category on the ethnic group, however it has been widely used in Lao PDR.
[3] Source: Luang Prabang City Lao Front 2017

belonging to ethnic minorities.

(2) Unexploded Ordinances (UXO)

Lao PDR may still have UXOs from the First (1946-1954) and Second Indochina Wars (1960-1975). The United States dropped more than two million tons of bombs between 1964 and 1973. All 17 provinces have UXO contamination[4].

In Luang Prabang city, one UXO was found in agricultural land north of the airport. No other UXO has been reported since.

(3) Night Market

A night market is held in the WHS where replacement of distribution pipelines is planned. The market operates from 4:30 pm to 10:30 pm throughout the year. During the night market, the section of 420m from the National Museum of Luang Prabang to the south on the main street called Sisavong Street is closed to traffic. About 320 stalls sell handicraft and clothing in this market. Aged distribution pipes under the pedestrian walkways on both sides of the road in this area are scheduled for replacement.

Stall owners register their stalls and pay a 35,000 kip (about 4 USD) annual license fee to the City Government. They also pay a maximum of 9,000 kip (about 1.2 USD) depending on the size of the stall, to Pakham Village for reserving the location each day. This charge covers electricity, water supply, and waste management. The City Government has sub-contracted the management of the night market to Pakham Village, which gets a share of the annual license fee under this arrangement.

These stalls are movable and can be easily relocated within the market area during construction. Thus, no resettlement is needed.

(4) Annual Events

Various events are held in Luang Prabang Province throughout the year, including popular tourist attractions such as the water festival (Laos New Year: 5 days around the middle of April) and boat race festival (from end of August to the first week of September).

1.3.3 Legal and Institutional Framework in Lao PDR

1.3.3.1 Legislations relevant to Environmental and Social Considerations

(1) Laws and Regulations

Table 1.3.1 shows the laws and regulations relevant to evaluation of environmental and social impacts for this project.

Table 1.3.1 Laws and regulations relevant to environmental and social considerations

No	Law	Enacted No. and Year	Key Contents
1	Constitution	No.25/NA May 2003	States the responsibility of all organizations and citizens to protect the natural environment and resources of the state

[4] UXO-NRA www.nra.gov.la

No	Law	Enacted No. and Year	Key Contents
2	Environmental Protection Law	No. 29/NA December 2012	Defines principles, regulations and measures related to environmental management, monitoring of protective measures, including control, preservation and rehabilitation, to sustain and protect natural resources and public health and to contribute to national socio-economic development and reduction of global warming.
3	Ministerial Instruction on the Process of Environmental and Social Impact Assessment of Investment Projects and Activities	No.8030/MONRE* December 2013	Establishes standardized environmental and social impact assessment requirements and procedures for all investment projects categorized as Group 2 in Ministerial Agreement No.8056/MONRE.
4	Ministerial Instruction on the Process of Initial Environmental Examination of Investment Projects and Activities	No.8029/MONRE December 2013	Establishes standardized initial environmental examination requirements and procedures for all investment project categorized as Group 1 in Ministerial Agreement No.8056/MONRE Article 2.4. Describes the review process for IEE.
5	Ministerial Agreement on the Environment and Promulgation of List of Investment Projects and Activities Requiring Environmental and Social Impact Assessment	No.8056/MONRE December 2013	Categorizes investment projects and activities into two groups: (1) Group 1 shall prepare Initial Environmental Examination (IEE) and (2) Group 2 shall prepare environmental and social impact assessment (ESIA); and classifies the investment projects and activities into 5 sectors: (1) Energy, (2) Agriculture and Forestry, (3) Industrial Processing, (4) Infrastructure and Service, and (5) Mining.
6	Environment Impact Assessment Report Guidelines	MONRE 2016	Establishes guidelines for preparing an EIA report pursuant to the Decree on Environmental Impact Assessment.
7	Initial Environmental Examination Report Guidelines	MONRE April 2016	Establishes guidelines for preparing an IEE report pursuant to the Decree on Environmental Impact Assessment.
8	Agreement on National Environmental Standards	No.0832/MONRE February 2017	Establishes national environmental standards as a basis for environmental monitoring and pollution control on water, air, soil and noise.
9	Water and Water Resources Law	No.23/ NA May 2017	Regulates the management, exploitation, development, protection and sustainable use of water and water resources. Article 38 defines users in 3 categories: small, medium and large-scale, and requires medium and large-scale users to obtain water use permits. Article 42 defines the water use permit as an official document that gives permission to use water. It stipulates that to obtain the water permit, environmental and social impact assessment is required as well as the need to follow related regulations.
10	Law on Aquatic Animals and Wild Life	No.07/NA December 2007	Establishes principles and measures to protect and manage wildlife and aquatic animals.
11	Law on Water Supply	No.04/NA July 2009	Sets principles, regulations and measures regarding the implementation, operation, support, management and monitoring of water supply business entities. Article 17 stipulates that water supply quality shall fulfill assurance of cleanliness, health and safety, consistent with the water supply quality regulations set by the Ministry of Health.
12	Minister's Decision on Water Quality Standard and Management for Drinking	No.561/MOH Feb 2014	Sets standards for drinking water quality for treated and untreated natural water as well as minimum requirements of water supply system, management of

No	Law	Enacted No. and Year	Key Contents
	and Domestic use		treated and untreated natural water monitoring and drinking water quality surveillance to ensure water safety and protect consumer health. It also defines the roles and responsibilities of key organizations in the implementation of these requirements. Article 9 stipulates the monitoring parameters and frequency, for water quality supplied by Water Supply State Enterprise.
13	Decree on Compensation and Resettlement of the Development Projects	No. 84/GOV April 2016	Establishes guidelines for resettlement and compensation to affected residents.
14	Land Law	No.04/NA Oct 2003	Establishes rules on management, protection and use of land.
15	Degree on the Implementation of the Land Law	No.88/PM June 2008	Establishes guidelines on implementation of the Land Law relating to the management, protection, use and development of land, as well as ensuring compliance with set-targets and the uniformity of practice throughout the country.
16	Public Road Law	No.03/ NA Oct 2016	Defines principles, regulations and measures relating to management, use, planning, survey, design, construction and maintenance of public roads. Articles 21and 22 stipulate total area of roads as road surface, road shoulder, footpaths, drainage channels, road slope and boundaries for public road.
17	Law on National Heritage	No.08/NA November 2005	Establishes the principles, regulations and measures for the administration, use, protection, conservation, restoration, rehabilitation of the national culture, history and natural heritage. Article 33 stipulates the responsibility to report to local authority the discovery of national heritage items during the conduct of any activities and requires the subsequent suspension of the activities. Article 42 stipulates the responsibility for individuals/organizations to obtain approval from the Ministry of Information and Culture prior to pursuing socio-economic development in national and cultural areas.
18	Agreement on the Organization and Movement of Heritage Department	No.535/MOICT** July 2012	Establishes status, roles, obligations, scope, organizational structure, principles and work plan as terms of reference for the movement of Heritage Department.

Note: *MONRE: Ministry of Natural Resources and Environment
**MOICT: Ministry of Information, Culture and Tourism

(2) Water Rights

Article 38 of the Water and Water Resource Law (No.23/N/A May 2017) classifies users by consumption scales (small, medium, and large-scale). Small-scale users are households or farmers. Articles 39, 40 and 41 require medium and large-scale users to obtain permits for using water from the river. To obtain water use permits, environmental and social impact assessment and compliance with other regulations is also required (Article 42).

This project does not require further approval from the Ministry of Natural Resources and Environment (MONRE) because the Namkhan WTP was already obtained approval for the current

capacity of 12,000 m^3/day, and no additional water intake is planned.

(3) Environmental Assessment Process

The project proponent must conduct an initial environmental examination (IEE) or environmental impact assessment (EIA) depending on the project classification according to the Ministerial Agreement on the Endorsement and Promulgation of List of Investment Projects and Activities Requiring for Conducting the Initial Environment Examination or Environmental and Social Impact Assessment (No.8056/MONRE 2013) and obtain an ECC before starting construction. Group 1 projects require IEE and Group 2 projects require EIA. This project is categorized as "3.35 water supply processing factory" under the Ministerial Agreement No.8056 and requires an IEE.

The IEE process is stipulated in the Ministerial Instruction on the Process of Initial Environmental Examination of the Investment Projects and Activities (No.8029/MONRE). The process to obtain an ECC is at least 50 business days, with 10 business days for administrative review and 40 business days for content review[5].

For this project, DPWT-LPB submits the IEE report to the Department of Natural Resources and Environment (DONRE) in Luang Prabang Province. DPWT-LPB holds a stakeholder meeting for all village heads, and concerned authorities in Luang Prabang city and Luang Prabang Province, to disseminate information on the project, results of the IEE, and collect feedback. The review of the IEE report will be given in writing to the DPWT-LPB. DPWT-LPB revises the report according to the comments and re-submit to DONRE, as required. Upon approval, DONRE issues the ECC to the DPWT-LPB.

The IEE report was submitted to DONRE in October 2018 and the ECC (attached in **Appendix 6-1**) was issued in November 2018.

(4) Environmental and Social Considerations by JICA

The project must comply with the JICA Guidelines for Environmental and Social Considerations (hereafter: the Guidelines).

Based on the Guidelines, this project is classified as a Category B project. Category B projects are described as follows: "generally, the proposed projects are site-specific, few if any of the project impacts are irreversible; and in most cases, usual mitigation measures can be designed relatively easily"[6]. For Category B projects, the environmental and social considerations for IEE will propose mitigation measures to avoid, minimize or mitigate adverse impacts and include a monitoring plan with institutional arrangements for its implementation. The alternatives of carrying out or not carrying out the project will also have to be analyzed. Stakeholder meetings on the results of the environmental and social considerations will be organized as appropriate in case of the Category B projects.

[5] Article 2.4 Review of the Initial Environmental Examination Report, Ministerial Instruction on the Process of Initial Environmental Examination of the Investment Projects and Activities (No.8029/MONRE)
[6] 2.2 Categorization, JICA Guidelines for Environmental and Social Considerations, 2010

(5) Comparing Government of Lao PDR and JICA IEE Requirements

The legislation in Lao PDR and JICA Guidelines both require IEE. The IEE requirement in the JICA Guidelines are covered in the Ministerial Instruction on the Process of Initial Environmental Examination of the Investment Project and Activities (No.8026/MONRE 2013) and Initial Environmental Examination Writing Guidelines (MONRE 2016). No gap was found on IEE requirements between Government of Lao PDR and JICA. The result of gap analysis on IEE requirements is shown in Table 1.3.2.

Table 1.3.2 Gap analysis on IEE requirements

Issue	JICA Guidelines	Lao PDR Law	Gap between JICA Guidelines and Lao PDR
Underlying Principles	Environmental impacts that may be caused by the project must be assessed and examined in at the earliest possible planning stage. (1. Underlying Principles, Appendix 1)	For the result of the IEE to be effectively incorporated into the project design, the environmental team shall coordinate with the technical/engineering team during the preliminary and detailed process. (3.7.2.2, IEE Guidelines)	None
Alternatives	Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (1. Underlying Principles, Appendix 1)	The IEE report shall include the description of realistic alternatives for achieving the basic development objectives of the project. The IEE report shall describe each alternative in reasonable detail to enable all potential biophysical, economic, social, health, cultural and visual impacts to be identified or predicted and evaluated. At least two alternatives plus the option of not proceeding with the project should be described. (3.5.1, IEE Guidelines)	None
Mitigation Measures		For each project phase, the IEE report shall specify the actions, infrastructure, design modifications, additions, or any other actions required to reduce the magnitude of the impact. Mitigation measures shall be as detailed as possible. (3.7.2.2, IEE Guidelines)	None
Impacts to be Assessed	Include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, accidents, water use, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDs, and working conditions including occupational safety. (3. Scope of Impacts to be Assessed)	The methodology for the assessment should consider project-related impacts that are positive, negative, direct, indirect, and if applicable, impacts that are cumulative, synergistic, reversible, and irreversible. Impact significance should be clearly presented. The significance of an impact depends on factors such as: 1) intrinsic value of the affected ecosystem component(s) (i.e., sensitivity, uniqueness, rareness, and reversibility); 2) social, cultural, economic, and aesthetic values attributed to the component(s) by the population. The more the population values a component in an ecosystem, the more likely the impact on this component will be considered significant; 3) The level of concern of the population regarding health and safety issues, or regarding protection of their archaeological sites, 4) Whether the affected environmental components(s) have already undergone modification. (3.7.2.2, IEE Guidelines)	None. However, the JICA Guidelines presents more specific parameters for impact assessment. Accordingly, theses parameters in the Guidelines will be used for the IEE of the project.
Monitoring	After the start of the project, the	The project owner shall be obliged to take the	None

Issue	JICA Guidelines	Lao PDR Law	Gap between JICA Guidelines and Lao PDR
	project proponent will monitor whether any unforeseeable situations have occurred and if the performance and effectiveness of mitigation measures are consistent with the assessment's prediction take appropriate measures based on the results of such monitoring. (8. Monitoring)	lead in monitoring by concluding and reporting the status of monitoring, the implementation of the mitigation measures for environmental and social impacts of the investment project and activities as specified under Environmental and Social Management and Monitoring Plan (ESMMP) and the Environmental Compliance Certificate to the Provincial/Capital Department of Natural Resources and Environment for information from time to time as specified in the Environmental Compliance Certificate. If necessary, in case of the IEE Reports, the project owner shall establish the environmental management office and the public involvement office in order to ensure the efficient implementation and performance, management and monitoring of mitigation measures of environmental and social impacts. (2.18 Self-monitoring by the Project Owner, Ministerial Instruction on the Process of Initial Environmental Examination of the Investment Projects and Activities)	
Stakeholder Meeting	For Category B project, JICA encourages project proponents to consult with local stakeholders when necessary.	During data collection for the preparation of the IEE report and ESMMP, information dissemination meetings shall be held for the project-affected persons and stakeholders in Lao and local dialect to explain the development plan of the investment project and activities, the benefits and social and environmental impacts, and gather comments. Consultation meetings shall be held at the village/district and district/provincial levels as required by the review process, to give an opportunity for stakeholders to comments on all stages of IEE reporting and ESMMP. At the start of project, the project owner shall inform the affected persons and stakeholders of the project activities which are likely to cause social and environmental impacts. In addition, the project owner shall access to general information about the project. (2.11 Public involvement process, Ministerial Instruction on the Process of Initial Environmental Examination of the Investment Projects and Activities)	None. However the Laos legislation describes the purpose and timing of stakeholder meetings in much more detail. The project will follow the Lao process.

1.3.3.2 Institutional Framework

The following institutions are relevant to environmental and social considerations.

(1) Environmental Impact Assessment Office at Department of Natural Resources and Environment in Luang Prabang Province (DONRE)

This office is responsible for reviewing and approving IEE reports and environmental and social management and monitoring plan (ESMMP) of new development projects located within its jurisdiction. It will issue the ECC and supervise monitoring activities implemented by the project proponent according to the IEE report.

For this project, DPWT-LPB shall obtain the ECC from DONRE in Luang Prabang.

During construction, staff from DONRE will inspect the construction site periodically and confirm the

effectiveness of the project's ESMMP. They will also review the monitoring report submitted regularly by DPWT-LPB.

(2) Office of Natural Resources and Environment in Luang Prabang City

This office is responsible for monitoring the natural and social environmental conditions in Luang Prabang city. During construction, staff from this office together with staff from DONRE in Luang Prabang will inspect the construction site regularly.

(3) Luang Prabang World Heritage Office

This office is under the Department of Culture, Information and Tourism in Luang Prabang Province. It is responsible for the management of the area in compliance with the World Heritage Convention, protection of the world heritage elements based on the provincial master plans, supporting local communities on building regulations, and providing the funds for preservation of traditional houses.

DPWT-LPB shall submit detailed information such as method of construction, location of construction activities, and measures to minimize the negative impacts on buildings, scenery or businesses, to this office for approval before the start of construction.

(4) Steering Committee

A project steering committee was established by the Governor of Luang Prabang Province in May 2018.

This committee will finalize the distribution network route, mediate complaints related to construction activities, and inspect and verify contractor's environmental mitigation measures.

1.3.4 Alternatives

The environmental and social considerations carried out on the 4 construction components of the project (see 1.3.1 Project Components and Potential Environmental Impacts) show no significant negative impact related to Component 2)[7] renewal of aged transmission/distribution pipes and extension of distribution pipes in Luang Prabang city, or Component 4)[7] development of facilities in and around the WHS. Any impacts of these components are minor and can be avoided or minimized by employing appropriate mitigation measures.

Alternatives are examined on 1)[7] the improvement of facilities in the Namkhan WTP (construction of wastewater facility) and 3)[7] the construction of the new reservoir away from the center of Luang Prabang city.

1.3.4.1 Wastewater Treatment Facilities

The impacts of treating or not treating the wastewater before discharge is compared in Table 1.3.3. At present, wastewater discharged from the water treatment plant does not satisfy the national standards on wastewater discharge. The wastewater treatment facilities to be added to the Namkhan WTP will improve the water quality to satisfy the national standard for wastewater discharge before discharging

[7] See"1.3.1 Project Components and Potential Environmental Impacts"

to the Khan River. Therefore, construction of the wastewater treatment facility is the preferred option.

Table 1.3.3 Alternatives on Wastewater Treatment Facilities

Parameter		Without wastewater treatment facility	Add wastewater treatment facility to Namkhan WTP
Impact on Natural Environment	Water Quality	△	◎
Result			
Overall Rating		△ Wastewater generated from the water treatment plant is directly discharged to the Khan River with no treatment. National standards on wastewater discharge[8] are not satisfied.	◎ Wastewater will be treated to meet the national standards on wastewater discharge before discharge to the Khan River. Negative impact on the environment will be reduced.

1.3.4.2 New Reservoir

The comparison of continuing to use the Phousi Reservoir as it is, rehabilitating the existing structure, or constructing a new reservoir, is summarized in Table 1.3.4. Constructing a new reservoir in Phanom Village is the preferred option.

Table 1.3.4 Alternatives on new reservoir

Parameter		Without project (use existing Phousi Reservoir)	Alternative 1 (rehabilitate existing Phousi Reservoir)	Alternative 2 (construct new reservoir in Phanom Village)
Impact on Social Environment	Land Availability	-	△	△
	Increase access to water supply	△	△	○
Result				
Overall Rating		△ Phousi Reservoir has been in use for more than 50 years. The concrete is deteriorated, and the risk of leakage and imminent collapse is increased.	△ Service life of Phousi Reservoir will be extended. However, land acquisition is necessary for the construction of an access road since there is no road to the site at present. The water pressure will remain inadequate for expanding the water supply area in future.	○ Compensation is required for a villager using 0.6% of the proposed construction land. The reservoir will be at a higher elevation and will accommodate expansion of the water supply area in the future and increase the number of people who can afford and connect to the water supply service.

The site for the new reservoir in Phanom Village was chosen as described below.

- JPST discussed the candidate sites with WSSE-LPB.
- WSSE-LPB proposed a site near the Khouthinieng reservoir. While the high elevation was suitable for gravity flow, the land was privately owned and the price was high. After consideration, it was determined that the Lao side could not pay this high amount.
- WSSE-LPB proposed another site in Phanom Village. The land was at a high elevation and owned by the government.

[8] See 2.2.2.3(7)

1.3.5 Scoping and TOR of an Environmental and Social Survey

1.3.5.1 Scoping

The project was reviewed in terms of environmental and social considerations. The result of scoping is summarized in Table 1.3.5.

No significant negative impact is expected. The main negative impacts include temporary and site-specific pollution such as air and water pollution, waste generation, noise and vibration resulting from heavy machinery operation and other construction activities.

The creation of employment during construction will contribute to the local economy.

Table 1.3.5 Scoping

No.	Impacts	Rating		Brief Description
		Pre-Construction /Construction	Operation	
1. Pollution Control				
1.1	Air Pollution	B-	D	**Construction**: Limited air pollution is expected due to heavy machinery operation and construction activities, particularly in the dry season. **Operation**: No air pollution is expected.
1.2	Water Pollution	B-	D	**Construction**: Temporally water pollution from contractor's camp is expected. **Operation**: No water pollution is expected.
1.3	Waste	B-	B-	**Construction**: Domestic waste will be generated from the contractor's camp. Waste such as asphalt and concrete will be generated at construction sites. **Operation**: Sludge will be generated in the process of treating water at the treatment plant.
1.4	Soil Contamination	D	D	**Construction/Operation**: No soil contamination is expected.
1.5	Noise and Vibration	B-	D	**Construction**: Noise and vibration resulting from construction activities is expected. **Operation**: No noise and vibration is expected.
1.6	Ground Subsidence	D	D	**Construction:** No activity that will cause ground subsidence is expected. **Operation**: Since water for Namkhan WTP is to be taken from the Khan River, no activity that will cause ground subsidence is expected.
1.7	Offensive Odor	D	B-	**Construction:** No activity that will cause offensive odor is expected. **Operation:** Offensive odor may be generated due to mishandling of chlorine chemicals.
1.8	Bottom Sediment	D	D	**Construction/Operation**: No activity that will affect bottom sediment is expected.
2. Natural Environment				
2.1	Protected Area	D	D	There are no protected areas in the project area.
2.2	Biodiversity	B-	D	**Construction**: Effect on flora, fauna, or biodiversity is not expected since project is implemented on existing sites (water treatment plant or public road). No rare species of flora or fauna is identified in the proposed site for the new reservoir. There may be hunting of wild animals or collecting wood in the new reservoir construction site. **Operation**: No negative impact on flora, fauna and biodiversity is expected.
2.3	Hydrological Situation	D	D	**Construction/Operation**: No negative impact on hydrological situation is expected.
2.4	Topography and Geographical Features	D	D	**Construction/Operation**: No negative impact on topography and geographical features is expected.
3. Social Environment				
3.1	Land Acquisition, Involuntary Resettlement	C	D	**Construction**: No resettlement is necessary. The new reservoir will be located on government land. The boundary of the land used by the villager is under survey. Other project components will be located in existing facilities or under public roads. **Operation**: No activity that will cause involuntary resettlement is expected.
3.2	Poor households	D	D	**Construction/Operation**: No direct impact on vulnerable residents near construction site is expected.
3.3	Indigenous and Ethnic Minority	D	D	**Construction/Operation**: No direct impact on ethnic minorities residing near construction site is expected.
3.4	Local Economy, Employment,	B+/-	A+	**Construction**: Positive impact such as creation of local employment is expected. Some disturbance to the businesses in the night market is

No.	Impacts	Rating		Brief Description
		Pre-Construction /Construction	Operation	
	Livelihood			expected during distribution pipe renewal. **Operation**: Increased water supply coverage will contribute to the well-being of residents in Luang Prabang city.
3.5	Land Use and Utilization of Local Resources	D	D	**Construction/Operation**: No significant impact on land use or change to local resources is expected since project is implemented either in the existing facilities (water treatment plant), under public roads or on government land.
3.6	Water Usage	C	C	**Construction/Operation**: Extent of impact on water usage near intake needs to be determined.
3.7	Existing Social Infrastructures and Services	B-	A+	**Construction**: Traffic would be disturbed temporally during pipe installation along public roads. Same for the night market in the World Heritage Site. **Operation**: Water supply coverage will be increased after expansion of supply area and water quality will be better after renewal of aged distribution pipe.
3.8	Social Institutions and Local Decision-Making	D	D	**Construction/Operation**: No negative impact on social institutions is expected.
3.9	Inappropriate distribution of benefits and damages	D	D	**Construction/Operation**: No inappropriate distribution of benefits and damages is expected.
3.10	Local Conflict of Interest	D	D	**Construction/Operation:** No local conflict of interest is expected.
3.11	Cultural Heritage	B-	A+	**Construction:** The cultural heritage could be affected during renewal of aged pipes in the World Heritage Site. **Operation**: Water distribution system in World Heritage Area will be improved.
3.12	Landscape	B-	B-	**Construction**: Disturbance of the scenery is expected at the sites of pipe installation in the World Heritage Site. **Operation**: Disturbance of scenery due to the installation of fire hydrants is expected in World Heritage Area.
3.13	Gender	D	D	**Construction/Operation**: No negative impact on gender equality is expected
3.14	Children's Rights	D	D	**Construction/Operation**: No negative impact on children's rights is expected.
3.15	Communicable Diseases such as HIV/AIDS	B-	D	**Construction**: Inflow of construction workers to local communities would raise risks of communicable diseases. **Operation**: No increase in risk of communicable diseases is expected.
3.16	Work Environment (including work safety)	B-	D	**Construction**: Inappropriate management of working environment would raise the risk of accidents and disease. **Operation**: No increase in risks in the work environment is expected.
4. Others				
4.1	Accidents	B-	D	**Construction**: Construction activities along public roads would increase the risk of accidents to the public. **Operation**: No increase in risk of accidents is expected.
4.2	Transboundary Impact and Global Warming	D	D	**Construction/Operation**: No transboundary or global warming impact is expected.
4.3	UXO	B-	D	**Construction**: Risk of UXO at the construction site of the new reservoir can be expected. **Operation:** No increase in risk of UXO is expected.

Rating

A+/-: Significant positive/negative impact is expected, B+/-: Positive/negative impact is expected, C: Extent of impact is unknown, and examination is needed (further examination is needed, and the impacts could be clarified as the study progresses) D: No impact is expected

1.3.5.2 TOR for the Environmental and Social Survey

The terms of reference (TOR) for the Environmental and Social Survey are prepared based on the scoping result and the contents of the TOR are shown in Table 1.3.6.

Table 1.3.6 TOR for environmental and social survey

No.	Impacts	Items for Study	Methodology
1. Pollution Control			
1.1	Air Pollution	1.Present air quality 2.Present condition in the project area 3.Impacts during construction	1.Collect existing information 2.Site investigation and interviews with relevant authorities, 3.Confirm content, method, period, location of construction activities and access for construction vehicles
1.2	Water Pollution	1.Present condition in project area 2.Impacts during construction	1.Collect information at the proposed employees' camp 2.Confirm content, period, location of employees' camp
1.3	Waste	1.Information on present waste management 2.Impacts during construction 3.Impacts during operation	1.Collect existing information on waste management in Luang Prabang city 2.Collect information on the domestic waste from employees' camp and amount of construction waste from construction sites 3.Confirm proposed disposal site for sludge from the Namkhan WTP
1.5	Noise and Vibration	1.Noise standard in Lao PDR 2.Present condition in the project area 3.Impacts during construction	1.Collect information on existing standards 2.Site investigation and interview with relevant authorities 3.Confirm content, method, period, location of construction activities
1.7	Offensive Odor	1.Impacts during operation	1.Confirm management system of existing facilities in the Namkhan WTP
3. Social Environment			
3.1	Land Acquisition, Involuntary Resettlement	1.Information on the land user at the site of the proposed new reservoir	1. Interview with village head about the use of government land for the new reservoir and the boundary of the land being used by villager on this site
3.4	Local Economy, Employment, Livelihood	1.Information on night market management 2. Impacts during construction	1.Interview with relevant authorities on the management of night market 2.Confirm content, method, period, location of construction activities
3.6	Water Usage or Water rights of Common	1.Present condition in existing intake area	1.Interview with relevant authorities and local communities on river usage around the existing intake area 2.Interview with relevant authorities on water rights of Khan River
3.7	Existing Social Infrastructures and Services	1.Impacts during construction	1.Confirm content, method, period, location of construction activities
3.11	Cultural Heritage	1. Legislation on construction activities in World Heritage Site 2. Impacts during construction	1.Interview with authorities (World Heritage Department etc.) on relevant legislation 2.Confirm content, method, period, location of construction activities
3.12	Landscape	1. Legislation on construction activities in World Heritage Site 2. Legislation on the scenery at World Heritage Site	1.Interview with relevant authorities (World Heritage Department etc.) to confirm content, method, period, location of construction activities 2.Interview with authorities (World Heritage Department etc.) on the legislations on the scenery in the World Heritage Site
3.15	Communicable Diseases such as HIV/AIDS	1.Impacts during construction	1.Confirm content, method, period, location, area of construction activities
3.16	Working Environment (includes work safety)	1.Confirm legislations on working environment in Lao PDR	1.Confirm existing legislations on working environment
4. Others			
4.1	Accidents	1.Impacts during construction	1.Confirm content, method, period, location, of construction activities
4.3	UXO	1. Location of UXO at new reservoir site 2. Clean-up of UXO at new reservoir site	1. Confirm the information on UXO near new reservoir site 2. Confirm the method for safe UXO disposal
	Stakeholder Meeting	1. Opinions of relevant authorities and individuals on scoping and IEE 2. Comments on drafted IEE report	1.Interviews with individuals and organizations around June 2018 Target: Officials at Luang Prabang City Government (Office of Agriculture and Forestry), Officials at Luang Prabang Province (Division of Natura Resources and Environment, Public Works and Transportation, Roads etc.), Village Heads at concerned villages, Officials in charge of night market at World Heritage Site

No.	Impacts	Items for Study	Methodology
			2. Stakeholder meeting (at village/district and provincial levels) after drafting IEE report in November 2018 Target: Village Heads at concerned villages, Officials at Luang Prabang City Government, Officials at Luang Prabang Province

1.3.6 Result of the Survey

1.3.6.1 Activities near Intake of Namkhan WTP

A meeting with village authorities and local people was organized to confirm the use of water from the Khan river near the existing intake of Namkhan WTP on 14th June 2018 at Phanom Village office, where the intake of the Namkhan WTP is located[9].

Intake Area of the Namkhan WTP

Hearing from Local Residents

Figure 1.3.6 Intake of the Namkhan WTP and meeting with residents

No recreation activities, washing, or irrigation is practiced near the intake of Namkhan WTP. Fishing and riverweed collection are carried out near the intake and those fish and riverweeds are used mainly for domestic consumption. Excess catch/collection is sold at a nearby market.

The amount of fish caught depends on the season: from less than 1 kg/time in the dry season to more than 10 kg/time during rainy season, especially between June and September. Riverweed collection takes place twice a year: from March to May and from November to December.

There are no data on the aquatic biota and habitats near the intake area in the Khan River. The information collected from residents is shown in Table 1.3.7. The fish caught near intake area are common species found in Lao PDR. There are no endangered species around the intake area.

Table 1.3.7 Type of fish caught near intake area

Name in Lao Language	Scientific Name	IUCN *Category
Pa Nai	Cyprinus carpio Linneaus	Least concern
Pa Khupheng	Hemibagrus wychioides	Least concern
Pa Hnam/Pa Hlang Hnam	Mystacoleucus ectypus	Least concern
Pa Khing	Osteochilus-vittatus	Least concern
Pa Pao	Tetraodon baileyi	Least concern
Pa Chao	Poropuntius laoensis	Least concern

*IUCN: International Union for Conservation of Nature

[9] Meeting result is summarized in **Appendix 6-3**.

No negative impacts from the project are expected around the intake area since there will be no construction activities at this location.

1.3.6.2 Renewal of Distribution Pipes and Installation of Fire Hydrants in the WHS

(1) Expected Impacts

The project will not make any changes to existing historical buildings or landscape in the WHS. The aged distribution pipes under public roads will be renewed at the same locations. Fire hydrants will be installed along public roads. The project will improve water quality and increase water pressure, allowing the installation of fire hydrants. The latter is essential to the conservation objective of the WHS.

During construction, the historical landscape will be disturbed but the site will be restored to its original state. Damage to buried archaeological object/structure could occur during excavation, or existing archaeological objects/structures may be damaged accidentally by construction activities. Adequate measures will be taken to avoid such incidents. Table 1.3.8 shows the expected negative impacts and mitigation measures.

Table 1.3.8 Expected impacts and mitigation measures during construction

Expected Impacts	Mitigation Measures	Detail
Disturbance to historical landscape	1. Minimize construction period with proper planning	3 days for construction activities for every 50 m section 1st Day: Excavate and install new water distribution pipe and backfill with sand for pipes and with roadbed material for exposed parts. No construction materials are to be left on site. The site will be restored by the end of the day. 2nd Day: Reserved day for the pipe installation 3rd Day (30 days or more after 2nd Day): Paving with original materials
Damage to buried historical object/structure	1. Instruction of handling historical object/structure discovered during construction will be given.	Instruct construction employees on handling historical object/structure before start of construction work on each day.
	2. When objects are found: stop activity immediately and report to the steering committee for further instruction.	
Damage to the existing historical object/building if excavating at the wrong location	1. Establish precise location of excavation and proper method of excavation (such as no excess digging).	Instruct construction employees on precise location and proper excavation method before start of construction work on each day.

(2) Approval from the Luang Prabang World Heritage Office

Luang Prabang World Heritage Office is responsible to review the contents of construction projects in WHS and approves the implementation of projects if the project has no negative impact on the world heritages.

After meeting with DPWT-LPB on the implementation of the project in the WHS, the Luang Prabang World Heritage Office concluded that no negative impact is expected and no further survey (Heritage Impact Assessment: HIA) is required. The official letter on this decision was issued by the head of

Luang Prabang World Heritage Office on 30th November 2018. (Attached in **Appendix 6-2**).

Before construction, WSSE-LPB will submit a detailed construction plan including schedule, location, and methods to the Luang Prabang World Heritage Office for approval.

During construction, a detailed construction schedule will be reported through a monthly progress report and approved by the project steering committee which includes a representative from the World Heritage Office. Moreover, WSSE-LPB is required to observe the following conditions in order to carry out construction activities in the WHS;

1. When historical objects/structures are found during excavation for installing distribution pipes, stop activity immediately, protect the site carefully, and report to the institution concerned for investigation,

2. When excavating grounds paved by concrete or stone near historical structure in the list of World Heritage Site, avoid using heavy machinery,

3. After completion of distribution pipe installation, restore the construction site to its original state,

4. Before changing the location of distribution pipe installation from the original plan, consult with World Heritage Office,

5. Before finalization of the location of fire hydrants, discuss with institutions concerned, and

6. In case problem occurs, consult with World Heritage Office for settling the problem with institutions concerned.

(3) Construction in the Night Market Area

The renewal of aged distribution pipes will impact the Night Market Area where about 320 stalls operate during a night market in the WHS. The Village Head indicated his support for the project after the purpose of the project and its contribution to improve water supply service for the villagers were explained to him. He had the following requests:

- The construction activities should be carried out during rainy season to avoid peak tourist season (dry season).
- Construction should proceed for 50 m at a time (50 m on one side of the pedestrian walkway or 25 m concurrently on both sides). This would allow the affected stalls to stay open by re-locating to another area in the market. (If the construction section is too short, it would prolong the construction period, if too long, there would not be enough space to relocate all the affected stalls.)
- The Village Head should be informed of the construction location and schedule well in advance, so that arrangements can be made for the affected stalls.

These requests are reflected in the construction plan (see “2.2.1.7(2) Construction Period and 2.2.4.2 Implementation Conditions”).

1.3.6.3 Land for New Reservoir

The boundary of the land used by an individual villager on the government land for a new reservoir site was not clear at the time of scoping. After confirming the boundary with the Village Head and the user of the land, it was found that this 30 m^2 of land has been used by the villager for a long time. The villager must be compensated for the loss of land use. Securing the entire land package requires the following two processes.

Land Use Right to be Transferred from Village to WSSE-LPB

The land of the new reservoir site (about 0.5 ha) is government land and under the management of Phanom village. The transfer of land use right from Phanom village to WEES-LPB has to be implemented. (see detail in 1.3.12 Land Acquisition).[10]

Compensation for the land used by a villager

Compensation to the villager for the loss of land use (about 0.6% of land for new reservoir, or 30 m^2) will follow the stipulation in Decree on Land Acquisition and Resettlement (No.84 2016). (see detail in 1.3.12 Land Acquisition).

1.3.6.4 Installing Transmission/Distribution Pipes

The following procedures have been used by WSSE-LPB for water transmission/distribution pipe installation. These procedures will be also applied to this project:

- Water pipes will be installed avoiding legal (electric pole, telecommunication tower) and illegal (fence belonging to private facilities) assets along public roads[11].
- If it is difficult to avoid these assets, the pipeline route will be shifted toward the roadside.
- After installation, the site will be restored to the original condition.

The water pipeline route will be finalized by the steering committee during detailed design phase.

1.3.6.5 UXO

UXO risk assessment was carried out in and around the new reservoir site. A certificate from the UXO Office in Luang Prabang Province confirming that no UXOs were found on the surface level was issued in May 2018.

During the detailed design phase, risk of UXOs deeper underground will be carried out if needed, depending on the excavation work. The UXO risk will be examined for the access road as necessary after the road condition is reviewed in the detailed design phase.

1.3.6.6 Stakeholder Meeting

Throughout the IEE process, formal and informal consultations were undertaken with key stakeholders, including local government officials, and affected persons and communities in the project area.

[10] The land use right was transferred from Phanom village to WSSE-LPB on 25 Dec, 2018. (see Appendix 6-7)

[11] The total area of the road is defined including road surface, road shoulder, footpaths, drainage channels, road slope and delimitation area for public roads at National, Provincial, District and Village level (Article 21, Public Road Law 2016)

Meetings with stakeholders have two main objectives. The first objective of stakeholder consultations is to provide information on the project, such as the purpose and location of the project, and collect information on natural and social conditions in the area in order to carry out an IEE and prepare an environmental management plan. The second objective is to disseminate information on the potential environmental and social impacts during construction and operation phases and gather public opinions for project planning.

Consultations with stakeholders were conducted through

- formal meetings with concerned departments of local government
- interviews with village heads and relevant residents
- a meeting on the drafted IEE

The outcomes of the stakeholder meetings are shown in Table 1.3.9. The information obtained from administrative bodies as well as opinions collected from individual and stakeholder meetings were used for IEE, as well as for preparing mitigation measures and monitoring plan. Details on the interviews with targeted village heads and meeting on the draft IEE report are shown in **Appendix 6-3**.

Table 1.3.9 Summary of stakeholder meetings

Type of Meeting	Stakeholders	Main Topics	Remarks
Formal meeting with administrative bodies	Division of Environmental and Social Impact Assessment, Department of Natural Resources and Environment in Luang Prabang Province (DONRE)	-Environmental assessment requirement for the project - Water rights	- IEE is required for this project - IEE report to be submitted to Department of Natural Resources and Environment (DONRE) in Luang Prabang Province to obtain ECC.
	Department of Public Works and Transportation	-Definition of Public Road	- Total area of public road as road surface, road shoulder, footpaths, drainage channels, road slope and delimitation area for public road (No.3 /NA Oct2016 Public Road Law)
	Office of Forestry and Agriculture in Luang Prabang city	-Protected forest in Luang Prabang city -Necessity of cutting trees at the new reservoir site	- No protected forest is found in the project area. - An officer from the office of forestry and agriculture visited and checked the type of trees in the new reservoir site (confirmed that no trees there require approval for cutting).
	Luang Prabang World Heritage Office	-Procedure on obtaining approval for the project in World Heritage Site	-Submit detail construction schedule, design and method to Luang Prabang World Heritage Office.
Interview (record of meeting at village level is attached as Appendix 1 Records on Consulting Meeting at Village Level)	Head of Phanom Village	- Activities near existing Namkhan water intake	- No commercial fishery near intake area. - Types of fish near intake area.
	Villagers in Phanom Village		
	Head of Phakam Village	- Night market management	- Request to adjust construction schedule to minimize impact on business.
	Head of Phanxay Village	- Information dissemination on project	- Offer workers for construction
	Head of Houayphiy Village		- Request for detail information on construction schedule prior to construction activity.
	Head of Lakpeath Village		- Strong support for project
	Head of Pongvane Village		- Strong support for project
	Head of Naxay Village		- Strong support for project
	Head of Pha Village		- Request for early start so that

Type of Meeting	Stakeholders	Main Topics	Remarks
			villagers can access water supply.
Stakeholder meeting on the result of drafted IEE report	Project affected persons, village heads, city and provincial government officials in the project area	- Project description - Result of IEE	- Support for implementation of the project - Request for detail construction schedule to be provided to village authority prior to start of construction activities

1.3.7 Result of Initial Environmental Examination (IEE)

The IEE was carried out based on the information from available data, interviews with stakeholders, and site visits. According to the result of IEE, expected impacts by the project are almost same as the scoping result. Therefore, no significant negative impacts are expected by the project. Any potential impacts are minor and could be avoided or minimized with mitigation measures. The main negative impacts include temporary and site-specific pollution resulting from operation of heavy machinery such as air pollution, water pollution, waste generation, noise and vibration during construction.

Scoping and IEE results are shown in Table 1.3.10. The Environmental Check List was prepared and attached in **Appendix6-4**.

Table 1.3.10 Scoping and IEE results

No.	**Impacts**	**Rating at Scoping**		**Rating Based on the Result of IEE**		**Description**
		Pre-Construction/Construction	Operation	Pre-Construction/Construction	Operation	
1. Anti-Pollution						
1.1	Air Pollution	B-	D	B-	N/A	**Construction**: Limited air pollution is expected due to operation of heavy machinery and construction activities particularly during the dry season. Mitigation measure such as sprinkling water around the construction site during the dry season would minimize dust generation. **Operation**: No air pollution is expected.
1.2	Water Pollution	B-	D	B-	B-	**Construction**: Temporary water pollution from construction workers' camp is expected. Installing temporary wastewater treatment system before discharging to the environment would avoid water pollution. **Operation**: Inappropriate handling of residuals from wastewater treatment facilities will pollute the Khan River. The negative impact can be avoided by managing the facilities properly. Wastewater is generated when filters are cleaned. Calcium hypochlorite can pollute the Khan River. Dilute the wastewater before discharge to the Khan River will avoid the negative impact.
1.3	Waste	B-	B-	B-	B-	**Construction**: Negative impact from waste generated during construction would be avoided by applying following methods: 1. Domestic waste such as food debris and human waste from construction workers' camp: collect regularly at designated collection points by contracted garbage collector.

No.	Impacts	Rating at Scoping		Rating Based on the Result of IEE		Description
		Pre-Construction/Construction	Operation	Pre-Construction/Construction	Operation	
						2. Waste soil: Stockpile behind the Namkhan WTP for future use or transport and dispose of at city owned disposal site 8.5 km south-east of the Namkhan WTP. 3. Concrete and asphalt: Transport and dispose of at city owned disposal site. **Operation**: Negative impact from sludge generated at new wastewater treatment facilities would be avoided by scraping and collecting the sludge for transport and disposal at city owned disposal site.
1.4	Soil Contamination	D	D	N/A	N/A	**Construction/Operation**: No soil contamination is expected.
1.5	Noise and Vibration	B-	D	B-	N/A	**Construction**: Noise and vibration resulting from operating heavy machinery is expected. Disturbance would be minimized by providing construction schedule well in advance to residents/business operators near the construction site for better understanding; and avoid inconvenience during business hours as much as possible. **Operation**: No noise and vibration pollution are expected.
1.6	Ground Subsidence	D	D	N/A	N/A	**Construction/Operation**: No activity that will cause ground subsidence is expected.
1.7	Offensive Odor	D	B-	N/A	B-	**Construction:** No activity that will cause offensive odor is expected. **Operation:** Offensive odor can be generated due to mishandling of chlorine chemicals. The impact would be avoided in providing proper instruction on dealing with chlorine chemicals by the operation and maintenance department of the existing Namkhan WTP.
1.8	Bottom Sediment	D	D	N/A	N/A	**Construction/Operation**: No activity that will affect bottom sediment is expected.
2. Natural Environment						
2.1	Protected Area	D	D	N/A	N/A	There is no protected area in the project area.
2.2	Biodiversity	B-	D	B-	N/A	**Construction:** Effect on flora, fauna, or biodiversity is not expected since the project is implemented either in the existing sites (Namkhan WTP) or urban area (public roads) of Luang Prabang city. The Office of Agriculture and Forest in Luang Prabang City confirms that trees in the new reservoir site are categorized as secondary forest, which does not require any further approval for cutting. Workers will be informed that hunting of wild animals or collecting wood in the new reservoir site is prohibited. **Operation:** No negative impact on biodiversity is expected.
2.3	Hydrological Situation	D	D	N/A	N/A	**Construction/Operation:** No negative impact on hydrological situation is expected.
2.4	Topography and Geographica	D	D	N/A	N/A	**Construction/Operation**: No negative impact on topography and geographical features is expected.

No.	Impacts	Rating at Scoping		Rating Based on the Result of IEE		Description
		Pre-Construction/Construction	Operation	Pre-Construction/Construction	Operation	
	l Features					
3. Social Environment						
3.1	Land Acquisition, Involuntary Resettlement	C	D	B-	N/A	**Construction:** No resettlement is needed. The land for the new reservoir is on government land, which is under the management of Phanom village. Arrangement among Phanom village, WSSE-LPBL, DPWT-LPB and DONRE Luang Prabang must be made for the transfer of land right of the government land. The villager who is using 0.6% of this land will be compensated for loss of land use, according to the stipulation in the legislations of Lao PDR and JICA Guidelines for Environmental and Social Considerations. No land acquisition is expected for the other project components since the construction is either at the existing facility or under public roads. **Operation:** No land acquisition or involuntary resettlement is needed.
3.2	Low income households	D	D	N/A	N/A	**Construction**/**Operation:** No direct impact on vulnerable residents near the construction site is expected.
3.3	Indigenous and Ethnic Minority	D	D	N/A	N/A	**Construction**/**Operation:** No direct impact on ethnic minority residing near the construction site is expected.
3.4	Local Economy, Employment, Livelihood	B+/-	A+	B+/-	A+	**Construction**: Positive impact such as creation of local employment is expected. Pakham village authority will be given advanced notice of construction location, dates and duration, to temporarily relocate affected stalls. **Operation**: Increase water supply coverage will contribute to the well-being of residents in Luang Prabang city.
3.5	Land Use and Utilization of Local Resources	D	D	N/A	N/A	**Construction**/**Operation:** No significant impact on land use or change to local resources is expected since project is implemented at the existing facilities (Namkhan WTP) or under public roads or on government land.
3.6	Water Usage	C	C	D	D	**Construction:** Water use: Fishing and collecting riverweed are practised around the intake of Namkhan WTP. Since there are no construction activities at the intake area, no direct impact is expected. Water rights: No further approval from MONRE is necessary because the Namkhan WTP is already authorized to operate at 12,000 m^3/day which remains unchanged and the project will only adjust its operation process.
3.7	Existing Social Infrastructures and Services	B-	A+	B-	A+	**Construction**: Installing distribution/transmission pipes will affect pedestrians and traffic temporarily. Materials, equipment or excavated soil may be stored along the road for one day and space is left for walkway to minimize inconvenience to pedestrians. Disturbance to night market activities at WHS would be avoided by giving information on construction schedule for relocation of affected stalls in advance.

No.	Impacts	Rating at Scoping		Rating Based on the Result of IEE		Description
		Pre-Construction/Construction	Operation	Pre-Construction/Construction	Operation	
						Operation: Water supply coverage will be increased after improvement of the WTP and water quality will improve with renewal of aged distribution pipe.
3.8	Social Institutions and Local Decision-Making	D	D	N/A	N/A	**Construction**/**Operation:** No negative impact on social institution is expected.
3.9	Inappropriate distribution of benefits and damages	D	D	N/A	N/A	**Construction**/**Operation:** No inappropriate distribution of benefits and damages is expected.
3.10	Local Conflict of Interest	D	D	N/A	N/A	**Construction**/**Operation:** No local conflict of interest is expected.
3.11	Cultural Heritage	B-	A+	B-	A+	**Construction**: There is no direct impact on historical buildings or structures in WHS due to renewal of aged pipelines or installation of fire hydrants. Installation sites are located along public roads only. All construction workers will be trained on the proper handling of historical objects/structures discovered during construction, exact location for excavation and proper method of excavation (i.e. no excess digging) and suspending activities when historical objects or structures are found and reporting to the project steering committee for further instruction. **Operation**: Water distribution system in WHS will be improved.
3.12	Landscape	B-	B-	B-	B-	**Construction:** Disturbance of WHS scenery would be minimized by scheduling construction in off-season (rainy season). **Operation:** Fire hydrants will be designed and installed with due care to avoid disturbance to WHS scenery and to fit the landscape.
3.13	Gender Equality	D	D	N/A	N/A	**Construction**/**Operation:** No negative impact on gender equality is expected.
3.14	Children's Rights	D	D	N/A	N/A	**Construction**/**Operation:** No negative impact on children's rights is expected.
3.15	Communicable Diseases such as HIV/AIDS	B-	D	B-	N/A	**Construction**: Risks of communicable disease due to inflow of construction workers would be avoided by implementing awareness/training for construction workers. **Operation**: No increase in risk of communicable diseases is expected.
3.16	Work Environment (includes work safety)	B-	D	B-	N/A	**Construction**: Risk of accident due to inappropriate management of work environment would be avoided/minimized by providing safety equipment and training on health and safety to construction workers regularly throughout construction period. **Operation**: No increased risk to work environment is expected.
4. Others						
4.1	Accidents	B-	D	B-	N/A	**Construction**: Risk of accidents to local community would be avoided with appropriate preventive

No.	Impacts	Rating at Scoping		Rating Based on the Result of IEE		Description
		Pre-Construction/Construction	Operation	Pre-Construction/Construction	Operation	
						measures such as fencing around the construction site and providing traffic control on site. **Operation**: No increase in the risk of accidents is expected.
4.2	Transboundary Impact and Global Warming	D	D	N/A	N/A	**Construction/Operation:** No transboundary or global warming impact is expected.
4.3	UXO	B-	D	B-	N/A	**Construction:** Risk of UXO would be avoided by examining the site for new reservoir before construction. **Operation:** No risk of UXO is expected.

Rating

A+/-: Significant positive/negative impact is expected, B+/-: Positive/negative impact is expected to some extent, C: Extent of impact is unknown and examination is needed (A further examination is needed, and the impact could be clarified as the study progresses) D: No impact is expected, N/A: Impact assessment isn't conducted because the item was categorized into D in scoping phase

1.3.8 Institutional Arrangement

The roles and responsibilities of institutions relevant to environmental and social management during construction and operation are summarized in Table 1.3.11.

Table 1.3.11 Institutional arrangement and the roles

Institution	Roles and Responsibilities
Construction Phase	
Department of Water Supply (DWS), Ministry of Public Works and Transport (MPWT)	- Supervise Project Implementation Unit (PIU)
DPWT of Luang Prabang Province (DPWT-LPB)	- Establish PIU with WSSE-LPB, and implement project and report to DWS/MPWT - Submit environmental monitoring report to DONRE, Luang Prabang
WSSE-LPB	- Establish PIU with DPWT-LPB
Project Implementation Unit (PIU)	- Assign environmental and social staff (ESS) to PIU - Disburse compensation for the affected land of new reservoir before construction - Review monitoring report prepared by ESS and submit to DWS/MPWT
Environmental and Social Staff (ESS) in PIU	- Responsible for environmental and social impact management based on environmental and social management and monitoring plan (ESMMP), approved by DONRE - Inspect the contractor's mitigation activities in accordance with ESMMP, record the result in monthly report to PIU
Project Steering Committee Chair: Vice Governor, Member*: DPWT-LPB, DPI, DF, DONRE, Vice Mayor of Luang Prabang city, Heritage Office, WSSE-LPB and DP	- Monitor compensation disbursement - Review and advise on pipeline route during detailed design - Mediate complaints resulting from construction activities - Inspect construction sites to confirm the effectiveness of environmental mitigation measures implemented by the contractor as required.
Contractor	- Assign environmental and social staff - Submit monthly environmental and social management report to PIU
Environmental and Social Staff in the construction contractor's organization	- Ensure the implementation of the contractor's ESMMP at all construction sites - Prepare environmental and social management report
Operation Phase	
WSSE-LPB	- Formulate policy on inspection and maintenance and supervision of Namkhan WTP - Implement routine inspection/maintenance of new facilities together with existing ones.

*DPWT-LPB (Department of Public Works and Transportation of Luang Prabang Province), DPI (Department of Planning and Investment of Luang Prabang Province), DF (Department of Forestry of Luang Prabang Province), DONRE (Department of Natural Resources and Environment of Luang Prabang Province), DP (Department of Police of Luang Prabang Province)

1.3.8.1 Pre-Construction

The land acquisition plan will be finalized at the detailed design phase. DPWT-LPB/WSSE-LPB will arrange the transfer of the government land from the village to WEES-LPB.[12] After estimation of the compensation amount for loss of land use, DPWT-LPB/WSSE-LPB will apply to DONRE for approval of the compensation amount and disburse the compensation to the villager. The whole process for land acquisition will be completed before the start of construction. The process including compensation disbursement will be monitored by the project steering committee.

1.3.8.2 Construction

Before the start of construction, DPWT-LPB will obtain approval from DONRE on the IEE and ESMMP[13,14]. Based on the mitigation measures in the ESMMP, the construction contractor will prepare the environmental and social management plan (contractor's ESMP) and carry out mitigation activities accordingly. The construction contractor will conduct water sampling at the discharge point of treated wastewater in the workers' camp. The result from the water sampling at the completion of construction of the camp will be used as a baseline for monitoring during construction. The construction contractor will record the pre-construction conditions at the stockyard for storing construction materials and the workers' camp. The record will be used to confirm that these sites are restored to their original conditions on completion of construction.

The construction contractor will report the result of the mitigation measures regularly to the PIU.

PIU will monitor the mitigation activities by the construction contractor based on the report from ESS. The result of ESS inspection will be reviewed by the PIU and in turn submitted to DONRE and JICA regularly throughout the construction period.

DONRE together with Office of Natural Resources and Environment in Luang Prabang City will visit the construction site every three months to monitor the environmental and social impact management throughout construction.

1.3.8.3 Operation

After completion of construction, WSSE-LPB will operate the new and existing facilities.

1.3.8.4 Handling Grievances

Construction Phase: PIU will be complaints reception desk and ESS will handle complaints and mediate between complainants and construction contractor to resolve issues caused by construction activities. If there is no satisfactory resolution, the issues will be referred to the steering committee to

[12] The land use right was transferred from Phanom village to WSSE-LPB on 25 Dec, 2018. (Appendix 6-7)

[13] Environmental and social management and monitoring plan (ESMMP) is comprised of institutional arrangement for environmental management, mitigation measures and monitoring plan.

[14] The IEE report and ESMMP were approved and an Environmental Compliance Certificate (ECC) was issued from DONRE on 22 November, 2018. (Appendix 6-1)

solve the problems.

ESS will inform the village authorities about the location of complaints reception desk and the procedure for handling grievances when the detail construction schedule is disclosed. The information is to be disseminated to the residents by the village authorities.

DPWT-LPB will report to JICA on the state of handling grievances through a quarterly progress report.

Operation Phase: WSSE-LPB will deal with complaints on natural and social environmental impacts resulting from the project. If the complaint is not solved, the dispute will be settled via mediation by DPWT-LPB and then by DONRE if necessary[15].

1.3.9 Mitigation Measures

Mitigation measures are prepared for each environmental impact based on the IEE result. Mitigation activities shall be monitored regularly. The mitigation measures, implementing organization, and responsible organizations for pre-construction/construction and operation phases are shown in Table 1.3.12 and Table 1.3.13 respectively.

The ESMMP will be reviewed and finalized during the detailed design phase. The construction contractor will prepare the contractor's ESMP in line with the ESMMP and obtain approval by PIU before commencement of construction.

The cost for mitigation measures during construction will be included in the construction cost (DPWT-LPB will prepare a budget on the mitigation measures which requires inter-governmental arrangement). The cost for mitigation measures during operation will be included in the O&M budget prepared by WSSE-LPB for the Namkhan WTP.

Table 1.3.12 Mitigation measures for pre-construction/construction phases

Predicted Impacts	**Proposed Mitigation Measures**	**Implementing Organization**	**Responsible Organization**
1.Pollution Control			
1.1 Air Pollution			
-Emission from construction vehicles	- Maintain vehicles in good condition to minimize exhaust emissions - Use fuels and lubricants of good quality in compliance with national standards - Implement traffic control to reduce congestion	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
-Dust especially when the weather is dry	- Cover load-carrying platforms properly when carrying earth/sand - Spray water at construction sites, on unpaved roads adjacent to restaurants/shops during dry conditions		
1.2 Water Pollution			
- Polluted water from worker's camp	-Ensure good sanitation, especially in kitchens and latrines, and install proper drainage and treatment pond for the wastewater from kitchen and bathing facilities and septic tanks.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
1.3 Waste			

[15] Part IX Dispute Settlement, Environmental Protection Law, No.29 N/A December 2012

Predicted Impacts	**Proposed Mitigation Measures**	**Implementing Organization**	**Responsible Organization**
- Domestic waste from worker's camp	- Designate temporary locations for garbage collection for transportation to city owned disposal site.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
- Construction waste	- Designate temporary waste disposal points for transportation to city owned disposal site.		
1.4 Noise and Vibration			
- Noise and vibrations from vehicles transporting construction materials and on-site construction activities	- Minimize construction activities during business hours and peak tourist season as much as possible	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
2.Natural Environment			
- Disturbance to wild life and loss of trees	- Instruct construction workers not to hunt or collect wood in the forest	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
3. Social Environment			
3.1 Land Acquisition, Involuntary Resettlement			
- Loss of Land	- Provide proper compensation	PIU (DPWT-LPB/ WSSE-LPB)	Steering Committee
3.2 Local Economy, Employment, Livelihood			
- Disruptions to businesses along the construction site	- Schedule construction activities to avoid business hours and peak tourist season as much as possible	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
	- Provide detailed information on construction schedule and location to Pakham village authorities so that they can make arrangement to temporarily relocate affected stalls during construction.	PIU (DPWT-LPB/ WSSE-LPB)	PIU (DPWT-LPB/ WSSE-LPB)
3.3 Existing Social Infrastructures and Services			
- Disruption to pedestrian and vehicle traffic during installation of transmission/ distribution pipes	- Provide temporary pedestrian walkway and assign traffic guides to control traffic where there is not enough space for pedestrian walkways.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
	- Provide detailed information on construction schedule and location to the village authorities in WHS so that they can deal with temporary parking prohibition during construction.	PIU (DPWT-LPB/ WSSE-LPB)	
- Disruption to businesses at the night market in WHS	- Provide detailed information on construction schedule and location to Phakam village authorities, so that they can relocate affected stalls inside the night market area.	PIU (DPWT-LPB/ WSSE-LPB)	
3.4 Cultural Heritage			
- Damage to the historical object/ structure underground	- Instruct all workers on proper handling of historical objects/structures discovered during construction. - Inform all workers regarding the exact location and proper method of excavation (no excess digging). - Suspend construction activities when historical objects or structures are found and report to the project steering committee for instruction.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
3.5 Landscape			
- Disturbance to the scenery in WHS	- Schedule construction during off season (rainy season) to avoid peak tourist season.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
3.6 Communicable Diseases such as HIV/AIDS			
- Spread of communicable diseases	- Conduct information, education and communication (IEC) campaigns targeting staff and workers and local communities, concerning the risks, dangers and impacts, and appropriate avoidance behavior with respect to sexually transmitted diseases (STD) - or sexually transmitted infections (STI) in general and HIV/AIDS in particular.	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
3.7 Work Environment (includes worker's safety)			
Risk of accidents due to inappropriate	- Prepare safety plan and safe construction plan - Provide personal protective equipment to workers	Construction contractor	PIU (DPWT-LPB/

Predicted Impacts	Proposed Mitigation Measures	Implementing Organization	Responsible Organization
management of work environment	- Give instructions on health and safety to workers regularly throughout construction phase		WSSE-LPB)
4. Others			
4.1 Accidents			
- Risk of accidents due to inappropriate management of construction activities	- Fence around the construction site - Assign traffic control person on site	Construction contractor	PIU (DPWT-LPB/ WSSE-LPB)
4.2 UXO			
- UXO Risk	- UXO survey before access road construction - Deeper ground investigation for UXOs at reservoir construction site as needed	PIU (DPWT-LPB/ WSSE-LPB)	Steering Committee

ESS: Environmental and Social Staff in PIU

Table 1.3.13 Mitigation measures during operation

Predicted Impacts	Proposed Mitigation Measures	Implementing Organization	Responsible Organization
1.Pollution Control			
1.1 Waste			
Improper management of sludge generated from water treatment process	- Scrape and collect the sludge and transport to city owned disposal site	Namkhan WTP	WSSE-LPB
1.2 Offensive Odor			
Improper management of chlorine at water treatment plant	- Ensure proper handling of chlorine chemicals	Namkhan WTP	WSSE-LPB
1.3 Water Quality			
Improper management of sludge generated from water treatment process	- Discharge only supernatant to the Khan River.	Namkhan WTP	WSSE-LPB
Improper management of chlorine at water treatment plant	- Dilute the wash water from calcium hypochlorite solution tank before discharge to avoid releasing high concentration of calcium hypochlorite to the Khan River	Namkhan WTP	WSSE-LPB

1.3.10 Monitoring Plan

1.3.10.1 Environmental Monitoring

The monitoring plans for construction and operation phases are shown in Table 1.3.14 and Table 1.3.15.

ESS in PIU will monitor the mitigation activities of the construction contractor. They will check the environmental reports submitted by the contractor and inspect the construction site. Effectiveness of the monitoring plan will be assessed regularly and revised as appropriate.

During operation, WSSE-LPB will regularly check the records on sludge treatment, water quality of the supernatant and wash water from the calcium hypochlorite solution tank and handling of chlorine chemicals in the Namkhan WTP. The monitoring plan will be finalized prior to the commencement of operation.

The proposed monitoring form is attached in **Appendix 6-5**. The site-specific inspection form is

prepared as shown in **Appendix 6-6**. In this form, the required monitoring items are classified by monitoring site such as the construction contractor's office/camp, disposal site and construction site of the Namkhan WTP. These forms are used at the time of regular inspection by ESS.

Table 1.3.14 Monitoring plan for pre-construction/construction phases

Monitoring Items	**Monitoring Methods**	**Measurement Point**	**Frequency**	**Organization Concerned**
Air Pollution				
- Maintain vehicles in good condition to minimize exhaust emissions	-Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Use fuels and lubricants of good quality in compliance with national standards	Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Implement traffic control to reduce congestion	Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Cover load-carrying platforms properly when carrying earth/sand	-Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Spray water at the construction sites, on unpaved roads, and adjacent to restaurant/shops during dry conditions	-Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Water Pollution				
-Ensure good sanitation especially in kitchens and latrines and install good drainage and install treatment pond for the wastewater from kitchens and bathing facilities and septic tanks.	-Visual inspection on site	Construction contractor's camp	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
	-Water sampling (BOD≤30mg/l, Turbidity, Temperature, Color)	- Discharge point to the Khan River		
Waste				
- Designate temporary locations for garbage collection in the contractor's' camp for transportation to city owned disposal site.	-Visual inspection on site	Construction contractor's camp	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Designate waste disposal points at the construction site for transportation to city owned disposal site.	-Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Noise and Vibration				
- Minimize construction activities during business hours and peak tourist season as much as possible	-Interviews with village head	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Ecosystem				
- Instruct the Construction workers not to hunt or collect wood in the forest	-Visual inspection on site	Construction site of the new reservoir	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Land Acquisition, Involuntary Resettlement				
- Provide proper compensation	-Confirm agreement on land compensation	Each project affected person	- Before the commencement of construction activity	Steering Committee
Local Economy, Employment, Livelihood				

Monitoring Items	Monitoring Methods	Measurement Point	Frequency	Organization Concerned
- Schedule construction activities to avoid business hours and peak tourist season as much as possible	-Confirm the number of complaints at PIU	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Provide detailed information on construction schedule and location to Pakham village authority so that they can make arrangement to temporarily relocate affected stalls during construction	-Confirm the number of complaints at PIU	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Existing Social Infrastructures and Services				
- Provide temporary pedestrian walkway and assign workers to control traffic where there is not enough space for pedestrian walkways	-Visual inspection on site	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Provide detailed information on construction schedule and location to the village authorities in WHS so that they can deal with temporary parking prohibition during construction	-Confirm the number of complaints at PIU	Construction sites in WHS	At the time of construction in WHS, weekly	PIU(DPWT-LPB/ WSSE-LPB)
- Provide detailed information on construction schedule and location to Pakham village authority so that they can relocate affected stalls inside the night market area	-Confirm the number of complaints at PIU	Construction site at night market area	At the time of construction at Night Market weekly	PIU(DPWT-LPB/ WSSE-LPB)
Cultural Heritage				
- Instruct all workers on proper handling of historical objects/structures discovered during construction	-Confirm the number of incidents at PIU	Construction sites of distribution pipes in WHS	At the time of construction at WHS monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Inform all workers regarding the exact location and proper method of excavation (no excess digging)	-Confirm the number of incidents at PIU	Construction sites of distribution pipes in WHS	At the time of construction at WHS monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Suspend construction activities when historical objects or structures are found and report to the project steering committee for instruction	-Confirm the number of incidents at PIU	Construction sites of distribution pipes in WHS	At the time of construction at WHS monthly	PIU(DPWT-LPB/ WSSE-LPB)
Landscape				
- Schedule construction in WHS during off season (rainy season) to avoid peak tourist season	-Visual inspection on site	Construction sites of distribution pipes in WHS	At the time of construction at WHS monthly	PIU(DPWT-LPB/ WSSE-LPB)
Communicable Diseases such as HIV/AIDS				
- Conduct Information, Education and Communication (IEC) campaigns targeting staff, workers and local communities concerning risks, dangers and appropriate avoidance behavior with respect to, sexually transmitted diseases (STD) - or sexually transmitted infections (STI) in general and HIV/AIDS in particular	-Check record of IEC	Construction contractor's camp	Every 6 Months	PIU(DPWT-LPB/ WSSE-LPB)
Working Environment (includes worker's safety)				
- Check safety measures conducted in accordance with safety plan and the detailed method statement	-Check plans	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
- Provide personal protective equipment to workers	-Visual inspection on site	All construction sites	Monthly	PIU(DPWT-LPB/ WSSE-LPB)

Monitoring Items	**Monitoring Methods**	**Measurement Point**	**Frequency**	**Organization Concerned**
- Give instruction on health and safety to workers regularly throughout construction phase	-Check record	Construction contractor's camp	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
Others				
Accidents				
- Fencing around the construction site	-Visual inspection on site	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
-Assign traffic control person on site	-Visual inspection on site	Construction sites of transmission/ distribution pipes	Monthly	PIU(DPWT-LPB/ WSSE-LPB)
UXO				
- UXO survey before access road construction	-Check record of examination	Construction site of the new reservoir and access road to the new reservoir	Before starting construction at new reservoir	PIU(DPWT-LPB/ Steering Committee
- Deeper ground investigation for UXOs at reservoir construction site as needed	-Check record of examination	Construction site of the new reservoir and access road to the new reservoir	Before starting construction at new reservoir	PIU(DPWT-LPB/ Steering Committee

Table 1.3.15 Monitoring plan during operation (draft)

Monitoring Items	**Monitoring Measures**	**Monitoring Point**	**Frequency**	**Organization Concerned**
Waste				
- Scrape and collect the sludge and transport to city owned disposal site	- Check record	Namkhan WTP	To be finalized	Implemented by Namkhan WTP, inspected by WSSE-LPB
Offensive Odor				
- Ensure proper handling of chlorine chemicals	- Check record	Namkhan WTP	To be finalized	Implemented by Namkhan WTP, inspected by WSSE-LPB
Water Quality				
- Discharge only supernatant to the Khan River	- Check record	Namkhan WTP	To be finalized	Implemented by Namkhan WTP, inspected by WSSE-LPB
- Dilute the wash water from calcium hypochlorite solution tank before discharge high concentration of calcium hypochlorite to the Khan River	- Check record	Namkhan WTP	To be finalized	Implemented by Namkhan WTP, inspected by WSSE-LPB

1.3.10.2 Monitoring Schedule

(1) Pre-Construction

The project steering committee will monitor the disbursement for loss of land use which should be completed before construction starts.

(2) Construction

The implementation of mitigation measures by the construction contractor will be monitored. The type of monitoring and brief description for each monitoring activity are as follows:

Monthly Monitoring

ESS will visit the project site on scheduled time once a month to monitor the mitigation measures implemented by the construction contractor as specified in the ESMMP.

The main tasks are:

(a) to evaluate the effectiveness of mitigation activities,

(b) to consult with the Technical Officer in PIU on the effectiveness of the ESMMP,

(c) to prepare a field report to the PIU.

Quarterly Monitoring

ESS, DONRE, and Office of Natural Resources and Environment in Luang Prabang City will conduct a joint visit to the project site every 3 months.

The main tasks are:

(a) to evaluate the construction contractor's mitigation activities,

(b) to review progress and determine if the ESMMP is still appropriate in terms of mitigation measures and timeframe,

(c) to examine the need for adjustment to the ESMMP to make it more effective,

(d) to consult with villagers on suggestions and opinions for resolving environmental problems and improvement of mitigation measures.

Table 1.3.16 Monitoring schedule during construction

Monitoring by:	Month							Project Completed
	1	2	3	4	5	6	~	
ESS	❋	❋	❋	❋	❋	❋	(until the end of construction)	❋
ESS, DONRE, Office of Natural Resources and Environment in Luang Prabang city			❋			❋		❋

(3) Operation

Namkhan WTP should maintain a record to demonstrate that sludge is properly transported to the city dumping site. Namkhan WTP should also track the water quality of the following wastewater before discharging to the Khan River. These records should be periodically checked by WSSE-LPB.

- Wastewater after the treatment by wastewater treatment facilities
- Wastewater from calcium hypochlorite solution tank

1.3.10.3 Monitoring Budget

The cost incurred for environmental monitoring is estimated based on the following assumptions:

- Construction period of 24 months
- ESS conducting monitoring once a month during the construction
- Officers from DONRE and Office of Natural Resources and Environment in Luang Prabang City conducting the monitoring once every 3 months during the construction

The cost estimate is shown in Table 1.3.17. DPWT-LPB will prepare the budget required for personnel expenses for the monitoring during the construction.

Water sampling and health awareness/training conducted by the construction contractor will be included in the construction cost.

Monitoring cost during operation is not calculated because this will be conducted for the whole facility by WSSE-LPB.

Table 1.3.17 Environmental management cost during construction

Environmental and Social Staff (PIU)

Description	Cost per unit (USD)	Number of Days	Amount (USD)
Field Work	12	48	576
Fuel	12	48	576
Total			1,152

- 2 PIU staff will conduct field monitoring once a month during construction, and submit the report to DONRE
- Fuel include driver and petrol cost
- The cost of field work for the PIU staff and DONRE and Office of Natural Resources and Environment in Luang Prabang City is calculated based on the Budget Administration of the Government of Laos 2017.

Water sampling

Description	Cost per Unit (USD)	Number of Days	Amount (USD)
Analysis	42	24	1,008
Water Sampling Container	15	-	15
Staff	50	48	240
Transportation	150	24	3,600
Total			4,863

- Sampling at discharge point at workers' camp
- Sampling parameters include turbidity, color, temperature, BOD
- 2 staff per day

Health awareness/training program

Description	Cost per Unit (USD)	Number of Days	Amount (USD)
Health/ Awareness/ Training Program	175	4	700
Total			700

- Health/ Awareness/ Training Program to be organized once every 6 months

DONRE

Description	Cost per Unit (USD)	Number of Days	Amount (USD)
Field Work	12	16	192
Fuel	12	8	96
Contingency**	10% of Total Amount		28.8
Total			316.8

- 2 staff for quarterly monitoring
- Contingency includes cost incurred for emergency inspection

Office of natural resources and environment in Luang Prabang City

Description	Cost per Unit (USD)	Number of Days	Amount (USD)
Field Work	12	8*	96
Vehicle	12	8	96
Contingency	10% of Total Amount		19.2
Total			211.2

- 1 staff for quarterly monitoring
- Contingency includes cost incurred for emergency inspection

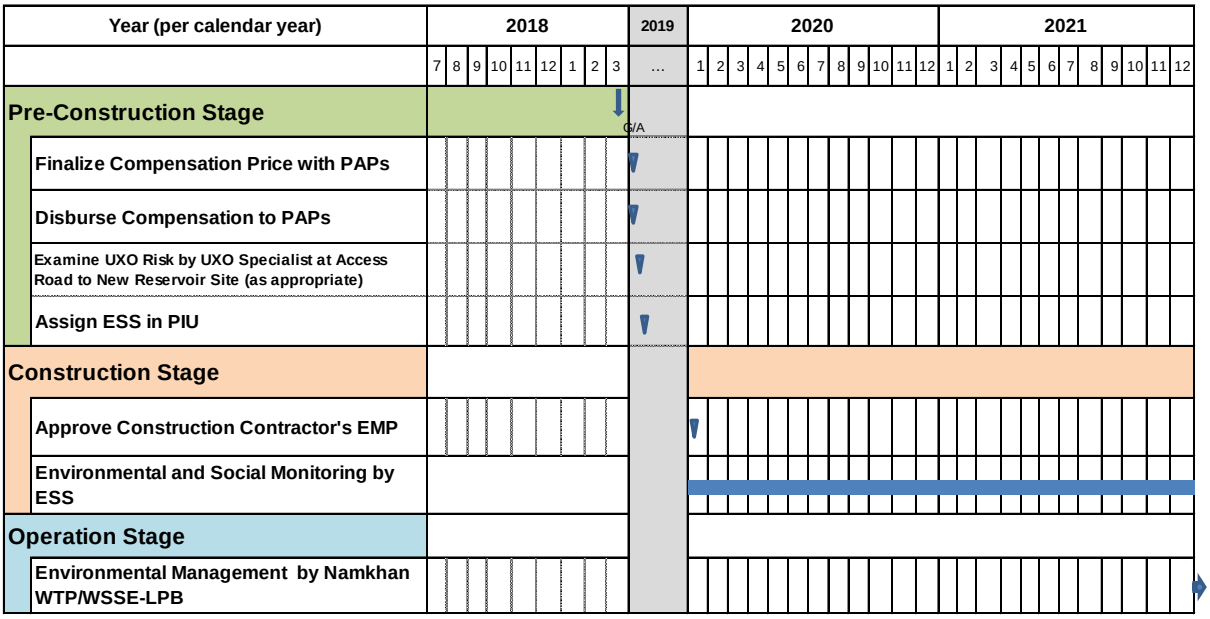
1.3.11 Implementation Schedule

Before construction starts, DPWT-LPB and WSSE-LPB will 1) confirm the risk of UXO around the new reservoir site; 2) compensate the villager for loss of land use, 3) establish a project implementation unit (PIU); and 4) assign environmental and social staff (ESS) from PIU.

The construction contractor shall submit the contractor's ESMP to PIU for approval before the start of construction.

The implementation schedule for the 24-month construction period is shown in Table 1.3.18.

Table 1.3.18 Implementation schedule



PAPs: Project Affected Persons

1.3.12 Land Acquisition

About 0.5 ha of land is necessary for constructing the new reservoir, and the land is owned by government. 0.6% of the land is being used by a villager.

1.3.12.1 Transferring Land Use Right

The required government land was previously under the management of the village. The land use right was transferred from the village authority to WSSE-LPB on 25 December, 2018. The official letter of the transfer of land use right is shown in **Appendix 6-7**.

The procedure of transferring land use right is as follows:

1. WSSE-LPB to confirm the exact location of the new reservoir site with the village head and make the agreement on the transfer of land use right.
2. WSSE-LPB to request DONRE for the transfer of land use right in writing.
3. DONRE to approve the transfer of land use right to WSSE-LPB.

1.3.12.2 Compensation for loss of land use

When DONRE and Steering Committee implemented a joint survey with village authorities, it was confirmed that about 0.6% (30 m^2) of the land had been used by a villager from Phanom village for a long time and compensation is required for loss of land use.

(1) Legal Procedure

The procedure of land acquisition is stipulated in Decree on Land Acquisition and Resettlement (No.84 2016) as follows:[16]

1. The project owner (or executor) shall coordinate with government authorities in collecting data on project affected persons (PAPs) and determine the appropriate compensation. Valuation and estimation of compensation value shall be based on prices applied by the state, market price or average price for period of compensation and type of property and location.
2. The estimated compensation price shall be stated in the compensation plan in the ESMMP for approval together with IEE report. In case of this project, the estimated compensation price will be stated after the approval of IEE report.
3. The PAPs shall participate in the consultation meetings in all levels to give their comments on the compensation plan.
4. Approval date of IEE and ESMMP shall become the cut-off date.[17]
5. The project owner (or executor) shall confirm the PAPs and the affected land and finalize the compensation price with the project steering committee.
6. The project owner (or executor) shall disburse the compensation to the PAPs in the presence of the project steering committee.

(2) Comparing JICA Guidelines and Legislations in Lao PDR

The analysis of JICA Guidelines and legislations of Lao PDR on land acquisition is shown in Table 1.3.19. Stipulations such as “When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people” and “Affected people are to be identified and recorded as early as possible” available in JICA Guidelines are not provided in legislations of Lao PDR. Accordingly, the project will follow JICA Guidelines on these issues.

[16] From No.1 to No.4 are addressed in Decree No.84. No.5 and No.6 are the practice in the past.

[17] Cut-off-date means the day, which the project area was finalized. In principal, the person moved into the project area after the cut-off-date is not eligible for compensation.

Table 1.3.19 Analysis of JICA guidelines and legislations in Lao PDR

No.	JICA Guidelines	Laws of Lao PDR (Decree on Compensation and Resettlement Management in Development Projects, No.84, 2016)	JICA Guidelines and Laws of Lao PDR
1.	Compensation must be based on the full replacement cost as much as possible.	In case the affected person possesses documents concerning the land use rights in accordance with the laws and their land has been all or partly affected, and the remaining piece of land cannot be used, the project owner must compensate for the whole piece of land by allocating a new piece of land for compensation. The project owner must obtain documents concerning the land use rights for the new piece of land and be responsible for all expanses for obtaining such documents. In case the allocation for the new piece of land cannot be organized or in case the new piece of land has lower value than the affected land, the project owner must provide other forms of compensation based on the value of affected land.	No gap
2.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	There is no specific explanation on this matter in the Decree on compensation.	The project will follow the JICA Guidelines
3.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	In case the affected persons are of the view that the project owner is not complying with the plan for compensation, resettlement and rehabilitation of people's livelihood in accordance with his decree or other related plans that affected their interests, they can request relevant authorities to resolve the issue according to the procedures stipulated in paragraph 1, article 24 of this decree. (Article 23)	No gap
4.	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 socio-economic survey), preferably at the project identification stage, to prevent an influx of encroachers who wish to take advantage of such benefits. (WB OP4.12 Para.6)	There is no specific explanation on this matter in the Decree on compensation.	The project will follow the JICA Guidelines

No.	JICA Guidelines	Laws of Lao PDR (Decree on Compensation and Resettlement Management in Development Projects, No.84, 2016)	JICA Guidelines and Laws of Lao PDR
5.	Eligibility for benefits are extended to 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)	In case the affected persons possesses the traditional land use right, the project owner has to compensate for the loss, provided that the affected persons have the land use rights for a long period of time and have taken care of, developed and used the land peacefully without invasion into protected forest areas or restricted areas and have certificates issued by local authorities and relevant state agencies. (3. Article 8) In case the affected persons do not have land use rights documents, they shall not be entitled to receive any compensation for the loss of such land. However, they will be entitled to receive compensation for the loss of constructed facilities, trees and crops from the project owner based on the calculated values. (4. Article8)	No gap. Both legislations recognize the rights of eligibility of benefits

(3) Scale of Land Acquisition

The villager who will lose the use of 30 m^2 of land in Phanom village must be compensated. The land is located in the village production forest. No agricultural activity is practiced on this land.

Table 1.3.20 Land acquisition

Affected Person	Occupation	Location	Land Type	Use of Land	Affected (m^2)
Villager A	Deputy Village Head/Owner of microfinance company	Part of government land of proposed new reservoir in Phanom Village	Forest land	No agricultural activity	30 m^2

(4) Detailed Compensation Plan

The entitlement matrix on land acquisition is prepared as shown in Table 1.3.21. The compensation shall be the replacement cost in compliance with the legislation of Lao PDR as well as JICA Guidelines. The compensation for the loss of land use will be disbursed in cash. The cut-off date for the entitlement is stipulated in Decree No.84 as the day when the IEE report is approved[18].

DPWT-LPB/WSSE-LPB has been consulting with the PAP on the compensation estimate. An agreement is to be formed by the end of the detailed design phase. DPWT-LPB/WSSE-LPB will finalize the compensation with the steering committee. The finalized compensation price will be included in the ESMMP after IEE report approval. Before the construction starts, DPWT-LPB shall disburse the compensation to the PAP.

[18] Article 7, Decree on Compensation of the Development Project (No.84, 2016)

Table 1.3.21 Entitlement matrix on the land acquisition

Type of Loss	Entitled Persons	Entitlement	Implementation Issues/Guidelines	Responsible Organization
Loss of land use	Land user of the land	Replacement value of land use (cash compensation)	A:Consultation/estimation/negotiation on compensation price B:Approval of compensation price C:Disbursement of compensation	A:DPWT-LPB/WSSE-LPB B:Steering Committee C:DPWT-LPB

(5) Cost and Budget

The consultation and negotiation of the compensation to be paid to the villager for his loss of land use (30 m^2) is under way between the affected person and DPWT-LPB/WSSE-LPB.

DPWT-LPB will prepare the funds for this cost.

2. Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

2.1.1.1 Overall Goal

The 8th National Socio-Economic Development Five-Year Plan (2016) aims to increase the water supply coverage in the center part of each city to 90% by 2020. The coverage of existing water supply area in Luang Prabang city is 95.3% and the 2020 target has already been achieved.

The JICA technical cooperation for "Capacity Development Project for Improvement of Management Ability of Water Supply Authorities (MaWaSU)" supported the Lao side in preparing guidelines and long-term plans for water supply systems. These guidelines and long-term plans refer not only to water supply coverage but also to the safety, stability and sustainability of the infrastructure to provide high quality service. The current water supply system needs to be improved to meet these targets.

To this end, the overall goal is as follows:

Overall Goal: The water supply service should provide customers with safe, stable and sustainable water supply, and thereby improve public health and living environment.

Safe water supply: All customers rely on water supply service by implementation of the following water supply service.

- Clean potable water supply that meets quality standards set by the Ministry of Health.
- Planning water supply service for use of safe water.

Stable Supply: Continuous water supply 24 hours a day, 7 days a week in all places

Sustainable Supply: Stable and sustainable supply of safe and clean water.

2.1.1.2 Project Objective

The project will expand the water supply systems to improve stability of water supply in Luang Prabang city, thereby contributing to the improvement of sustainable urban environment of Luang Prabang city and the World Heritage Site (WHS).

2.1.2 Project Description

The project will construct the facilities for water supply and implement soft component (technical assistance). Strengthening of stable water supply is expected by the project implementation.

The major project components are as follows:

Table 2.1.1 Project Components

Facility	Components
Intake facilities	Intake pump (capacity: 13,200 m^3/day) No. of pumps: 6 (Large pumps: 3 including 1 standby, Small pumps: 3 including 1 standby)
Water Treatment Facility	Receiving well, Mixing well (capacity: 12,000 m^3/ day) (reinforced concrete structure)
	Flocculation basin, Sedimentation basin (reinforced concrete structure) (capacity: 6,000 m^3/ day) Chemical feed facility
Wastewater treatment Facilities	Wastewater & sludge basin, Lagoon (sludge drying bed) (450 m^3)
Transmission Facilities	Treated water transmission pump Treated water transmission pump with flywheel No. of pumps: 2 including 1 standby Transmission pipeline From Phouphueng WTP to Khouthinieng Reservoir; HDPE OD 225 3.4 km From existing transmission line to new reservoir; HDPE OD 400 1.6 km
Distribution Facilities	New Service Reservoir; 1,500 m^3 (Reinforced Concrete Structure)
	Total Length: approx. 60.2 km • From new reservoir to distribution branch; HDPE OD 400, 1.6 km • Lines for service expansion area: HDPE OD 80~225, 14.3 km • Renewal of old pipes: HDPE OD 80～225, 44.3 km
Fire Hydrants	45 units
Monitoring system	Data logger monitoring device, data logger panel, instrumentation equipment, water level gauge 5 units, flow meter 7 units

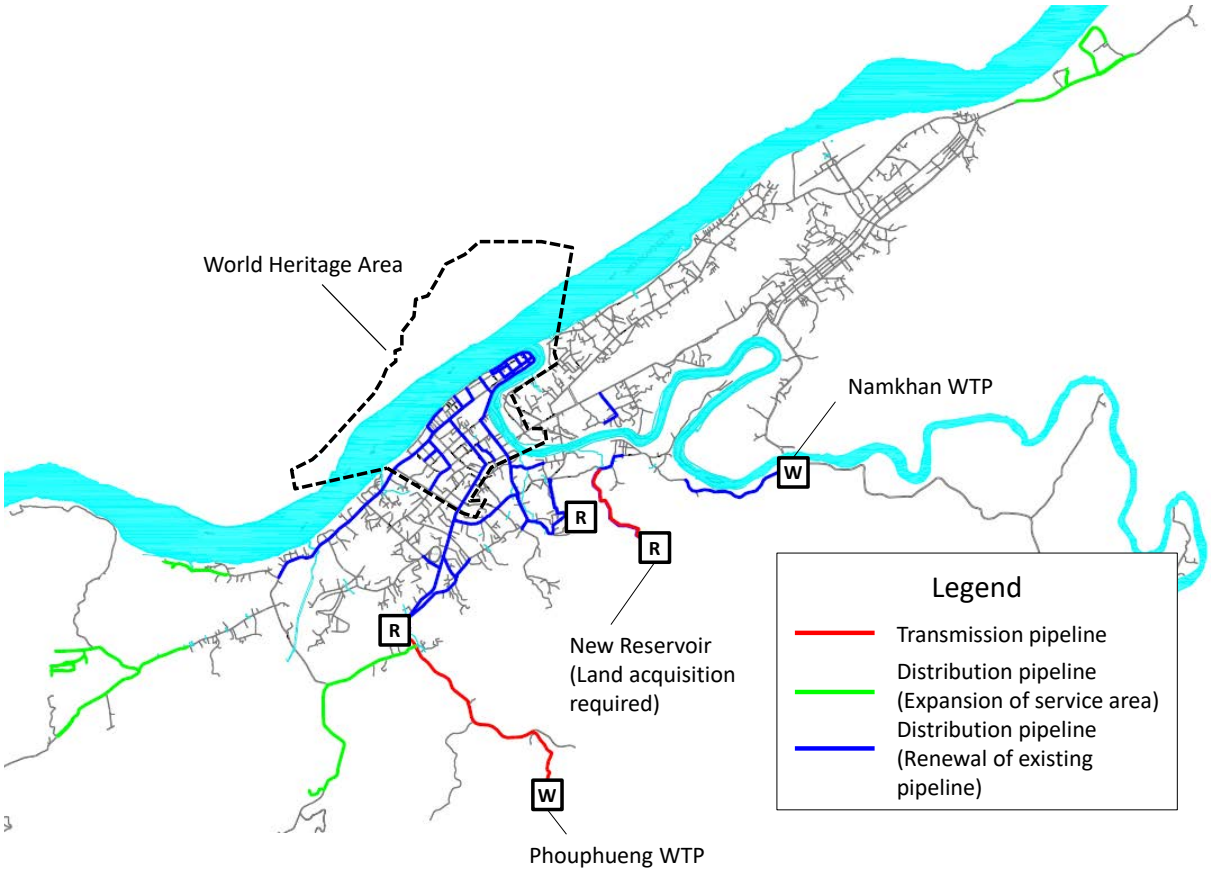


Figure 2.1.1 Location of each project component

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Targets

(1) Target Year

The target year of the project is 2025 which is 3 years after facilities construction.

(2) Capacity of Water Treatment Facilities

The project does not expand the water treatment capacity. The current capacity, which includes WSSE-LPB WTPs and WTPs operated by Asia and Demco, is enough for the water demand in 2025. However, the improvement of Namkhan WTP will be implemented for stable water production and improvement of treated water quality.

(3) New Reservoir

The project will construct a new service reservoir in the mountain area on the southeast side of the existing Phounanong Reservoir.

The existing Phousi Reservoir constructed in 1969 has deteriorated and will be abandoned.

(4) Design Standards

The design is carried out based on "MPWT (2009) Management and Technical Guidelines Water

Supply" which is the standard for water supply facilities in Lao PDR (Lao standard), with reference to Japanese design standard “Japan Water Works Association (2012) Design criteria for waterworks facilities” (Japanese standard) as necessary.

(5) House Connections

1) Existing Service Area

The project will renew some of the existing distribution pipelines and take care of the associated reconnection of house connection pipes to the new pipes.

2) Expansion of Water Supply Service Area

The project will construct new distribution pipelines in the water supply expansion area. House connections in the expansion area are not included in the project, since the house connection pipes and water meters will be installed based on the request of the residents. The house connection fee shall be borne by the residents following the current practice.

(6) Soft Component (technical assistance)

The project will change the operation of the Namkhan WTP. Training will be provided by the consultant to ensure that plant staff have the capability to operate the new facilities.

The project will introduce a monitoring system to monitor flow volume and water level. Staff will be trained in the use of the monitoring system.

2.2.1.2 Socio-economic Conditions

(1) Socio-economic Conditions of Lao PDR and Luang Prabang City

The Lao PDR is a land locked country with an area of 237,000 km^2 bordered by China, Vietnam, Myanmar, Thailand, and Cambodia. The population is 6.5 million in 2013 and 6.9 million in 2017, with a growth rate of 1.3 to 1.5%.

Table 2.2.1 shows the GDP per capita and share of GDP by sector for Lao PDR and Luang Prabang city. Annual GDP per capita for Luang Prabang city is approximately 40% higher than the national average. Service and trade sectors account for more than half of the total GDP at 59.6%, demonstrating the importance of tourism in the World Heritage Site.

Table 2.2.1 GDP per capita and share of GDP by sector

No.	Item	GDP
1	Laos GDP	1,730 (USD/person/year)
2	Luang Prabang City GDP	2,401 (USD/person/year)
3	GDP Sector	Agriculture 21.5%
		Industry 18.9%
		Service and Trade 59.6%

Source: National Statistics Bureau, Luang Prabang city Social-economic development plan 2016-2017

The station for the China-Laos Railway is under construction in the eastern part of Luang Prabang city. JICA Preparatory Survey Team (JPST) has requested the Lao side to collect information on the railway project. As the water demand related to the railway station is not available at this time, this aspect is not considered in the water demand projection. The following information related to the railway station is confirmed through interviews with WSSE-LPB.

- Construction is scheduled to be completed in 2021.
- The project area is approximately 3 km x 5 km.
- The Lao side is responsible for water and electricity supply to the railway project area.

(2) Constraints on Design and Construction in the World Heritage Site

The construction plan must take into consideration the daily operation of a night market visited by tourists on the main street of Luang Prabang city. The following measure is considered based on the meeting with the night market manager:

- Construction should take place along a maximum of 50 m at a time, to allow relocating affected stalls.

Other considerations for design and construction are:

- Installation of fire hydrants to take into consideration their effect on the overall visual aesthetics around the area.
- All construction activities to be stopped if archaeological artifacts are discovered under the ground during construction. No such discovery has occurred so far.

2.2.1.3 Construction Materials Procurement

Construction materials can be procured in Lao PDR or imported from neighboring countries such as Thailand or Vietnam and the imported materials are available in domestic markets.

Piping material is not produced in Lao PDR. Ductile cast iron and high-density polyethylene pipes are likely to be imported from another country such as Thailand, Vietnam or Taiwan where the prices are more competitive compared to Japanese products. The procurement country will be selected considering quality, price, and availability of the products.

2.2.1.4 Use of Local Contractor

(1) Capacity of Local Contractors

1) General Construction

Japanese contractors have worked with local subcontractors in Japanese Grant Aid projects in Lao PDR. Construction companies in Lao PDR possess general-purpose construction machinery for earthwork and concrete work.

2) Installation of House Connections

Private companies in Luang Prabang city have no experience on repair and renewal of transmission

and distribution pipelines, since all the works related to the pipelines have been carried out by WSSE-LPB. While, some of installation work of house connection have been subcontracted to private companies in Luang Prabang city by WSSE-LPB. Therefore, there are the private companies with experiences of installation of house connection.

(2) Policy on Utilization of Local Contractors

Lao construction companies have experience with WTP construction and pipeline installation. They own general-purpose construction machinery. However, local contractors may not be able to manage large-scale construction on their own. They should work with Japanese construction companies which have a lot more experience.

2.2.1.5 Operation and Maintenance

Guidance of initial operation for each facility and equipment will be given by the contractor. However, WSSE-LPB needs to acquire the skills shown in Table 2.2.2 for the comprehensive operation of the facilities put in place by the project. Technical assistance and management guidance for the comprehensive operation will be provided through soft component (technical assistance).

Table 2.2.2 New Skills Required for Operation of the Facilities

Category	New Skills Required
Improvements to Namkhan WTP facilities	Training on comprehensive operation is required related to the following: − Flow control of intake facility − Operation of waste wash water basin, sludge basin, and lagoon − Draining of the supernatant from the existing and new sedimentation basins
Monitoring system	Operation of the monitoring system

2.2.1.6 Design Philosophy for Facilities, Materials and Equipment

The simple design of the existing flocculation basin and sedimentation basin in the Namkhan WTP is appropriate in terms of O&M and cost.

Chemicals to be used will also be the same as the existing system (solid PAC (Poly-Aluminum Chloride), polymer, and calcium hypochlorite).

Mechanical and electrical equipment shall be minimized as much as possible to reduce O&M costs. Construction design will consider gravity flow as much as possible to economize on energy use.

Ductile cast iron pipes will be used at the WTP and reservoir site considering the workability and number of fittings and high-density polyethylene pipes (HDPE) for transmission and distribution pipes because of their lower cost and better durability.

2.2.1.7 Construction/Procurement Method and Construction Period

(1) Construction and Procurement Method

Main construction components and procurement methods are shown in Table 2.2.3. The construction

components include general excavation for pipeline installation, construction of facilities at WTP and for the new reservoir, and installation of mechanical and electrical equipment.

Table 2.2.3 Main construction and procurement methods

Construction Component	Construction method	Procurement method
Transmission and distribution pipe (pipeline installation)	ordinary pipeline excavation work	Piping material procured from third countries
Inside the WTP, reservoir	excavation and reinforced concrete construction	Reinforced concrete materials: procured in Lao PDR.
Mechanical and electrical	installation of mechanical equipment, such as pumps and accompanying electrical equipment	Procured from Japan

(2) Construction Period

During the construction at the Namkhan WTP, treatment operations may need to be stopped for certain periods. Therefore, it is necessary to consider the timing and duration of disruptions.

Pipeline installation at multiple sites must be conducted in parallel due to the limited construction period. Therefore, not only the number of construction personnel and teams but also the number of personnel and teams for construction supervision shall be arranged to deal with multiple construction sites.

In addition, it is necessary to pay attention to the event shown in Table 2.2.4 on the construction planning.

Table 2.2.4 Other considerations related to construction planning

Events	Considerations
Water Festival (New Year)	− Approximately 5 days in the middle of April − Basically it is necessary to suspend all construction activities.
Boat Race Festival	− From the last week of August to the first week of September − Boat races take place in each village for about 2 days, and the dates of the event varies by village. − Construction schedule can be adjusted, since the schedule of the event is announced in advance.

2.2.2 Basic Plan

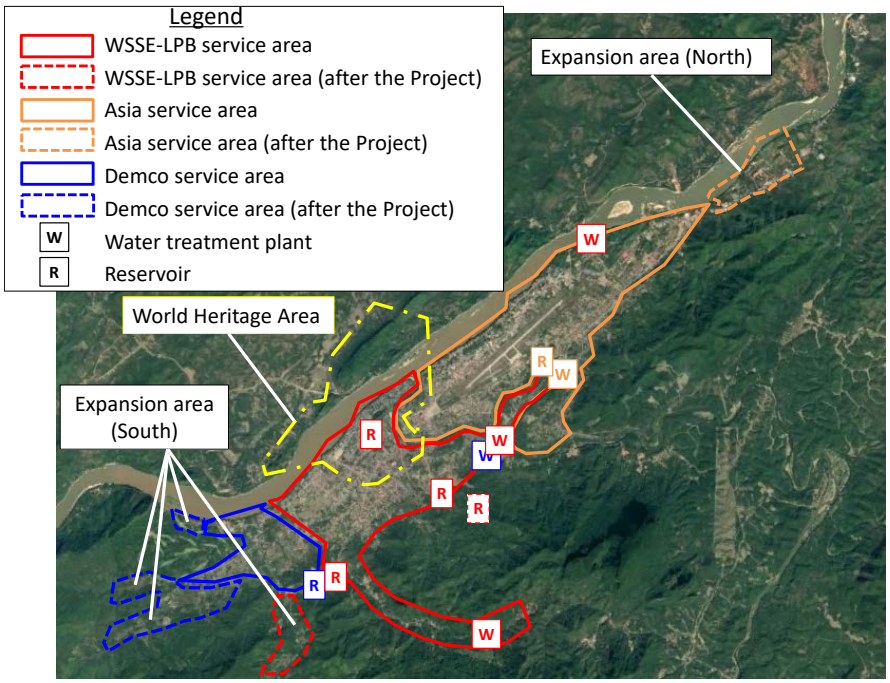
2.2.2.1 Water Demand Projection

(1) Service Area

1) Target Area

A) Water Supply Expansion Area Requested by the Lao Side

The areas for water supply expansion are shown in Figure 2.2.1. The target areas are in the north and south of the existing water supply area and five villages are included.



Map source: Google, DigitalGlobe

Figure 2.2.1 Candidate areas for water supply expansion

The general information on the 5 villages is shown in Table 2.2.6.

Table 2.2.5 General information on candidate villages for water supply expansion

area	Name of village	2017 Population (person)	area (ha)	Population density (person/ha)	Distance from existing service area	Current water use
North	Phao	1,043	67.3	15.5	2.2 km	Well, river water, bottled water
South	Phonxay	535	13.9	38.5	1.1 km	Well, river water, bottled water, water supply system (partially)
South	Lakpaeth	508	52.5	9.7	2.3 km	Well, river water, bottled water
South	Huayphaiy	934	28.8	32.4	2.0 km	Well, bottled water
South	Naxay	476	28.4	16.8	2.0 km	Well, river water, bottled water

Source: Prepared by JPST based on the information by WSSE-LPB

WSSE-LPB confirms the priority for water supply expansion as follows:

- The priority for the southern area is higher, since it is easier for the residents in the northern area to use the water from the Mekong River located nearby.
- The priority for the southern area is higher also because the volume of bulk water purchased from the Demco WTP does not satisfy the minimum purchase amount stipulated in the contract. The amount of bulk water purchased from the Asia WTP supplying the north satisfies the minimum purchase amount and therefore expansion in this area is a lower priority.
- Residents of Naxay village in the southern area needs improvement to their water supply as soon as possible. They must fetch stream water every day. This water source is polluted by household

waste and discharge from a pig farm upstream.

- Phonxay village located in southern area has the problem of low water pressure. The village is of a lesser priority than other villages in the area because half of the village is supplied by Demco's reservoir. On the other hand, the expansion of water supply service to the village will correct the unfair situation between the residents with and without water supply.

Residents without water supply were interviewed to determine the current situation of water use and willingness to connect to the water supply system in the target areas. The information gathered is shown below.

- Bottled water is used. Since this is expensive, people also draw well water by pumping. About 33 households (out of 100) carry river water by hand.
  - For 30 households, it takes less than 30 minutes to get river water, and more than 30 minutes for 3 households.
  - Most of the households draw river water once a day, but some households do this more than twice a day.
- 92 of 100 households are not satisfied with the current situation.
- 94 of 100 are not satisfied with the water quality.
- 97 of 100 are not satisfied with amount of the water they can use.
- 96 households are interested in connecting to the water supply system.

A summary of the site survey in the expansion area by JPST is shown below.

- In Naxay village, target of expansion area, a stream runs through the village as shown in Photo 2.2.1. Residents pump water from the stream. However, wastewater from households is also discharged to the same stream. Wastewater is also discharged from a pig farm upstream. Even though the residents understand the problem with the water quality, they have no choice because the stream is their only water source. They would like to connect to the water supply system.

Photo 2.2.1 Current water use in Naxay village

- Huayphaiy village in the southern area has high population density. The benefits for every unit investment in the expansion of the water supply system is therefore quite high.
- Population of Phao village in the northern area is rapidly increasing due to the construction of a monastic school and a lot of houses. Site preparations are already underway. The population growth trend is expected to continue upwards in the future.

The survey confirms that the demand and necessity for water supply service is high in the 5 target areas and therefore justifies the installation of distribution pipelines in these areas. The areas are near the existing water supply service area. Hydraulic analysis shows that pumping stations will not be required. This represents lesser technical input and thus further validates the service expansion.

Asia WTP supplies water to the northern areas and Demco WTP to the southern areas. WSSE-LPB needs to adjust the bulk water supply volume and pressure at the delivery points with these private companies. Demco reservoir cannot supply water by gravity to Naxay village in the south because of its high elevation. Phouphueng WTP can do this instead.

Table 2.2.6 Target villages for water supply expansion area

Area	Village	Current situation and necessity of water supply service	Implementation contents by the project
South	Naxay	Urgent improvement is required, since the residents are using water from the stream polluted by wastewater from households and a pig farm.	Pipelines will be installed to distribute water from the Phouphueng WTP by gravity.
South	Huayphaiy	There is no easily accessible water source. The cost effectiveness for pipeline construction is very high, since the population density is high.	New pipelines will be installed to connect to existing pipelines to distribute water from the Demco WTP.
South	Lakpaeth	There is no easily accessible water source. The village is located near Huayphaiy village and it is cost effective to extend distribution pipelines to this village.	Similar to what is being done for Huayphaiy village.
North	Phao	The residents can use water from the Mekong River. However, the demand for water supply service is increasing due to the new monastic school and residential housing construction.	New pipelines will be installed to connect to existing pipelines to distribute water from the Asia WTP.
South	Phonxay	There is an unfair situation, since half of the residents in the village has no water supply service. There is the problem of low water pressure in the existing service area. The expansion of water supply service to this area will address both issues.	New pipelines will be installed to connect to existing pipelines to distribute water from the Demco WTP.

(2) Population Projection

1) Population Data

Table 2.2.7 shows the population data for Luang Prabang city, the planned and existing water supply area, the served population, coverage ratio and the respective annual average increase from 2010 to 2017. A breakdown of the population for the villages included in item "⑥Population (Project target area: ③ + ⑤)", is described later in the report.

Table 2.2.7 Population and coverage ratio of water supply system (2010-2017)

Item	2010	2011	2012	2013	2014	2015	2016	2017	Annual increasing ratio (2010-2017)
①Population in Luang Prabang City	82,056	80,952	81,994	82,189	86,556	87,761	88,495	90,291	1.38%
②Population in planned service area	64,277	62,363	62,945	63,300	69,321	69,079	72,190	73,018	1.84%
③Population in existing service area	56,316	53,950	54,807	54,735	59,694	60,045	61,399	61,658	1.36%
④Population outside of planned service area(②－③)	7,961	8,413	8,138	8,565	9,627	9,034	10,791	11,360	5.21%
⑤Population in expantion area by the Project	2,001	1,994	2,202	2,512	2,446	2,487	3,009	3,496	4.30%
⑥Population（Target area of the Project: ③＋⑤）	58,317	55,944	57,009	57,247	62,140	62,532	64,408	65,154	1.60%
⑦Present served population	42,097	44,391	48,525	51,200	53,167	54,679	56,718	58,760	4.88%
⑧Coverage ratio（Planned service area）	65.5%	71.2%	77.1%	80.9%	76.7%	79.2%	78.6%	80.5%	2.99%
⑨Coverage ratio (Existing service area）	74.8%	82.3%	88.5%	93.5%	89.1%	91.1%	92.4%	95.3%	3.53%
⑩Coverage ratio（Target area of the Project）	72.2%	79.3%	85.1%	89.4%	85.6%	87.4%	88.1%	90.2%	3.23%

Source： Prepared by JPST based on the information from WSSE-LPB

2) Population in Planned Water Supply Area

Table 2.2.8 shows the population of each village in the planned water supply area of Luang Prabang city. In the table, "Expansion" refers to areas in the northern, southern and eastern parts of Luang Prabang city that will be covered by the expanded service in future.

Villages No. 58, 62 to 64 and 75 are newly included in the project.

Table 2.2.8 Population in planned water supply area

No	Village name	Existing/ Expansion	Service Area	Population							
				2010	2011	2012	2013	2014	2015	2016	2017
1	B. Xiangthong	Existing	NPLP	362	350	347	345	351	356	513	515
2	B. Phonhuang	Existing	NPLP	456	420	428	428	454	468	537	539
3	B. Vatsen	Existing	NPLP	306	263	274	274	246	217	216	217
4	B. Vatnong	Existing	NPLP	356	341	322	351	286	357	346	347
5	B. Xiangmoun	Existing	NPLP	256	247	266	194	250	353	301	302
6	B. Choumkhong	Existing	NPLP	329	289	284	270	281	274	252	253
7	B. Pakham	Existing	NPLP	631	634	641	625	675	644	699	702
8	B. Khamyong	Existing	NPLP	368	353	357	345	353	353	356	358
9	B. Aham	Existing	NPLP	392	303	315	317	347	347	316	317
10	B. Aphai	Existing	NPLP	346	339	327	322	281	318	288	289
11	B. Vixoun	Existing	NPLP	743	757	644	623	600	597	555	557
12	B. Munna	Existing	NPLP	388	527	553	492	561	451	521	523
13	B. Thatbosot	Existing	NPLP	820	765	675	767	810	623	706	709
14	B. Viang-Mai	Existing	NPLP	1,966	1,744	1,823	1,803	1,981	2,116	1,671	1,678
15	B. Nasangveuy	Existing	NPLP	1,859	1,609	1,703	1,853	2,158	2,709	3,836	3,852
16	B. Phanom	Existing	NPLP	1,343	1,256	1,256	1,378	1,421	1,489	1,412	1,418
17	B. Donkeo	Existing	NPLP	309	317	324	324	369	360	368	370
18	B. Muangnga	Existing	North (Asia)	1,956	1,811	1,814	1,216	1,869	1,686	1,628	1,635
19	B. Phanlouang	Existing	North (Asia)	2,065	2,065	1,837	1,837	2,018	1,936	1,809	1,817
20	B. Phasouk	Existing	North (Asia)	1,380	1,471	1,469	1,518	1,802	1,696	933	937
21	B. Hathian	Existing	North (Asia)	1,914	1,849	1,594	1,551	1,573	1,484	1,422	1,428
22	B. Thongchaleun	Existing	NPLP	330	331	330	329	328	320	329	330
23	B. Houaxiang	Existing	NPLP	498	393	439	421	434	393	448	450
24	B. Vatthat	Existing	NPLP	368	319	340	291	327	273	278	279
25	B. Tatlouang	Existing	NPLP	1,093	1,041	1,041	1,025	970	930	813	816
26	B. Phabat	Existing	NPLP	1,737	1,301	1,243	1,670	1,192	1,132	1,028	1,032
27	B. Phosi	Existing	NPLP	1,628	1,556	1,609	1,609	1,701	1,540	1,636	1,643
28	B. Saylom	Existing	NPLP	808	734	785	820	730	718	721	724
29	B. Nongkham	Existing	South (Demco)	669	687	742	774	897	1,155	1,846	1,883
30	B. Phonpheng	Existing	NPLP	1,096	474	929	929	1,078	1,326	1,875	897
31	B. Pongkham	Existing	NPLP	961	977	942	932	959	974	893	1,026
32	B. Mano	Existing	NPLP	1,320	1,212	1,323	1,300	1,273	1,142	1,022	964
33	B. Viangxai	Existing	NPLP	1,054	925	1,041	1,026	967	967	960	341
34	B. Viangkeo	Existing	NPLP	408	423	418	448	391	357	340	469
35	B. Naviangkham	Existing	NPLP	521	432	486	486	485	481	467	1,320
36	B. Nasamphan	Existing	NPLP	1,419	1,384	1,493	1,489	1,528	1,416	1,314	1,422
37	B. Nalouang	Existing	NPLP	1,533	1,479	1,532	1,538	1,608	1,387	1,416	1,542
38	B. Khouathi 1	Existing	NPLP	2,062	1,563	1,800	1,791	1,926	1,814	1,535	2,221
39	B. Don-Kang	Existing	NPLP	2,237	2,196	2,161	2,161	2,195	2,310	2,212	399
40	B. Ma	Existing	South (Demco)	420	431	436	428	443	453	397	608
41	B. Naxang	Existing	NPLP	589	622	784	627	721	753	605	554
42	B. Phoumok	Existing	South (Demco)	435	461	462	491	930	800	552	1,262
43	B. Khoy	Existing	South (Demco)	1,247	1,139	1,299	1,396	1,445	1,492	1,257	1,854
44	B. Sangkhalok	Existing	South (Demco)	1,603	1,495	1,599	1,599	1,678	1,550	1,508	1,514
45	B. Xiangkeo	Existing	South (Demco)	851	732	805	805	805	794	769	772
46	B. Phonxai	Existing	North (Asia)	382	364	371	371	365	333	325	326
47	B. Poungvan	Existing	South (Demco)	1,998	1,847	1,922	1,913	2,054	2,046	2,565	2,576
48	B. Phonsa-At	Existing	North (Asia)	928	884	973	1,014	1,067	924	1,056	1,061
49	B. Xianglek	Existing	North (Asia)	341	331	400	415	453	425	388	390
50	B. Xangkhong	Existing	North (Asia)	341	470	571	514	634	578	551	553
51	B. Nongxay	Existing	North (Asia)	648	669	712	712	747	654	763	766
52	B. Khomkhouang	Existing	North (Asia)	671	1,004	1,071	1,072	1,135	1,769	1,077	1,082
53	B. Phakhom	Existing	North (Asia)	1,361	434	427	427	523	686	591	594
54	B. Khokva	Existing	North (Asia)	878	1,427	1,532	1,532	1,520	1,451	1,429	1,435
55	B. Don-Kao1	Existing	North (Asia)	916	777	515	496	568	537	513	515
56	B. Don-Kao2	Existing	North (Asia)	915	776	514	496	568	536	512	514
57	B. Don-Mai	Existing	North (Asia)	2,476	691	487	565	592	1,284	2,749	2,761
58	B. Phonxay	Existing	South (Demco)	283	231	440	469	553	453	533	535
59	B. Phou Xarng Kh	Existing	North (Asia)	0	2,655	2,055	1,881	2,555	2,231	2,263	3,192
60	B. Phoulek	Existing	North (Asia)	746	1,373	1,525	1,640	2,663	2,827	3,178	2,273
58	B. Phonxai	Expansion	South (Demco)	283	231	441	470	553	453	534	535
61	B. Naduay	Expansion	South (Demco)	313	294	316	316	313	314	241	242
62	B. Huayphaiy	Expansion	South (Demco)	863	835	879	902	940	968	930	934
63	B. Lakpaeth	Expansion	South (Demco)	615	662	605	845	556	552	506	508
64	B. Phao	Expansion	North (Asia)	240	266	277	295	397	514	1,039	1,043
65	B. Sensouk	Expansion	North (Asia)	468	448	454	471	491	461	783	786
66	B. Pakxuang	Expansion	North (Asia)	614	661	651	677	1,166	1,269	2,452	2,462
67	B. Viangsavan	Expansion	North (Asia)	382	374	423	426	948	426	422	424
68	xienloun	Expansion	East side	805	770	790	803	826	808	743	746
69	Pikyai	Expansion	East side	381	370	399	357	402	331	367	369
70	Piknoi	Expansion	East side	336	347	351	370	348	334	292	293
71	Nounsavat	Expansion	East side	543	569	559	618	650	605	594	597
72	B. Koknglou	Expansion	East side	1,136	1,033	1,033	1,030	1,053	1,033	979	983
73	B. Lak 10	Expansion	East side	488	1,003	446	471	519	441	433	435
74	Ansavanh	Expansion	East side	494	550	514	514	465	525	476	527
75	B. Naxay	Expansion	South (Demco)	-	-	-	-	-	-	-	476
	Sub-total	Existing	-	56,316	53,950	54,807	54,735	59,694	60,045	61,399	61,658
	Sub-total	Expansion	-	7,961	8,413	8,138	8,565	9,627	9,034	10,791	11,360
	Total		-	64,277	62,363	62,945	63,300	69,321	69,079	72,190	73,018

Source: Prepared by JPST based on the information from WSSE-LPB

(3) Population Projection in Planned Water Supply Area

The JPST has prepared a population projection for the existing water supply service areas and the proposed expansion areas.

1) Population Trend

Table 2.2.9 and Table 2.2.10 show the population growth of villages in the existing water supply areas and the expansion areas.

The average annual population growth from 2010 to 2017 is 1.36 % in the existing water supply areas and 4.30% in the expansion areas.

Table 2.2.9 Population growth in existing water supply areas

No	村名	Existing/ Expansion	Service Area	Population								Groth ratio/year
				2010	2011	2012	2013	2014	2015	2016	2017	2010-2017
1	B. Xiangthong	Existing	NPLP	362	350	347	345	351	356	513	515	5.17%
2	B. Phonhuang	Existing	NPLP	456	420	428	428	454	468	537	539	2.42%
3	B. Vatsen	Existing	NPLP	306	263	274	274	246	217	216	217	-4.79%
4	B. Vatnong	Existing	NPLP	356	341	322	351	286	357	346	347	-0.37%
5	B. Xiangmoun	Existing	NPLP	256	247	266	194	250	353	301	302	2.39%
6	B. Choumkhong	Existing	NPLP	329	289	284	270	281	274	252	253	-3.68%
7	B. Pakham	Existing	NPLP	631	634	641	625	675	644	699	702	1.53%
8	B. Khamyong	Existing	NPLP	368	353	357	345	353	353	356	358	-0.39%
9	B. Aham	Existing	NPLP	392	303	315	317	347	347	316	317	-2.99%
10	B. Aphai	Existing	NPLP	346	339	327	322	281	318	288	289	-2.54%
11	B. Vixoun	Existing	NPLP	743	757	644	623	600	597	555	557	-4.03%
12	B. Munna	Existing	NPLP	388	527	553	492	561	451	521	523	4.36%
13	B. Thatbosot	Existing	NPLP	820	765	675	767	810	623	706	709	-2.06%
14	B. Viang-Mai	Existing	NPLP	1,966	1,744	1,823	1,803	1,981	2,116	1,671	1,678	-2.24%
15	B. Nasangveuy	Existing	NPLP	1,859	1,609	1,703	1,853	2,158	2,709	3,836	3,852	10.97%
16	B. Phanom	Existing	NPLP	1,343	1,256	1,256	1,378	1,421	1,489	1,412	1,418	0.78%
17	B. Donkeo	Existing	NPLP	309	317	324	324	369	360	368	370	2.61%
18	B. Muangnga	Existing	North (Asia)	1,956	1,811	1,814	1,216	1,869	1,686	1,628	1,635	-2.53%
19	B. Phanlouang	Existing	North (Asia)	2,065	2,065	1,837	1,837	2,018	1,936	1,809	1,817	-1.81%
20	B. Phasouk	Existing	North (Asia)	1,380	1,471	1,469	1,518	1,802	1,696	933	937	-5.38%
21	B. Hathian	Existing	North (Asia)	1,914	1,849	1,594	1,551	1,573	1,484	1,422	1,428	-4.10%
22	B. Thongchaleun	Existing	NPLP	330	331	330	329	328	320	329	330	0.00%
23	B. Houaxiang	Existing	NPLP	498	393	439	421	434	393	448	450	-1.44%
24	B. Vatthat	Existing	NPLP	368	319	340	291	327	273	278	279	-3.88%
25	B. Tatlouang	Existing	NPLP	1,093	1,041	1,041	1,025	970	930	813	816	-4.09%
26	B. Phabat	Existing	NPLP	1,737	1,301	1,243	1,670	1,192	1,132	1,028	1,032	-7.17%
27	B. Phosi	Existing	NPLP	1,628	1,556	1,609	1,609	1,701	1,540	1,636	1,643	0.13%
28	B. Saylom	Existing	NPLP	808	734	785	820	730	718	721	724	-1.56%
29	B. Nongkham	Existing	South (Demco)	669	687	742	774	897	1,155	1,846	1,883	15.93%
30	B. Phonpheng	Existing	NPLP	1,096	474	929	929	1,078	1,326	1,875	897	-2.82%
31	B. Pongkham	Existing	NPLP	961	977	942	932	959	974	893	1,026	0.94%
32	B. Mano	Existing	NPLP	1,320	1,212	1,323	1,300	1,273	1,142	1,022	964	-4.39%
33	B. Viangxai	Existing	NPLP	1,054	925	1,041	1,026	967	967	960	341	-14.89%
34	B. Viangkeo	Existing	NPLP	408	423	418	448	391	357	340	469	2.01%
35	B. Naviangkham	Existing	NPLP	521	432	486	486	485	481	467	1,320	14.20%
36	B. Nasamphan	Existing	NPLP	1,419	1,384	1,493	1,489	1,528	1,416	1,314	1,422	0.03%
37	B. Nalouang	Existing	NPLP	1,533	1,479	1,532	1,538	1,608	1,387	1,416	1,542	0.08%
38	B. Khouathi 1	Existing	NPLP	2,062	1,563	1,800	1,791	1,926	1,814	1,535	2,221	1.07%
39	B. Don-Kang	Existing	NPLP	2,237	2,196	2,161	2,161	2,195	2,310	2,212	399	-21.83%
40	B. Ma	Existing	South (Demco)	420	431	436	428	443	453	397	608	5.43%
41	B. Naxang	Existing	NPLP	589	622	784	627	721	753	605	554	-0.87%
42	B. Phoumok	Existing	South (Demco)	435	461	462	491	930	800	552	1,262	16.43%
43	B. Khoy	Existing	South (Demco)	1,247	1,139	1,299	1,396	1,445	1,492	1,257	1,854	5.83%
44	B. Sangkhalok	Existing	South (Demco)	1,603	1,495	1,599	1,599	1,678	1,550	1,508	1,514	-0.81%
45	B. Xiangkeo	Existing	South (Demco)	851	732	805	805	805	794	769	772	-1.38%
46	B. Phonxai	Existing	North (Asia)	382	364	371	371	365	333	325	326	-2.24%
47	B. Poungvan	Existing	South (Demco)	1,998	1,847	1,922	1,913	2,054	2,046	2,565	2,576	3.70%
48	B. Phonsa-At	Existing	North (Asia)	928	884	973	1,014	1,067	924	1,056	1,061	1.93%
49	B. Xianglek	Existing	North (Asia)	341	331	400	415	453	425	388	390	1.94%
50	B. Xangkhong	Existing	North (Asia)	341	470	571	514	634	578	551	553	7.15%
51	B. Nongxay	Existing	North (Asia)	648	669	712	712	747	654	763	766	2.42%
52	B. Khomkhouang	Existing	North (Asia)	671	1,004	1,071	1,072	1,135	1,769	1,077	1,082	7.06%
53	B. Phakhom	Existing	North (Asia)	1,361	434	427	427	523	686	591	594	-11.17%
54	B. Khokva	Existing	North (Asia)	878	1,427	1,532	1,532	1,520	1,451	1,429	1,435	7.27%
55	B. Don-Kao1	Existing	North (Asia)	916	777	515	496	568	537	513	515	-7.90%
56	B. Don-Kao2	Existing	North (Asia)	915	776	514	496	568	536	512	514	-7.91%
57	B. Don-Mai	Existing	North (Asia)	2,476	691	487	565	592	1,284	2,749	2,761	1.57%
58	B. Phonxay	Existing	South (Demco)	283	231	440	469	553	453	533	535	9.52%
59	B. Phou Xarng Kham	Existing	North (Asia)	0	2,655	2,055	1,881	2,555	2,231	2,263	3,192	3.12%
60	B. Phoulek	Existing	North (Asia)	746	1,373	1,525	1,640	2,663	2,827	3,178	2,273	17.25%
		Total		56,316	53,950	54,807	54,735	59,694	60,045	61,399	61,658	1.36%

Source: Prepared by JPST based on the information from WSSE-LPB

Table 2.2.10 Population growth in expansion areas

No	村名	Existing/ Expansion	Service Area	Population								Groth ratio/year
				2010	2011	2012	2013	2014	2015	2016	2017	2010-2017
58	B. Phonxay	Existing	South (Demco)	283	231	441	470	553	453	534	535	9.52%
62	B. Huayphaiy	Expansion	South (Demco)	863	835	879	902	940	968	930	934	1.14%
63	B. Lakpaeth	Expansion	South (Demco)	615	662	605	845	556	552	506	508	-2.69%
64	B. Phao	Expansion	North (Asia)	240	266	277	295	397	514	1,039	1,043	23.35%
75	B. Naxay	Expansion	South (Demco)	-	-	-	-	-	-	-	476	-
Total				2,001	1,994	2,202	2,512	2,446	2,487	3,009	3,496	4.30%

* The data of Naxay village are not used for calculation of growth ratio, since the data are available only for 2017.

Source: Prepared by JPST based on the information from WSSE-LPB

2) Population Projection

Based on the past trend, population growth is expected to continue. The projection is carried out for the existing and expanded water supply areas. The projection is not based on individual village data for the following reasons:

Population growth varies widely from village to village (see Table 2.2.9 and Table 2.2.10). There are also huge year to year fluctuations for some villages. The reliability of such data is not so high, therefore village level data are not appropriate for the water supply population projection. Instead, data for the villages in the existing water supply area and water supply expansion area are combined to form an average.

The results of the population projection are shown in Table 2.2.11 and Figure 2.2.2.

Table 2.2.11 Population projections

Year	Population			Growth ratio/year	
	Existing	Expansion	Total	Existing	Expansion
2017	61,658	3,496	65,154		
2018	62,497	3,646	66,143		
2019	63,347	3,803	67,150		
2020	64,209	3,967	68,176		
2021	65,082	4,138	69,220		
2022	65,967	4,316	70,283		
2023	66,864	4,502	71,366		
2024	67,773	4,696	72,469		
2025	68,695	4,898	73,593		
2026	69,629	5,109	74,738	1.36%	4.30%
2027	70,576	5,329	75,905		
2028	71,536	5,558	77,094		
2029	72,509	5,797	78,306		
2030	73,495	6,046	79,541		
2031	74,495	6,306	80,801		
2032	75,508	6,577	82,085		
2033	76,535	6,860	83,395		
2034	77,576	7,155	84,731		
2035	78,631	7,463	86,094		

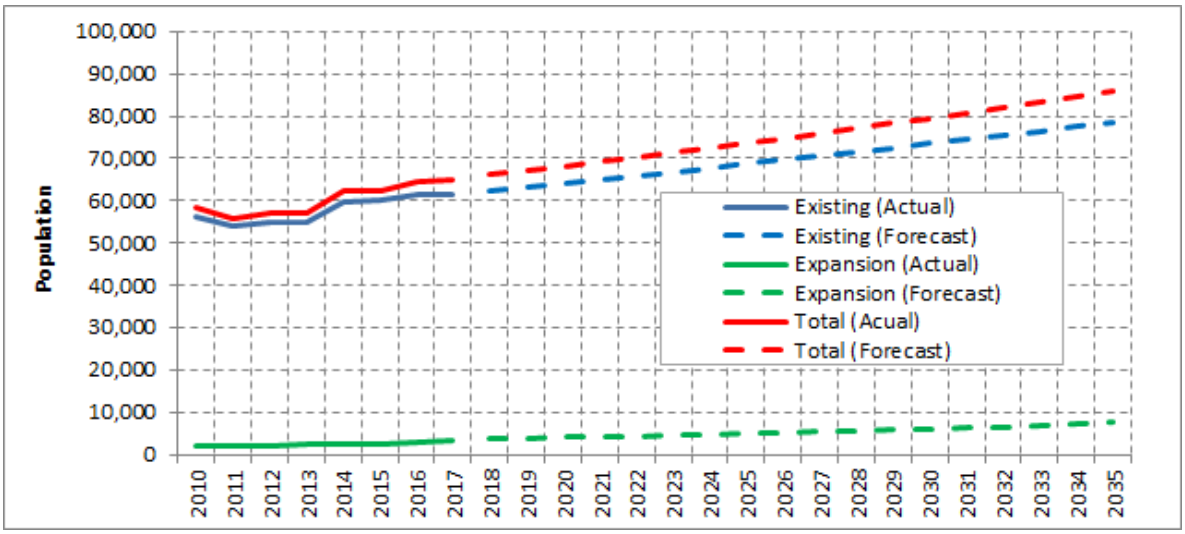


Figure 2.2.2 Population projections

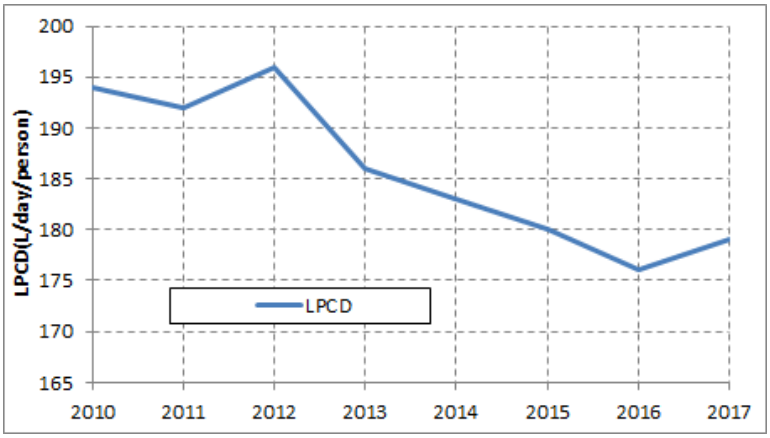
(4) Per Capita Daily Water Consumption (LPCD: Liter per Capita per Day)

Table 2.2.12 shows the water supply population, number of customers, and revenue water from 2010 to 2017. Figure 2.2.3 shows the average daily water consumption calculated from the data.

Table 2.2.12 Water supply record (2010-2017)

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017
Served Population	Person	42,097	44,391	48,525	51,200	53,167	54,679	56,718	58,760
Number of household in planned area	connection	-	-	11,489	11,776	12,071	12,372	12,624	12,880
Connection total in planned area	connection	8,819	9,318	10,088	10,642	11,298	12,117	12,848	13,774
House connection in planned area	connection	7,654	8,071	8,737	9,219	9,823	10,507	11,099	11,914
Average people in each household	Person/ connection	5.5	5.5	5.6	5.6	5.4	5.2	5.3	5.2
Other connection in planned area (Government, Business, Factory)	connection	1,165	1,247	1,351	1,423	1,475	1,610	1,749	1,860
Total yearly amount of revenue water	m3/year	4,897,533	5,193,683	5,719,310	5,786,054	6,098,769	6,097,768	6,481,827	7,011,928
Category 1 (Domestic)	m3/year	2,977,223	3,110,545	3,487,510	3,476,191	3,559,404	3,590,015	3,793,928	4,093,560
Category 1 (Domestic)	m3/day	8,157	8,522	9,529	9,524	9,752	9,836	10,366	11,215
LPCD	ℓ/day/person	194	192	196	186	183	180	176	179

Source: Prepared by JPST based on the information from WSSE-LPB



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.3 Trend of average daily water consumption per person (2010-2017)

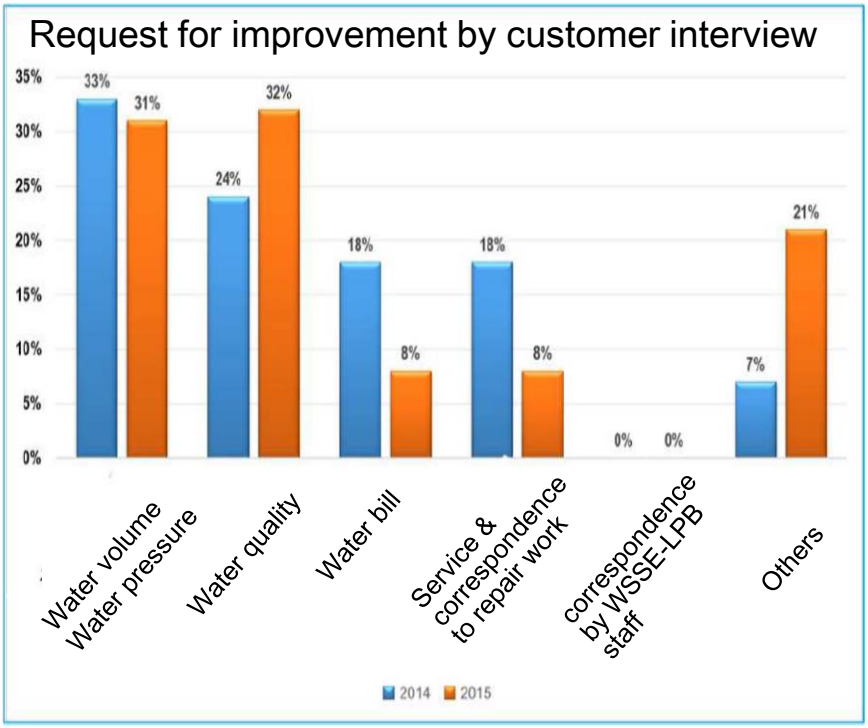
Generally, the average daily water consumption increases when washing machines, flush toilets and showers are introduced as standard of living rises. However, in the target area, the average daily water consumption has been decreasing in recent years as shown in Figure 2.2.3.

Figure 2.2.5 shows the increase in revenue water (4.7%) not corresponding to the increase in number of customers (6.5%) from 2010 to 2017. This reflects that some customers may not be using as much water as they would like because of insufficient supply volume and pressure caused by the increase in demand.

This explains the decrease in average daily water consumption instead of the expected increase associated with the improvement of service.

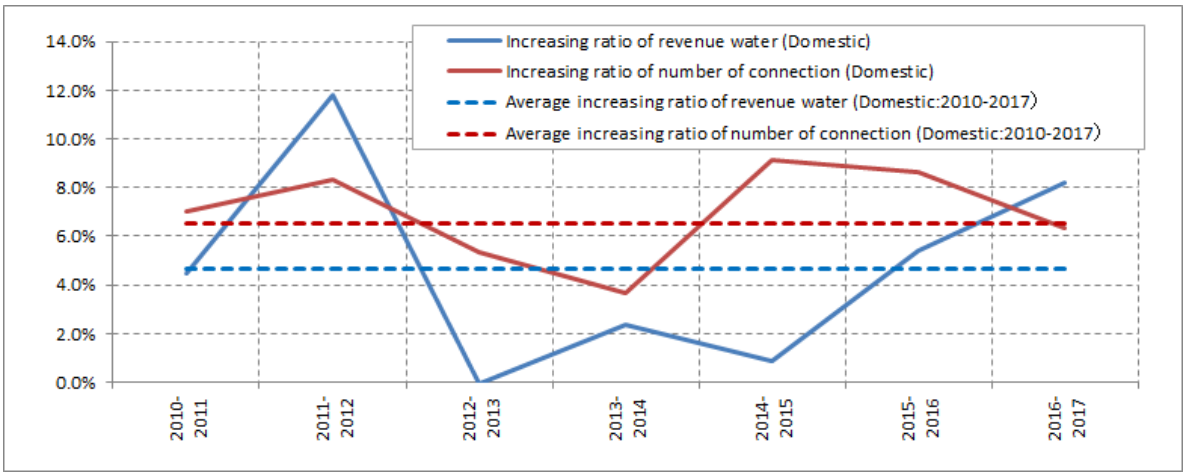
Table 2.2.13 shows the standard average daily water consumption in Lao standard. The target area corresponds to No. II Large City, and the standard average daily water consumption is 120 to 200 L / day / person.

The population of the target area is on the rise, edging close to the No. 1 Municipality (population over 100,000). The water demand was 194 L / day / person in 2010. Considering the above, the project will apply 200 L / day / person as the average daily water consumption.



Source: Annual report of WSSE-LPB (2015)

Figure 2.2.4 Results of customer survey



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.5 Increase in revenue water vs. number of customers (2010-2017)

Table 2.2.13 LPCD guidelines for water supply planning

No	Group	Existing service population	LPCD[1)]
I	Municipality	> 100,000	200 -250
II	Large City	50,000 - 100,000	120 - 200
III	Small City	20,000 - 50,000	100 - 120
IV	Small Town (but many people living)	5,000 - 20,000	80 - 120
V	Small Town (but not many people living)	2,000 - 5,000	60 - 80
VI	Community	< 2,000	40 - 60

source: *Management and Technical Guidance Water Supply (2009)*, WSD of DHUP in MPWT

[1)] *LPCD: Liters per Capita per Day*

(5) Water Supply Coverage

The 8th National Socio-Economic Development Five-Year Plan (2016) aims to increase the water supply coverage in the central part of each city to 90% by 2020. The "Water and Water Supply Sector Development Plan"(2016) by MPWT states that the coverage targets by 2020, 2025 and 2030 are 80, 85 and 90% respectively. The existing water supply area has 95.3% coverage as of 2017. The expanded water supply areas as a result of this project will bring the coverage to 90.2% which is still above set targets (see Table 2.2.7).

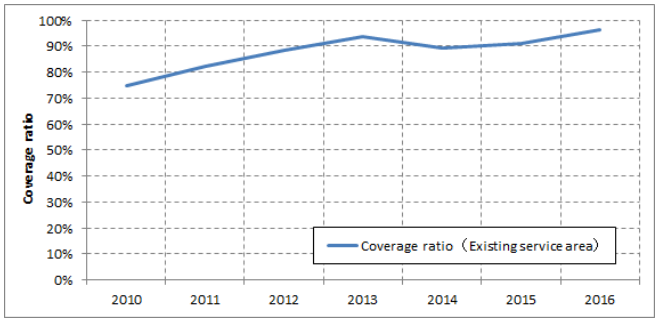
As shown in Figure 2.2.6 the coverage is increasing and should reach 98% by 2030 as shown in Table 2.2.14 based on the following reasons:

- In the customer survey, only 4 out of 100 households indicated that they did not want to connect to the water supply system.
- Some households in the existing service area are not connected to water supply service.
- The coverage will approach but not reach 100%.

Table 2.2.14 Water supply coverage

Area	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing service area	95.3	95.5	95.7	95.9	96.1	96.3	96.5	96.7	96.9	97.1	97.3	97.5	97.7	98.0
Expantion area by the Project	0	0	0	0	0	32.9	63.0	90.6	91.8	93.0	94.0	94.8	95.4	98.0

Unit: %



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.6 Water supply coverage (2010-2016)

(6) Domestic Consumption

Figure 2.2.7 shows the forecast for domestic consumption calculated from the population projection and estimated increase in water supply coverage.

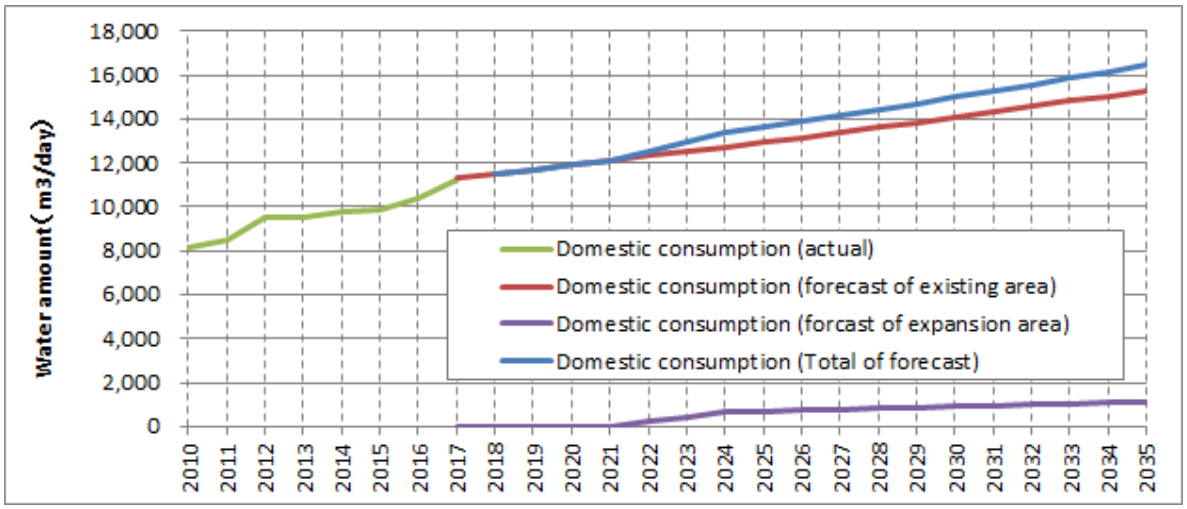


Figure 2.2.7 Projection for domestic consumption

(7) Non-Domestic Consumption

WSSE-LPB has data on government, commercial and industrial consumption. The demand projection for non-domestic consumption was carried out by the JPST based on this record.

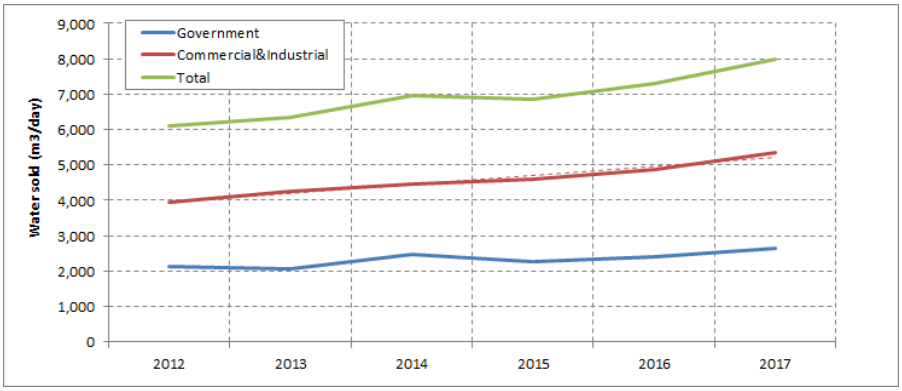
1) Record of Non-Domestic Consumption

The data on water consumption by government, commercial and industrial customers are shown in Table 2.2.15 and Figure 2.2.8.

Table 2.2.15 Non-domestic consumption (2010-2017)

Item	Group	Unit	2012	2013	2014	2015	2016	2017
Number of connection	Government	connection	241	246	252	252	266	275
	Commercial /Industrial	connection	1,110	1,177	1,223	1,358	1,472	1,585
	Sub-total	connection	1,351	1,423	1,475	1,610	1,738	1,860
Annual revenue water	Government	m3/year	786,431	753,166	907,256	833,917	883,217	968,419
	Commercial /Industrial	m3/year	1,445,369	1,556,697	1,632,109	1,673,836	1,789,358	1,949,949
	Sub-total	m3/year	2,231,800	2,309,863	2,539,365	2,507,753	2,672,575	2,918,368
Daily average revenue water	Government	m3/day	2,149	2,063	2,486	2,285	2,413	2,653
	Commercial /Industrial	m3/day	3,949	4,265	4,472	4,586	4,889	5,342
	Sub-total	m3/day	6,098	6,328	6,958	6,871	7,302	7,995
Average water consumption per connection	Government	m3/day/ connection	8.9	8.4	9.9	9.1	9.1	9.6
	Commercial /Industrial	m3/day/ connection	3.6	3.6	3.7	3.4	3.3	3.4
	Sub-total	m3/day/ connection	12.5	12.0	13.6	12.5	12.4	13.0

Source: Prepared by JPST based on the information from WSSE-LPB



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.8 Water supplied to government, commercial and industrial customers (2010-2017)

2) Demand Projection for Non-Domestic Consumption

The two methods shown in Table 2.2.16 can be used to project the amount of non-domestic consumption. Both methods are examined to determine which is appropriate for the demand projection of non-domestic consumption.

Table 2.2.16 Method for projection of non-domestic consumption

No	Demand projection	Methodology
1	Method 1	trend of non-domestic consumption as a whole
2	Method 2	trend of consumption by sector: government, and commercial/industrial customer.

A) Method 1

Figure 2.2.9 shows the trend of non-domestic consumption calculated using the formula "Y = 352.17 x + 5692.7".

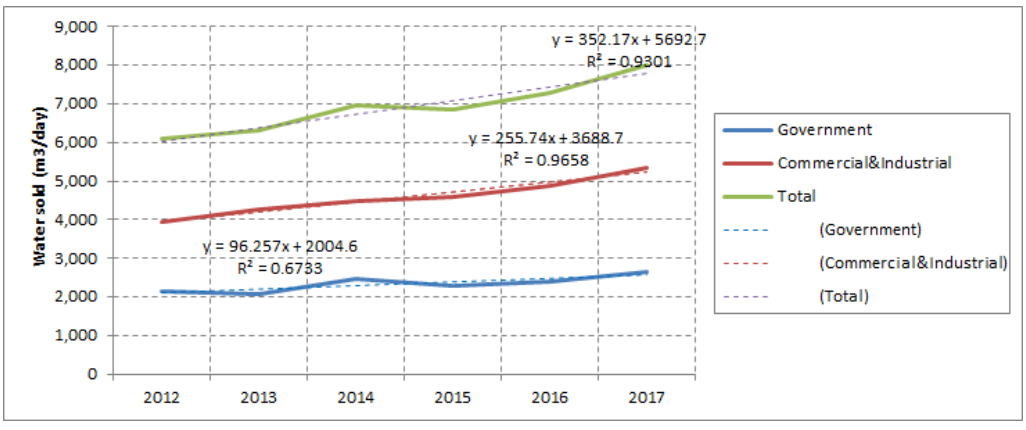


Figure 2.2.9 Trend of non-domestic consumption

B) Method 2

This method uses the amount supplied to each sector: government and commercial/industrial.

Trend for government sector： Y=96.257 x +2004.6

Trend for commercial and industrial sector： Y=255.74 x +3688.7

C) Comparison of Demand Projection of Non-Domestic Consumption

The demand projection calculated by the above methods is shown in Table 2.2.17 and Figure 2.2.10.

Table 2.2.17 Comparison of demand projection for non-domestic consumption

Item	Unit	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Projection by method 1	m3/day	8,228	8,589	8,949	9,310	9,670	10,031	10,391	10,751	11,112	11,472	11,833	12,193	12,554	12,914	13,275	13,635	13,995	14,356
Projection by method 2	m3/day	8,157	8,510	8,861	9,213	9,565	9,918	10,269	10,621	10,973	11,326	11,677	12,029	12,381	12,734	13,085	13,437	13,790	14,141

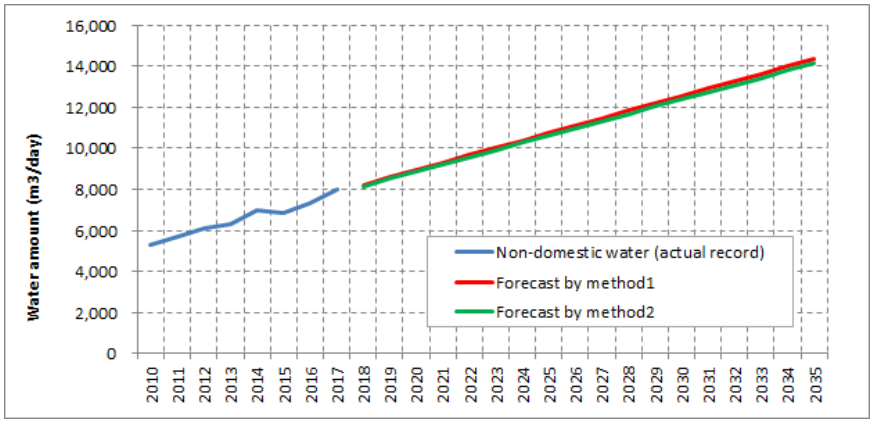
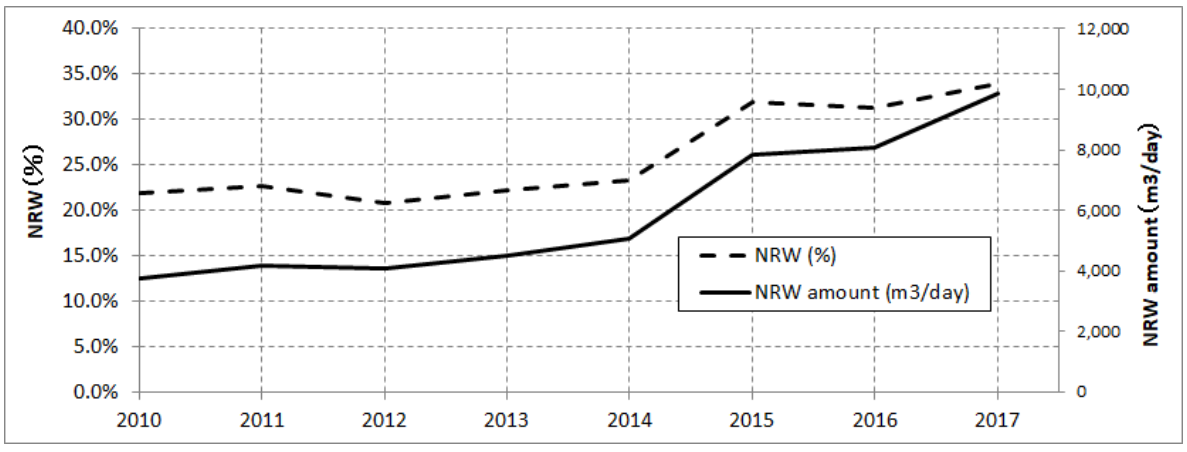


Figure 2.2.10 Comparison of demand projections for non-domestic consumption

The projection based on method 1 with the bigger demand is used because it would reflect the expected increase of tourists when the high-speed railway opens.

(8) Non-Revenue Water (NRW)

Figure 2.2.11 shows the NRW from 2010-2017, calculated from the difference between production and billed amount. As shown in Figure 2.2.11, NRW has been increasing in recent years.



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.11 Non-revenue water from 2010 to 2017

The renewal of old pipelines will reduce leakage and improve supply pressure. However, the latter outcome may exacerbate leakage from pipelines that are not renewed. The overall improvement in

leakage reduction may not be as good as it should be.

Considering the above, NRW is expected to be reduced to 30% down from the current 34%. Further reduction to 25% will have to come from WSSE-LPB's continued effort in leakage repair and the use of the monitoring system. The NRW projections are shown in Table 2.2.18.

The correlation between NRW and leakage rate has not been measured in Luang Prabang city. In developing countries, in general when the NRW is as high as 50%, leakage may only account for half of the NRW. Other factors are responsible for the rest of the NRW.

In Luang Prabang city, the leakage rate in NRW is assumed to be high for the following reasons:

- All customers have water meters and the volume of water sold is recorded.
- Phouphueng WTP (1969) has been in operation for 50 years. A lot of leakage can be expected from the old pipelines.

Not all the water meters are working properly, therefore leakage does not account for all the NRW.

Considering the above, it is assumed that 80% of the NRW is attributable to leakage. (see Table 2.2.18).

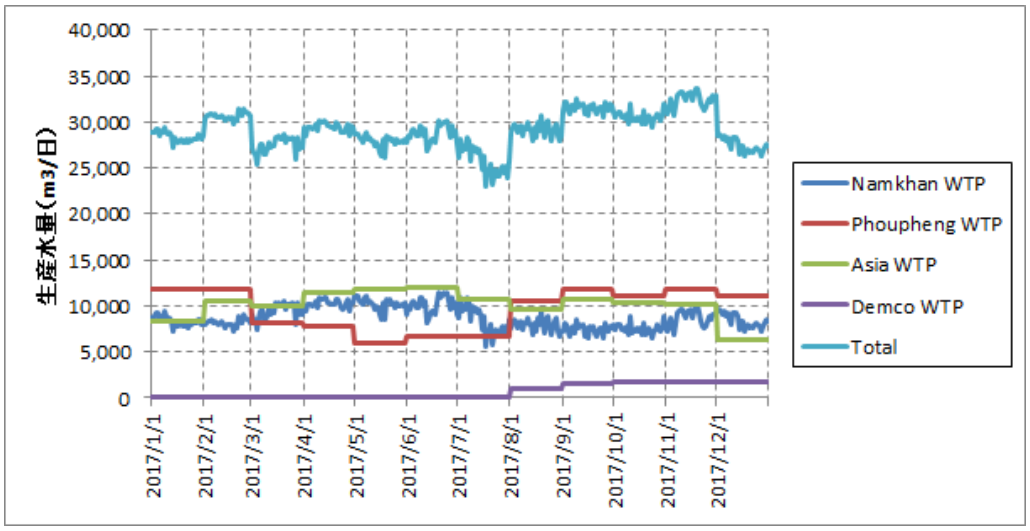
Table 2.2.18 Projection for Non-Revenue Water and Leakage Ratio

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NRW（%）	34	34	34	34	34	34	30	29	28	27	26	25	25	25	25	25	25	25	25
Leakage（%）	27.2	27.2	27.2	27.2	27.2	27.2	24.0	23.2	22.4	21.6	20.8	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

(9) Daily Peak Factor

1) Daily Peak Factor Based on Past Record

Figure 2.2.12 shows the daily flow data for the four WTPs in Luang Prabang city for 2017. Only Namkhan WTP has daily data, the other WTPs have monthly data. For the other WTPs, the same flow is used for every day of the month.



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.12 Daily flow data

The daily peak factor is calculated as shown below based on the daily flow data.

Daily peak factor = Daily maximum supply amount / Daily average supply amount =33,695/29,112=1.16

The ratio between the daily average and daily maximum supply is expected to be larger than 1.16, since the same flow amount during each month is applied to Phouphueng, Asia and Demco WTPs.

The validity of the calculated peak factor (1.16) is compared to the Lao standard and statistical data in Japan and results are shown below.

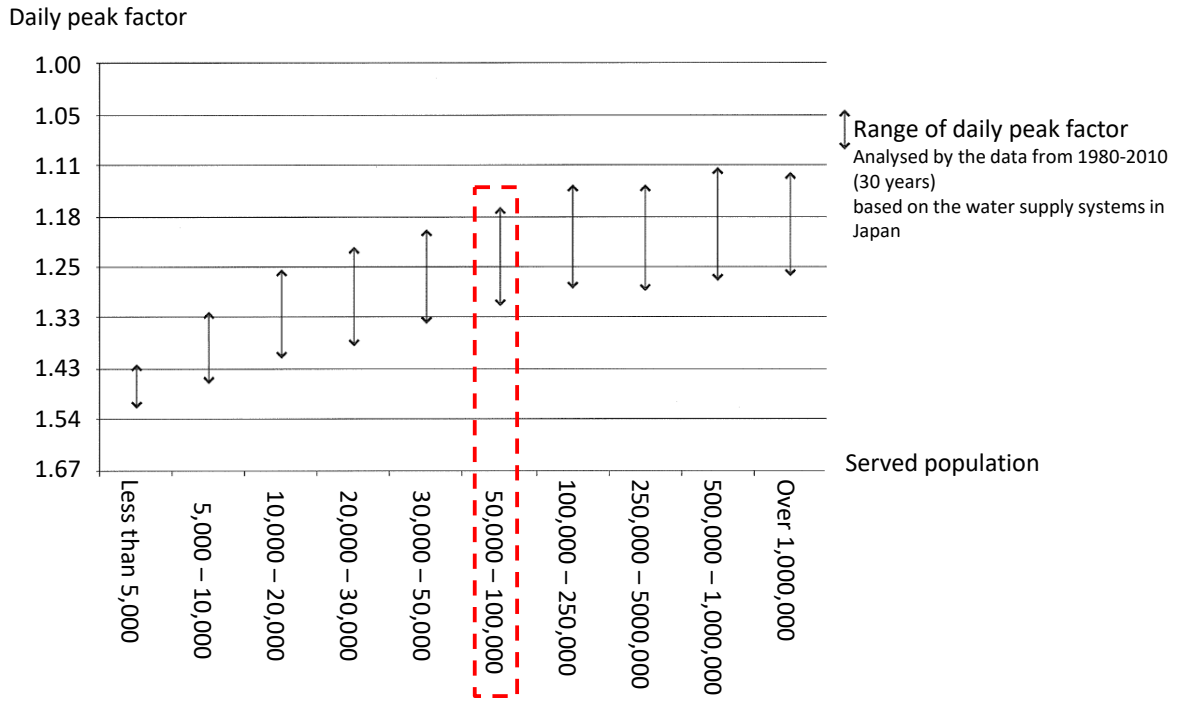
2) Daily Peak Factor in Lao Standard

The daily peak factor should be around 1.2 to 1.5 as shown in the Lao standard (p.B-10).

Daily maximum water supply amount = Daily peak factor (1.2 to 1.5) × Daily average water supply amount

3) Daily Peak Factor in Japanese Standard

Daily peak factors described in the Japanese standard are grouped by served population and compiled from statistical data collected from waterworks in Japan. The daily peak factors are shown in Figure 2.2.13.



Source: the Japanese standard, p.21

Figure 2.2.13 Relationship between served population and daily peak factor

The daily peak factor, which is applicable to Luang Prabang city, is between 1.16 to 1.32 based on the Figure 2.2.13, since the population in the target year (2025) will be about 70,000. The daily peak factor of 1.32 corresponds to a population of 50,000 and 1.16 to a population of 100,000. Therefore,

the daily peak factor of 1.25 would apply to a population of 70,000.

4) Setting Daily Peak Factor

Table 2.2.19 shows the daily peak factors discussed above for comparison.

Table 2.2.19 Comparison of daily peak factors

Setting daily peak factor	Value	Remarks
Daily peak factor based on past record	1.16	Calculated from the daily flow data of Namkhan WTP and the monthly flow data of Phouphueng, Asia and Demco WTPs
Daily peak factor based on the Lao standard	1.2-1.5	-
Daily peak factor based on the Japanese standard	1.16-1.32	1.25 (for a population of 70,000)

The daily peak factor elected for the project is 1.25 considering the following:

- The daily peak factor calculated from the past supply record is 1.16 at a minimum and the value falls out of the range of the Lao standard.
- The daily peak factor of the target area calculated from the Japanese standard is 1.25 and the value falls within the range given in the Lao standard.

(10) Water Demand Projection

Figure 2.2.14 and Table 2.2.20 show the water demand projection calculated based on the set conditions.

The daily average demand is 32,700 m^3/day and the maximum water demand is 40,900 m^3/day in the year 2025, the target year of the project. The estimated demand can be covered by the combined capacity of the existing WTPs (dry season: 46,400 m^3/day, rainy season: 50,400 m^3/day).

The water demand projection estimated by the JPST is bigger than that shown in the M/P 2013. The difference is assumed to be for the following reasons:

- The demand for non-domestic water was underestimated in the M/P 2013.
- The volume of leakage was underestimated in the M/P 2013, as shown by the recent increase in leakage.
- The M/P adopted a daily peak factor of 1.1 and the preparatory survey is using 1.25.

Based on projections, the water demand would exceed the treatment capacity during the dry season in 2032. The water demand projection should be updated at regular intervals and funding for expansion should be secured before demand exceeds capacity.

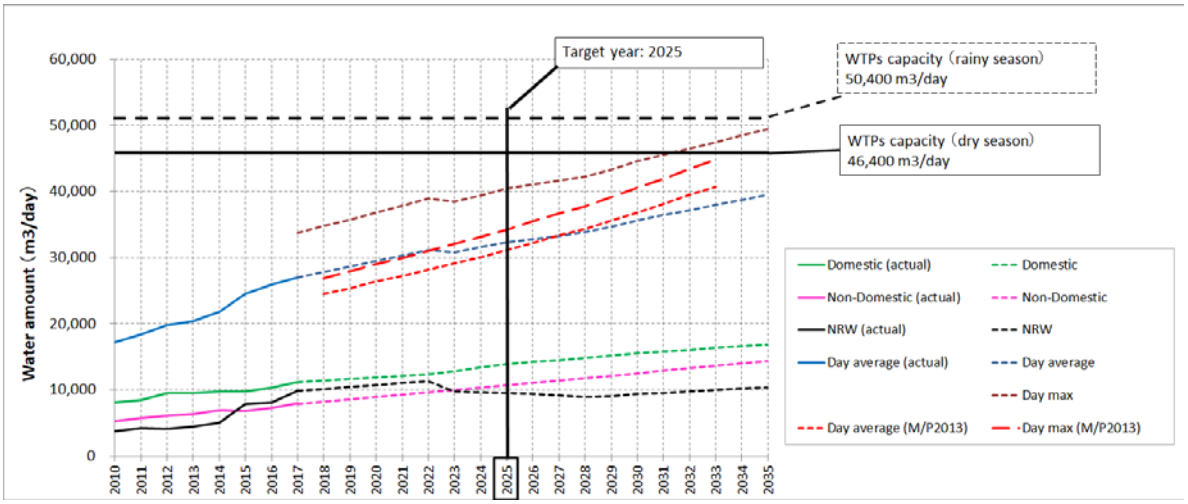


Figure 2.2.14 Water demand projection

Table 2.2.20 Water demand projection

Item	Unit	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Population in planned service area	Person	66,143	67,150	68,176	69,220	70,283	71,366	72,469	73,593	74,738	75,905	77,094	78,306	79,541	80,801	82,085	83,395	84,731	86,094
Population in existing service area	Person	62,497	63,347	64,209	65,082	65,967	66,864	67,773	68,695	69,629	70,576	71,536	72,509	73,495	74,495	75,508	76,535	77,576	78,631
Population in expansion area by the Project	Person	3,646	3,803	3,967	4,138	4,316	4,502	4,696	4,898	5,109	5,329	5,558	5,797	6,046	6,306	6,577	6,860	7,155	7,463
Served population (existing service area)	Person	59,685	60,623	61,576	62,544	63,526	64,524	65,536	66,565	67,610	68,670	69,748	70,841	72,025	73,005	73,998	75,004	76,024	77,058
Served population (expansion area)	Person	0	0	0	0	0	1,423	2,836	4,247	4,547	4,839	5,124	5,414	5,925	6,180	6,445	6,723	7,012	7,314
Served population (total)	Person	59,685	60,623	61,576	62,544	63,526	65,947	68,372	70,812	72,157	73,509	74,872	76,255	77,950	79,185	80,443	81,727	83,036	84,372
Coverage ratio (existing service area)	%	95.5	95.7	95.9	96.1	96.3	96.5	96.7	96.9	97.1	97.3	97.5	97.7	98.0	98.0	98.0	98.0	98.0	98.0
Coverage ratio (expansion area)	%	0	0	0	0	0.0	31.6	60.4	86.7	89.0	90.8	92.2	93.4	98.0	98.0	98.0	98.0	98.0	98.0
Coverage ratio (target area of the Project)	%	90.2	90.3	90.3	90.4	90.4	92.4	94.3	96.2	96.5	96.8	97.1	97.4	98	98	98	98	98	98
Number of connection (existing area)	Connection	10,793	10,963	11,135	11,310	11,488	11,668	11,851	12,037	12,226	12,418	12,613	12,810	13,024	13,202	13,381	13,563	13,748	13,935
Number of connection (expansion area)	Connection	0	0	0	0	0	257	513	768	822	875	927	979	1,071	1,118	1,165	1,216	1,268	1,323
LPCD	L/day /person	186	186	186	186	186	200	200	200	200	200	200	200	200	200	200	200	200	200
Domestic consumption (existing area)	m3/day	11,101	11,276	11,453	11,633	11,816	12,905	13,107	13,313	13,522	13,734	13,950	14,168	14,405	14,601	14,800	15,001	15,205	15,412
Domestic consumption (expansion area)	m3/day	0	0	0	0	0	285	567	849	909	968	1,025	1,083	1,185	1,236	1,289	1,345	1,402	1,463
Domestic consumption (total)	m3/day	11,101	11,276	11,453	11,633	11,816	13,190	13,674	14,162	14,431	14,702	14,975	15,251	15,590	15,837	16,089	16,346	16,607	16,875
Non-domestic consumption	m3/day	8,228	8,589	8,949	9,310	9,670	10,031	10,391	10,751	11,112	11,472	11,833	12,193	12,554	12,914	13,275	13,635	13,995	14,356
NRW	m3/day	9,957	10,233	10,510	10,789	11,069	9,952	9,829	9,688	9,447	9,196	8,936	9,148	9,381	9,584	9,788	9,994	10,201	10,410
Leakage amount	m3/day	7,966	8,186	8,408	8,631	8,855	7,962	7,863	7,750	7,558	7,357	7,149	7,318	7,505	7,667	7,830	7,995	8,161	8,328
NRW ratio	%	34	34	34	34	34	30	29	28	27	26	25	25	25	25	25	25	25	25
Leakage ratio	%	27.2	27.2	27.2	27.2	27.2	24	23.2	22.4	21.6	20.8	20	20	20	20	20	20	20	20
Daily peak factor	-	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Daily average water supply amount	m3/day	27,295	28,051	28,810	29,574	30,341	31,183	31,928	32,663	33,101	33,531	33,957	34,762	35,649	36,418	37,194	37,976	38,763	39,559
Daily maximum water supply amount	m3/day	34,119	35,064	36,013	36,968	37,926	38,979	39,910	40,829	41,376	41,914	42,446	43,453	44,561	45,523	46,493	47,470	48,454	49,449

2.2.2.2 Transmission and Distribution System Planning

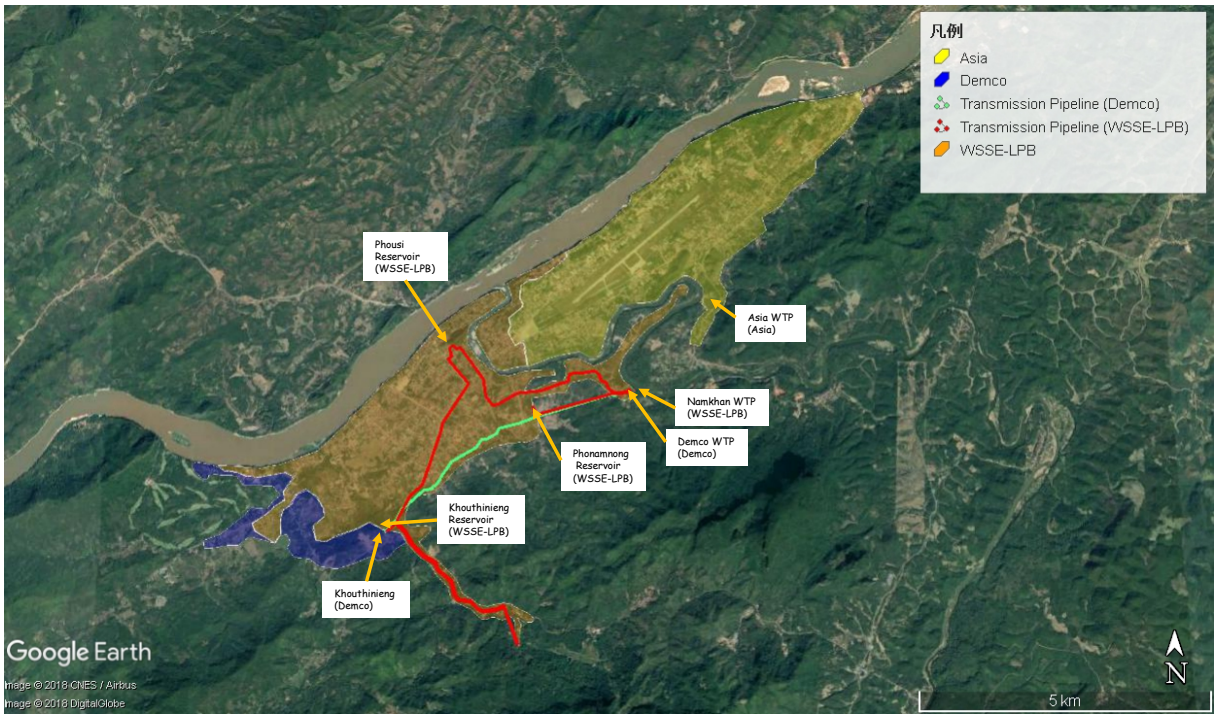
(1) Existing System

1) Network Pipes

A) Transmission Pipelines

The WSSE-LPB owns and operates transmission system as shown in Figure 2.2.15 and Table 2.2.21.

These transmission pipelines run from Namkhan WTP to Phousi Reservoir, from Namkhan WTP to Phounanong Reservoir, from Phouphueng WTP to Khouthinieng Reservoir and Phousi Reservoir.



Map data: Google, DigitalGlobe

Figure 2.2.15 WSSE-LPB transmission mains

Table 2.2.21 Installation year and length of WSSE-LPB transmission mains

Pipe	Diameter	Construction year (1969-1975)	Construction year (2000)	Construction year (2007-2017)	Total
DIP	200	6,492	3,140	2,752	12,384
	250	-	-	2,190	2,190
	300	-	308	-	308
	350	-	4,391	-	4,391
	Sub-total	6,492	7,839	4,942	19,273
GSP	200	-	-	460	460
	250	-	-	264	264
	300	-	-	60	60
	Sub-total	-	-	784	784
u-PVC	300	-	-	340	340
Total		6,492	7,839	6,066	20,397

(unit: m)

DIP (Ductile Iron Pipe)

GSP (Galvanized Steel Pipe)

u-PVC (Un-Plasticized Polyvinyl Chloride)

Source: Prepared by JPST based on the information from WSSE-LPB

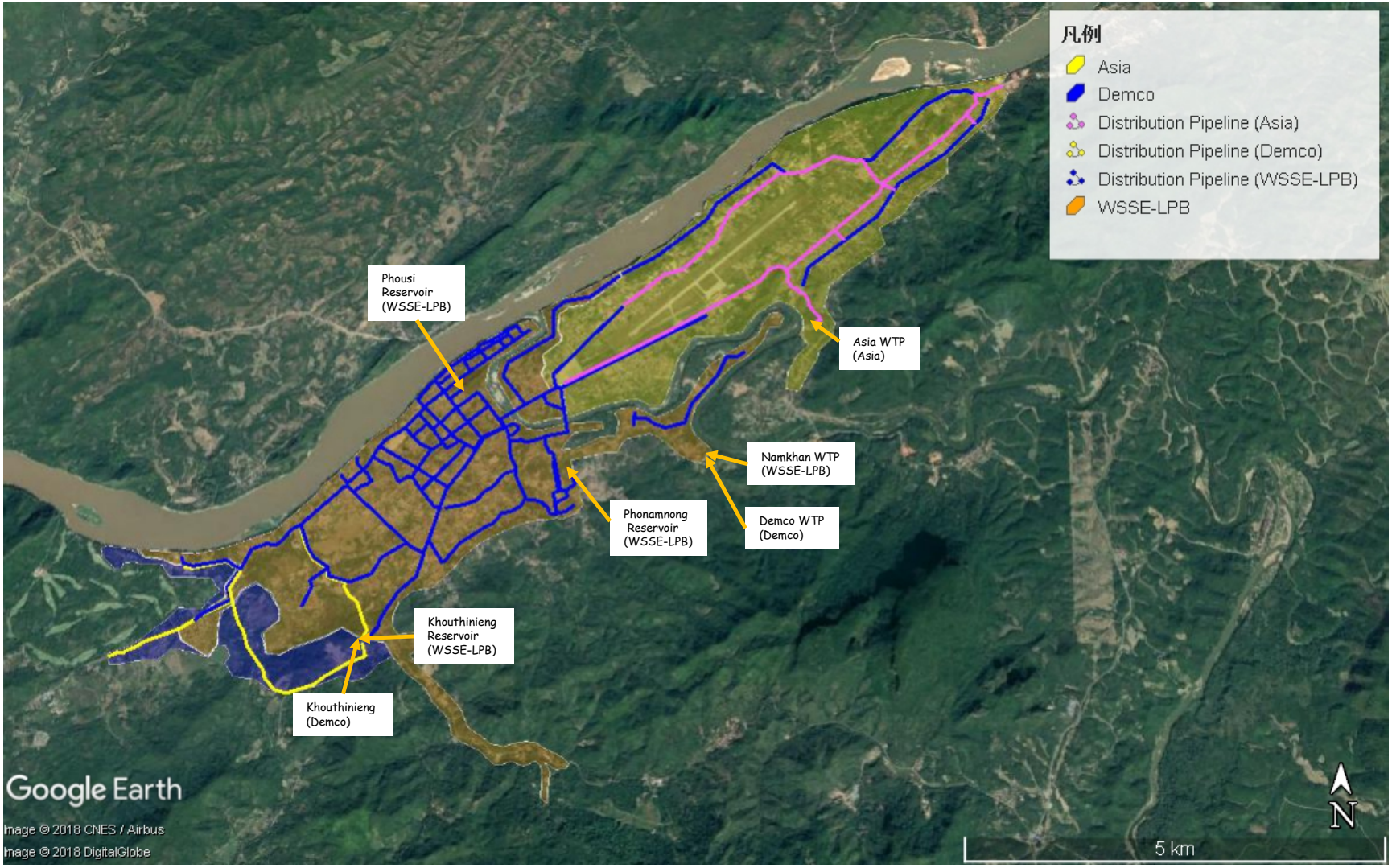
The transmission main installed in 1969 from Phouphueng WTP to Phousi Reservoir is old. The pipeline is difficult to inspect because of its depth(*) and is probably quite deteriorated. The Lao side has requested the renewal of a 6.5 km section.

* WSSE-LPB does not know the exact depth which is assumed to be 3 to 4 meters.

B) Distribution Pipelines

The distribution network is shown in Figure 2.2.16 and Table 2.2.22. WSSE-LPB owns the distribution pipelines from Phousi Reservoir to the city center and World Heritage Site, Phounanong Reservoir to the city, and Khouthinieng Reservoir to the city.

Distribution mains are owned by Asia WTP in the north and Demco WTP in the south. These distribution mains are connected to the WSSE-LPB network, with bulk meters installed at each connection point where supply volume and pressure are monitored.



Google, DigitalGlobe

Figure 2.2.16 Distribution pipelines – location and ownership

Table 2.2.22 Installation year and length of WSSE-LPB distribution pipelines

Pipe	Diameter	Construction year (1969-1975)	Construction year (2000)	Construction year (2007-2017)	Total
DIP	100	739	794	15	1,548
	150	2,157	-	-	2,157
	200	3,278	-	-	3,278
	250	782	1,680	-	2,462
	300	-	235	-	235
	350	-	3,066	618	3,684
	Sub-total	6,956	5,775	633	13,364
GSP	15	-	-	2,342	2,342
	20	-	-	2,190	2,190
	25	-	-	348	348
	30	-	-	1,765	1,765
	40	-	-	6	6
	50	-	-	224	224
	63	2,794	-	2,945	5,739
	80	-	-	831	831
	100	665	-	1,483	2,148
	110	-	-	12	12
	150	-	-	314	314
	200	-	-	749	749
	210	-	-	278	278
	250	-	-	1,742	1,742
	400	-	-	12	12
	Sub-total	3,459	-	15,240	18,699
u-PVC	15	-	-	27	27
	25	-	-	11	11
	30	-	-	13	13
	40	1,281	-	3,513	4,794
	50	-	5,065	515	5,580
	80	-	4,331	3,856	8,187
	100	-	8,030	5,780	13,810
	150	4,219	7,472	4,417	16,108
	200	1,120	5,369	258	6,747
	250	-	1,639	2,768	4,407
	Sub-total	6,620	31,906	21,157	59,683
HDPE	15	-	-	2,542	2,542
	20	-	-	2,733	2,733
	25	-	-	2,991	2,991
	40	-	-	6,893	6,893
	50	-	-	10,869	10,869
	63	-	-	24,197	24,197
	80	-	-	3,068	3,068
	100	-	100	4,082	4,182
	150	-	-	904	904
	200	-	-	5,736	5,736
	Sub-total	-	100	64,015	64115
Total		17,035	37,781	101,045	155,861

(unit: m)

DIP (Ductile Iron Pipe)
GSP (Galvanized Steel Pipe)
u-PVC (Un-Plasticized Polyvinyl Chloride)
HDPE (High Density Polyethylene)
Source: Prepared by JPST based on the information from WSSE-LPB

17 km of distribution pipelines, or 11% of the network, were installed during the construction of the Phouphueng WTP from1969 to 1975. Since then, road developments and other activities have further buried the pipes to a deeper level, making access and maintenance difficult.

2) Reservoirs

Reservoirs operated by WSSE-LPB were visually inspected for leaks, cracks and efflorescence by JPST. The results are summarized in Table 2.2.23.

Table 2.2.23 Site survey results (reservoirs)

Reservoir	Structure	On-line	Results
Phousi Reservoir (1470 m^3)	Sidewall	1970	• Comprehensive inspection was not possible due to mortar finish. • Sections without mortar (mortar separation) were inspected. Condition of the underlying concrete is good.
	Top		• Several cracks, which may lead to collapse, were found on the dome section.
	Others		• The operator reported that there is water leaking into the ground.
Khouthinieng Reservoir (1,570 m^3)	Sidewall	2000	• Efflorescence was observed at a dozen locations, of which two are leaking.
	Top		• No major issues found.
Phounanong Reservoir (1,000 m^3)	Sidewall	2011	• Efflorescence was observed in the concrete joint area.
	Top		• No major issues found.

Phousi Reservoir has a lot of cracks on the top as shown in Photo 2.2.2 and there is a risk of collapse.

Photo 2.2.2 Conditions of cracks on the top of the Phousi Reservoir

(2) Water Supply System

1) Current Condition

The existing water supply system is shown in Figure 2.2.17.

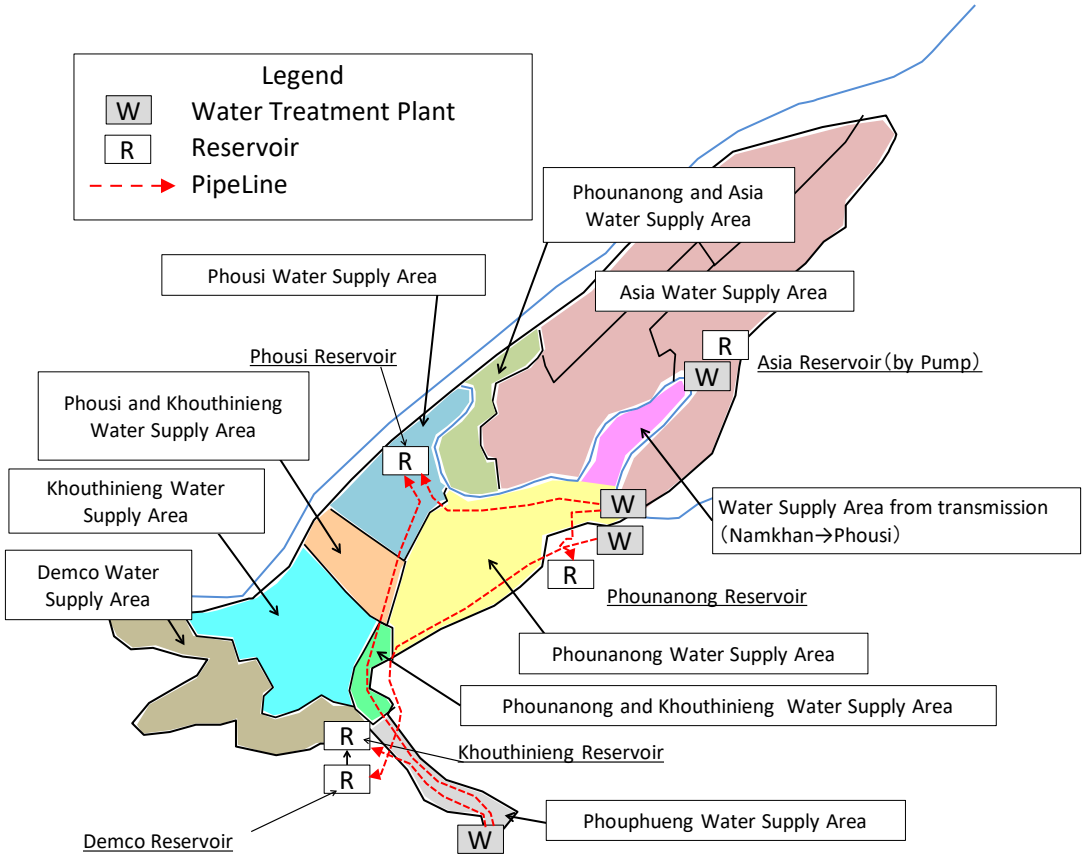


Figure 2.2.17 Existing water supply system

Issues regarding the current supply system are as follows:

- If Phousi Reservoir becomes inoperable due to old age; there will be a large negative impact on the Phousi distribution area.
- Distribution pipelines were constructed and connected to the transmission main from Namkhan WTP to Phousi Reservoir. (Transmission system and distribution system should be separated to stabilize the transmission flow and pressure.)
- The southern part of the Phounanong service area is at a high elevation and service pressure is low (0 ~ 5 meters).

The current system will have the following issues if improvements are not made:

- Phousi Reservoir will continue to deteriorate and eventually become inoperable.
- Since the transmission main from Namkhan WTP to Phousi Reservoir is not separated from the distribution pipelines, controlling supply volume and pressure will become difficult.
- The demand is increasing, resulting in more service area experiencing insufficient pressure

because the existing distribution pipes are too narrow to handle the supply volume for future water demand.

The areas with low water pressure would be expanded for the demand in the target year 2025. Further, the water supply system must be rearranged if the Phousi Reservoir can no longer remain in operation. Study of the future water supply system is required.

2) Transmission and Distribution System

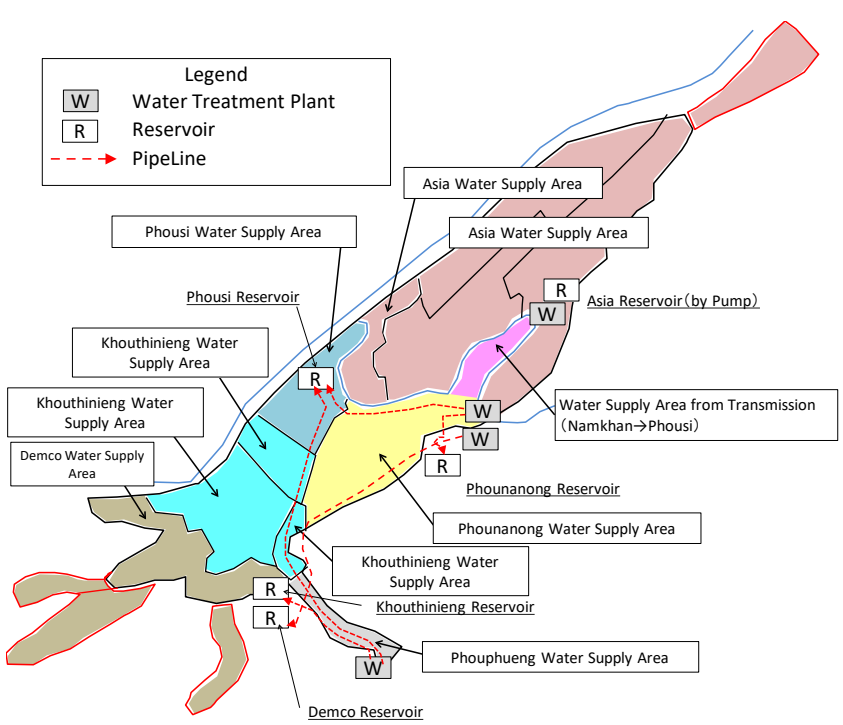
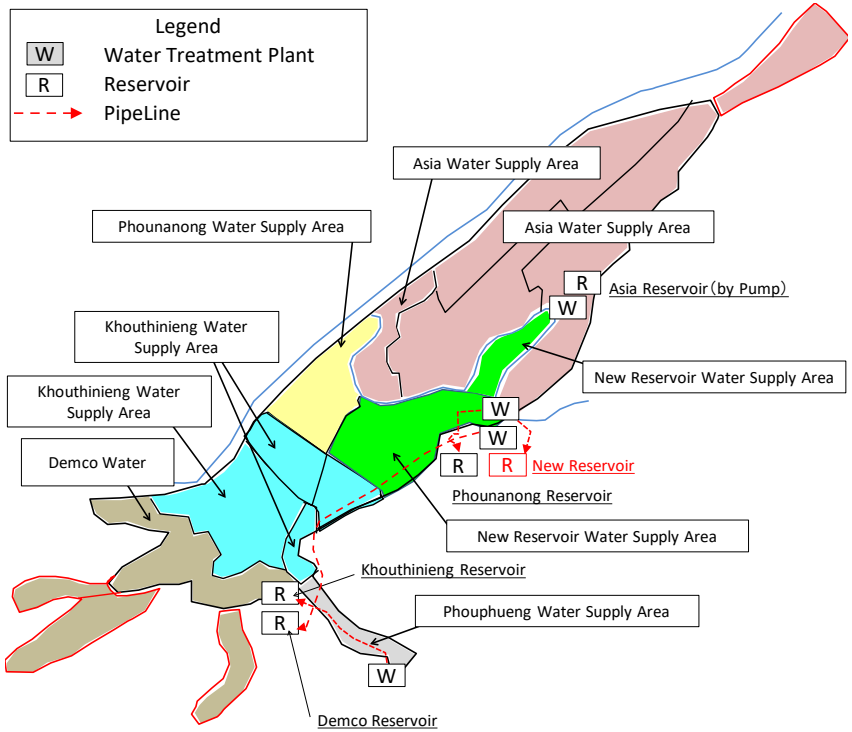
The following needs to be considered when planning future transmission and distribution systems in Luang Prabang city.

- Reservoir capacity
- Age and condition of Phousi Reservoir (50 years old)
- Supply volume capacity and minimum purchase volume from Asia Co. and Demco Co.

The future of the water supply system can be considered under 2 scenarios: Case 1 - continue to use Phousi Reservoir; Case 2 – decommission Phousi Reservoir, and build a new reservoir big enough to accommodate the required retention time for the supply volume. The two cases are compared in Table 2.2.24.

After consulting with the Lao side, it was decided that Phousi Reservoir will be decommissioned and replaced by a new reservoir.

Table 2.2.24 Comparison of whether to decommission Phousi Reservoir

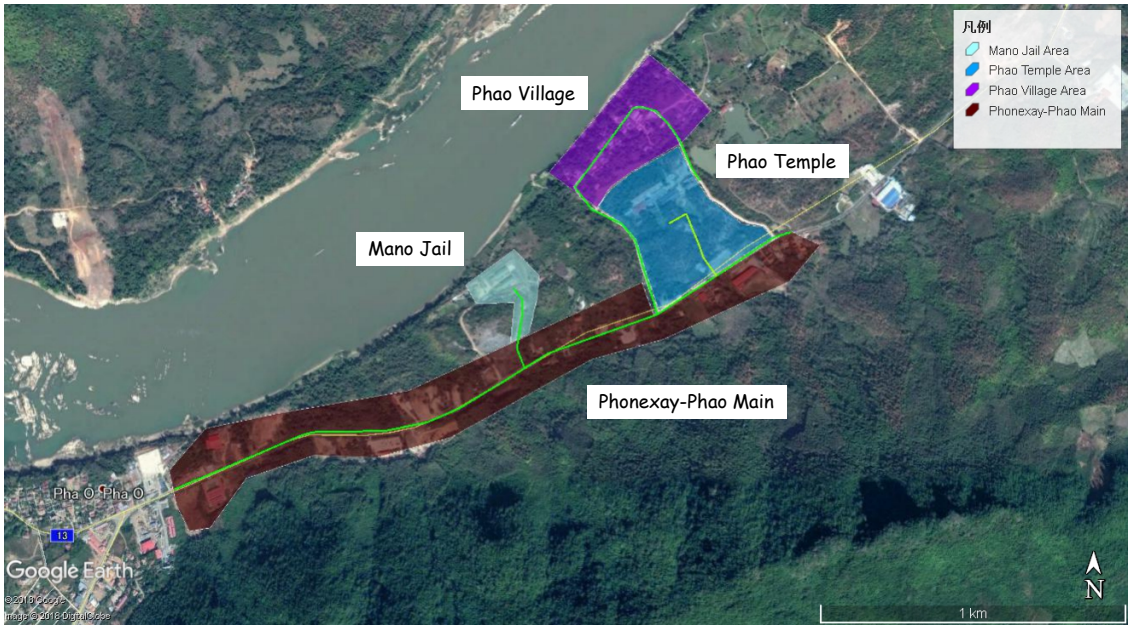
Case	No.1 Continue to use Phousi Reservoir	No.2 Replace Phousi Reservoir with new reservoir)
Diagram		
Pros	− No need to construct new reservoir.	− Able to supply water to high elevation areas, which are also experiencing population growth. − Greater ability to ensure water pressure. − Possible to separate transmission and distribution for water produced at Namkhan WTP.
Cons	− Phousi Reservoir will become inoperable, this would have significant negative impact on the whole water supply system.	− Need land and access.

Case	No.1 Continue to use Phousi Reservoir	No.2 Replace Phousi Reservoir with new reservoir)
	(Renovation of Phousi Reservoir is not feasible due to lack of access road.) − The transmission line from Phouphueng WTP to Phousi Reservoir is over 50 years old and requires replacement. However, there is risk in this investment if the future of Phousi Reservoir is uncertain. − Phousi Reservoir cannot meet future water supply requirement: water pressure cannot be guaranteed in the future. − Water supply to World Heritage Site cannot be guaranteed in the future. − Residential areas are expanding, especially in high elevation areas. Phousi Reservoir cannot guarantee enough water pressure to these areas. − From Namkhan WTP to Phousi Reservoir, transmission and distribution are not separated in some areas.	
Selection	NOT SELECTED	SELECTED

3) Expansion of the Service Area

A) Target Area for Expansion (North)

The target area for service expansion in the north is shown in Figure 2.2.18.

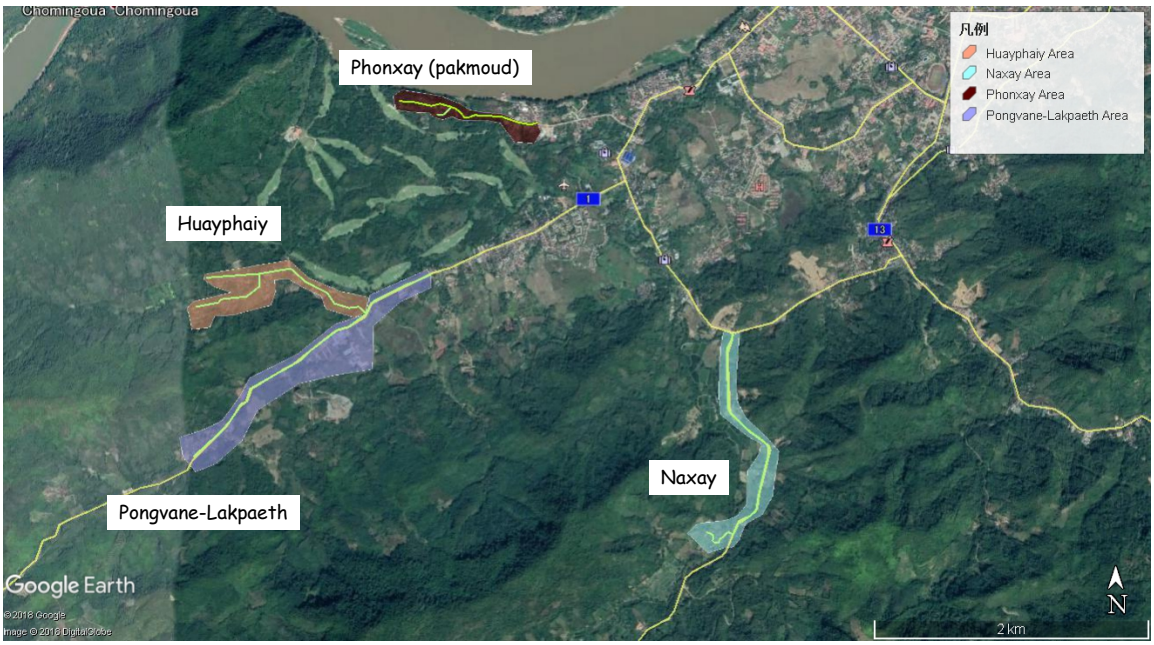


Map Data: Google, DigitalGlobe

Figure 2.2.18 Service expansion area (North – detailed view)

B) Target Area for Service Expansion (South)

The target area for service expansion in the south is shown in Figure 2.2.19.



Map Data: Google, DigitalGlobe

Figure 2.2.19 Service expansion area (South)

(3) Pipeline Renewal

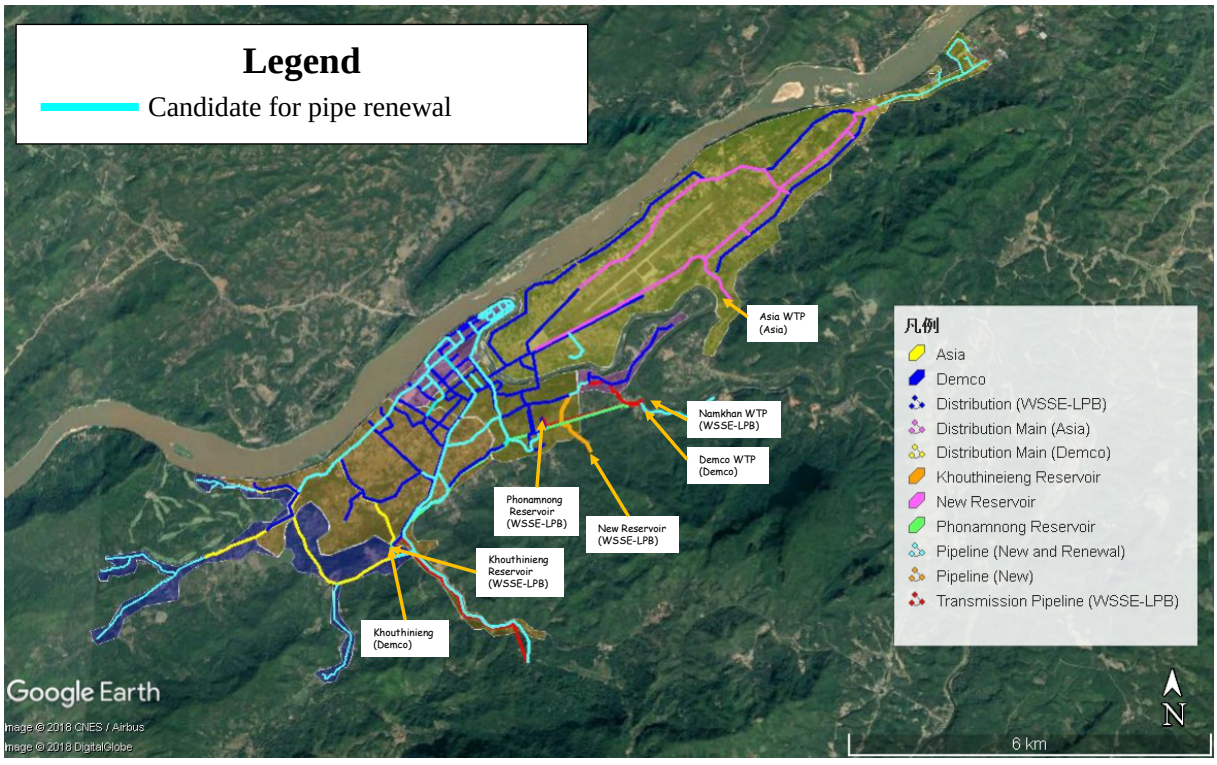
1) Selection Method for Pipes to be renewed

In addition to renew aged pipes, new pipelines are needed to transmit water from the new reservoir (2.2.2.2 Transmission and Distribution System Planning) as well as ensure adequate water pressure for fire hydrants (2.2.2.2(6) Fire Hydrant**)** essential for the protection of the World Heritage Site. The following criteria are considered for selection of pipe renewal.

Criteria for pipe renewal

① Old and deteriorating pipes (mainly ones installed in 1969)
② Pipes with inadequate diameter to serve the new supply system
③ Pipes with inadequate diameter to ensure enough pressure for fire hydrants
④ Pipes that are buried too deep for proper inspection and maintenance
⑤ Pipes in areas with insufficient pressure
⑥ Pipes selected for renewal will be further scrutinized and grouped by location for efficient implementation of the effort
⑦ Care will be taken in the implementation of ①~⑤ so that multiple objectives can be achieved. (i.e.: While implementing ① the diameter of the renewal pipe will be considered to fulfill ②③④ and ⑤).

The pipe renewal plan based on the above criteria is shown in Figure 2.2.20. Pipe lengths are shown in Table 2.2.25.



Map Data: Google, DigitalGlobe

Figure 2.2.20 Pipe renewal plan

Table 2.2.25 Length of renewal pipes

Category		Item
Water Supply System	Transmission pipelines	Length: approx. 5.0 km − From Phouphueng WTP to Khouthinieng Reservoir (approx. 3.4 km) − From Namkhan WTP to New Reservoir (approx. 1.6 km)
	Distribution pipelines	Length: 45.9 km − From New Reservoir to branch point (approx. 1.6 km) − Renewal of old pipes (approx. 44.3 km)

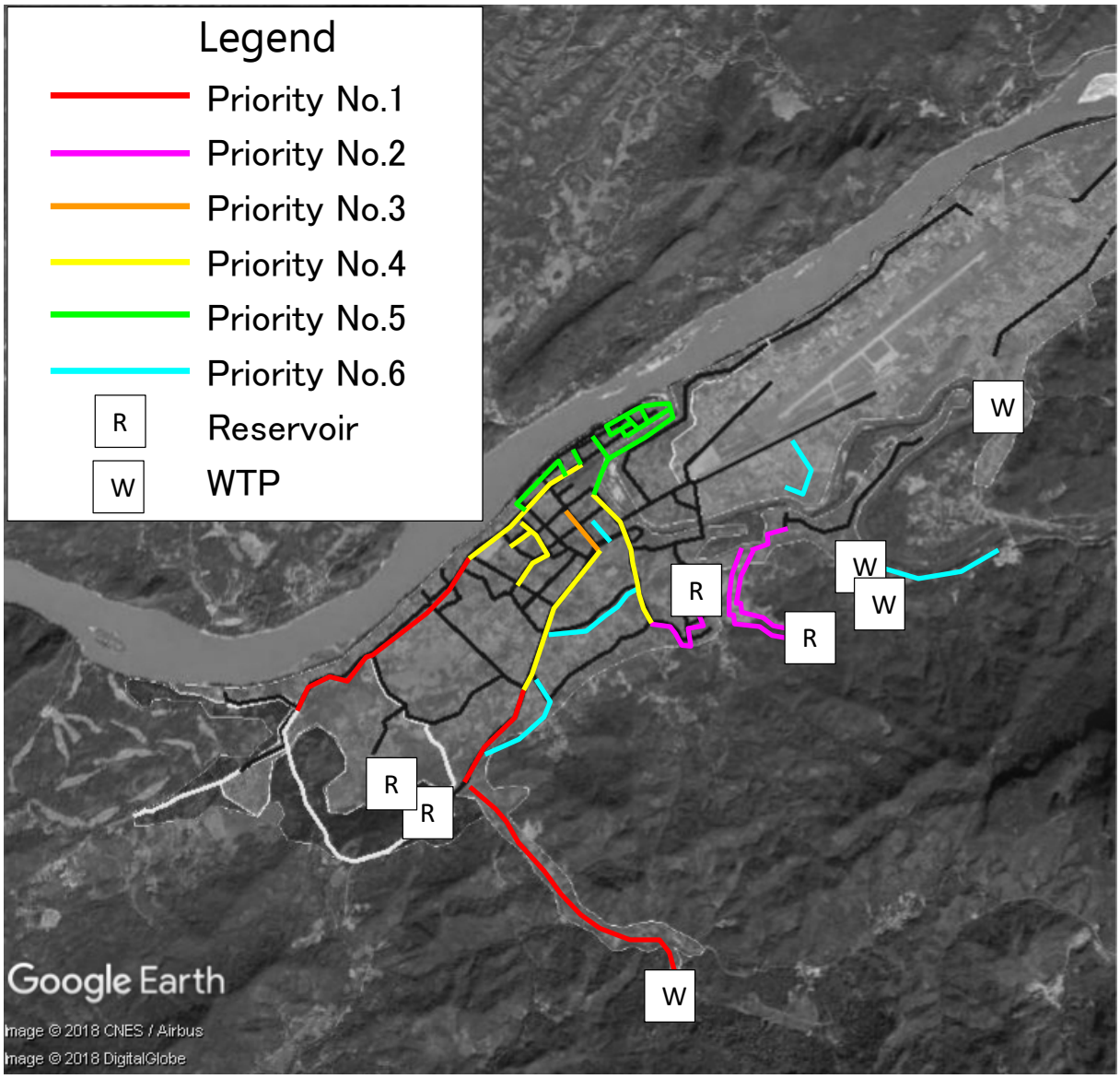
2) Prioritization for Renewal of Pipeline

Priority for pipe renewal is established as shown in Table 2.2.26 and Figure 2.2.21.

Pipes with inadequate diameter to serve the new supply system (criteria ②) are the first in priority for installation. The next priority, favored by the Lao side, is the renewal of pipes installed in 1969 to reduce leakage. Next on the list are pipes that need to provide higher water pressure for firefighting. Finally, the pipes in areas suffering from low water pressure will also be renewed.

Table 2.2.26 Priority of pipe renewal

No.	Section	Criteria for pipe renewal
1	Pipes required for main line in the new water supply system and those constructed in 1969	Criteria ①, ②
2	Pipes required for main line in the new water supply system	Criteria ②
3	Pipes buried too deep for easy inspection and maintenance and those constructed in 1969	Criteria ①, ④
4	Old and deteriorating pipes constructed in 1969	Criteria ①
5	Pipes that require larger diameter to ensure enough pressure for firefighting	Criteria ③
6	Pipes with insufficient pressure	Criteria ⑤



Google, DigitalGlobe

Figure 2.2.21 Priority of pipe renewal

3) Changeover of Service Pipes

In addition to renewing the existing distribution pipelines, existing service connection pipes will need to be reconnected to the new distribution pipes. This will be undertaken as a part of the project.

(4) Reservoir Capacity

1) New Reservoir capacity

The capacity of the new reservoir is 1,500 m^3, including the water needed for firefighting. The design for the new reservoir is shown in Table 2.2.27.

Table 2.2.27 Reservoir design

Item	Design	Comments
Retention Time	4 hours	The Lao standard: 2~4 hours
Distribution volume	8,000 m^3/day	Maximum demand in target year (2025)
Additional capacity for firefighting	100 m^3	volume for 10,000 people according to the Japanese standard[1)]
Reservoir Capacity	1,500 m^3	1,333 m^3 (4 hours of demand) ＋100 m^3 (firefighting demand) ＝ 1,433 ≒1,500 m^3

1) the Japanese standard (JWWA (2012) Design Criteria for Waterworks Facilities)

Table 2.2.28 Additional water supply for firefighting based on population

Population (x1000)	Fire Protection volume (m^3)	Comments
10	100	Applied for the new reservoir
20	200	
30	300	
40	350	
50	400	

Source: the Japanese standard (JWWA (2012) Design Criteria for Waterworks Facilities)

2) Reservoir Capacity: 2025

The retention time calculated from water demand at 2025 of each reservoir is shown in Table 2.2.29.

Table 2.2.29 Retention time in each reservoir

Reservoir	Capacity (m^3)	Maximum Supply (m^3/day)	Retention Time (hour)	Comments
Phounanong Reservoir	1,000	6,000	4	
New Reservoir	1,500	8,000	4 + 0.5	0.5 hour is for firefighting
Khouthinieng Reservoir	1,570	18,000	3.9	Combined retention time is given since Kouthinieng Reservoir and Demco Reservoir are connected to each other.
Demco Reservoir	1,350			
Asia Reservoir	1,500	14,000	2.6	

The Lao standard for retention time over 2~4 hours is met for maximum distribution flow in all reservoirs, including the new reservoir, for the target year (2025).

(5) New Reservoir

1) Design Plan

A) Site Details

A)-1 Location

The new reservoir is planned to be located approximately 1 km southeast of the existing Phounanong Reservoir. The location is shown in the figure below.

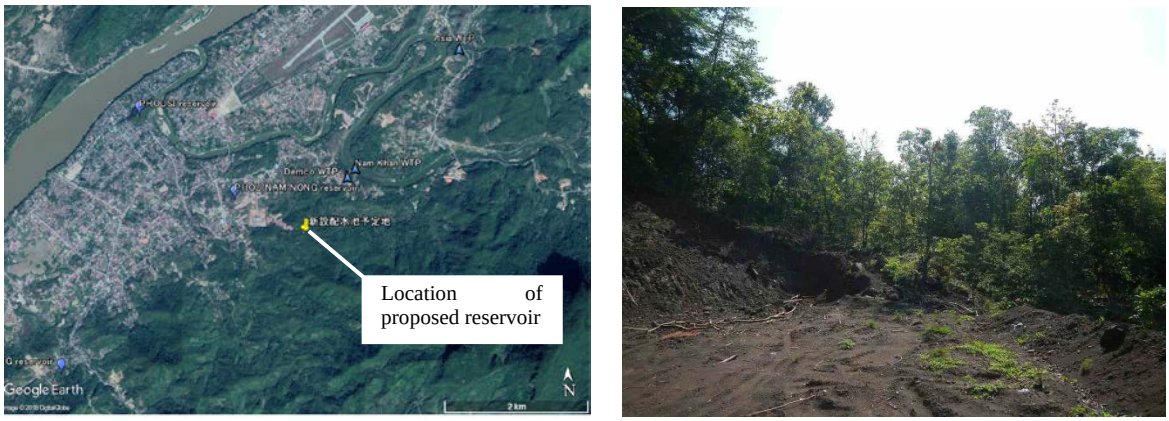


Figure 2.2.22 Location and photo of proposed new reservoir

A)-2 Geological Condition

Soil investigation shows bedrock depth of 1.5 meters. The geological condition is suitable for direct foundation. This is confirmed by similar practice on developed areas nearby, and rock outcrops found in the area as shown in Photo 2.2.3.

Photo 2.2.3 Nearby developed land

B) Elevation

Elevations of the reservoir and the service area are shown in Table 2.2.30.

Table 2.2.30 Reservoir and service area elevations

Elevation	Details	Comments
Reservoir	+305 ~ +315 m	Survey data
Service area of the reservoir	+256 ~ +265 m	

C) Design Conditions

C)-1 Structure

The structure of the reservoir is determined by considering the site and nearby road conditions, as well as cost.

Structure: Flat slabs which are generally used in many applications.
Planar Shape: Rectangle
Effective Depth: Maximum depth (3~6 meters) allowed by the Japanese standard.
Material: Reinforced concrete.
The other parts will be designed according to the Japanese standard.

C)-2 Type of Foundation

Direct foundation will be used.

D) Yard Pipe

The following piping components are needed.

D)-1 Inlet pipe
D)-2 Outlet pipe
D)-3 Reservoir connection pipe
D)-4 Overflow and drainage pipe

Drainage pipe will drain water to the ridge in front of the reservoir site. There is a waterway downstream from the ridge.

The reservoir and yard pipes are shown in Figure 2.2.23.

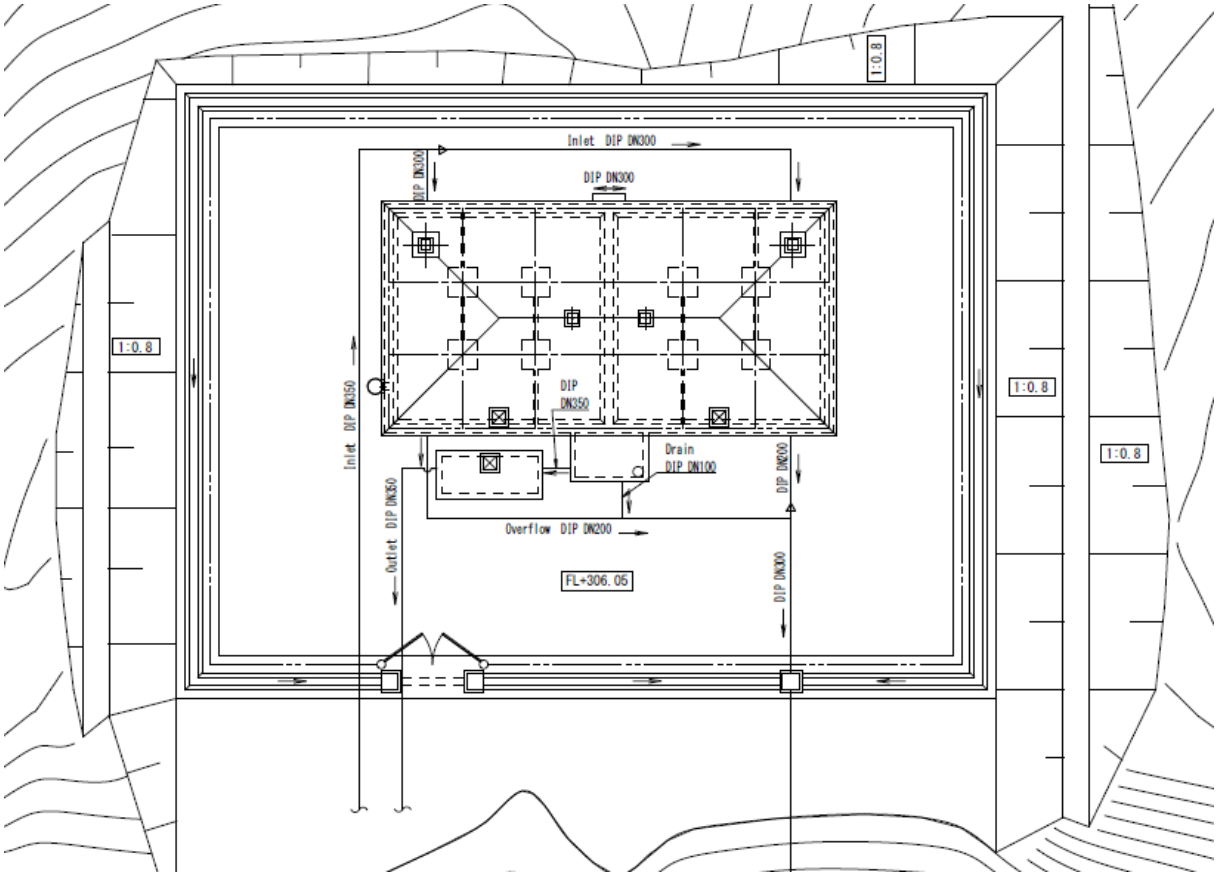


Figure 2.2.23 Yard piping plan for the new reservoir

(6) Fire Hydrants

1) Locations in City

At present, only four fire hydrants are installed in Luang Prabang city. There exist several kilometers intervals between those hydrants. Lao standard recommends a maximum distance of 300 meters between fire hydrants in urban areas. The Japanese standard recommends 100 to 200 meters, and with consideration of where buildings are situated along the water supply distribution line and fire hose length.

Firefighting is possible near the existing installation locations. However, where the fire hydrant is far away, rapid response is not possible. Most of the buildings in the area do not have fire hydrants nearby.

The fire hydrants installed by Demco do not match the hose coupling used by the fire department. More fire hydrants are needed not only in the World Heritage Site. They are needed in other areas for the following reasons:

- Where fire hydrants are not easily accessible, water may be taken from the river. However, there are not so many places where access to the river is easy.
- Rapid firefighting response can be achieved if water can be taken from hydrants along the road.

Photo 2.2.4 Fire hydrants installed in the World Heritage Site and in the city area
(Left; World Heritage Site, Right; city area)

Photo 2.2.5 Coupling on existing fire hydrants

2) Installation Type of Fire Hydrant

Table 2.2.31 shows the installation type of fire hydrants. Above ground and underground types will be applied to the project.

3) Design Plan

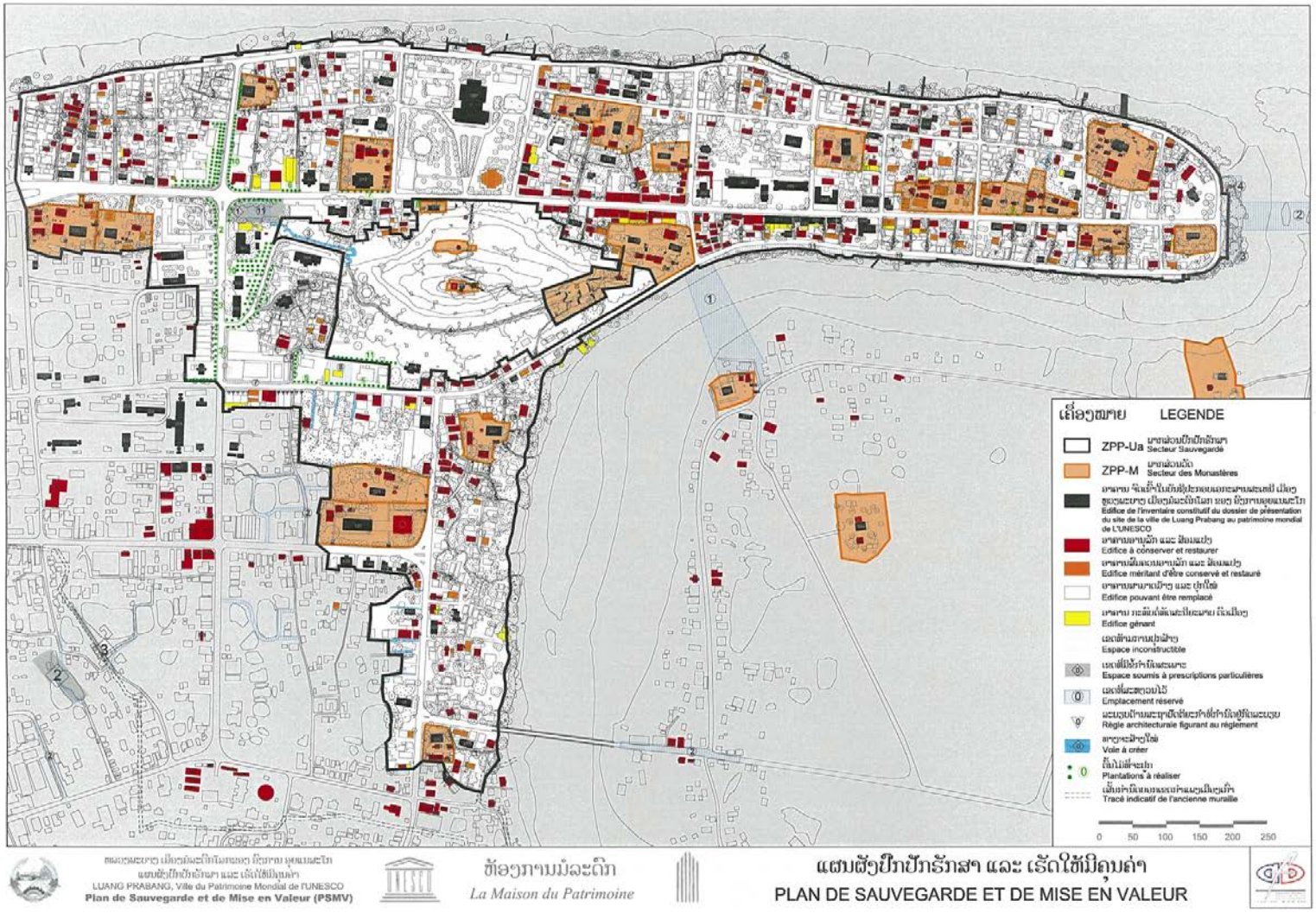
Fire hydrants will be installed for the following purposes:

- to reduce the risk of damage to buildings by fire, especially for ones registered as World Heritage (registered buildings are shown in Figure 2.2.24 in black).
- to provide access to water for firefighting outside the World Heritage Site, since there is currently almost no provision for firefighting.
- Type of hydrants (above or under) will be selected according to installation locations.

Table 2.2.31 Above ground and underground fire hydrants and water gun

	Above ground fire hydrant	Underground fire hydrant	Water gun
Photo			
Application Examples	Fire hydrant used in Luang Prabang.	Used in Japan in locations where above ground fire hydrants are not practical, especially in urban areas.	Used in Japan only in limited places such as areas with buildings are registered as world heritage.
How to Use	− Attach a hose to the fire hydrant and discharge water toward the fire. (Discharge pressure depends on the water pressure at the installation point.) − Attach a hose to the fire hydrant, supply water to the fire engine, and then discharge water from the fire engine at higher pressure.		− Discharge water toward the fire. Direction of the water gun nozzle is adjustable, but the installation location is fixed.
Applicable Condition	− Places where pressure to supply water to fire engine can be secured (water pressure for hydrant plug opening is 0 m or more). − Places where the water distribution pipe diameter is ≥ 150 mm so that hydraulic pressure can be secured during the use of fire hydrant.		− It is applicable in places where there is enough water pressure (approx. 50 m). − Where the water distribution pipe diameter is ≥ 150 mm
Installation Cost	Low	Medium	High
Applicability In This Project	Applicable	Applicable	Not Applicable[1)]

1)Application of the water gun requires high water pressure and the high pressure causes leakages in pipeline networks. So its application is not appropriate for water supply system. If pumps have to be installed for the water guns for all the registered buildings, the initial and O&M costs will be very high.



Source: Plan de sauvegarde et de mise en valeur (2001)

Figure 2.2.24 Registered buildings in World Heritage Site (in black)

The Lao standard recommends a maximum of 300 m between fire hydrants, and that they should be less than 75 m from buildings. However, buildings to be protected by fire hydrants are not specified, so it is up to the judgment of the authority responsible for the installation. It is assumed that the Lao standard are based on the idea that fire hydrants shall be installed at approx. 300 m apart so that firefighting can be carried out smoothly, and that fire hydrants shall be installed as close as possible to important buildings.

Fire hydrants will be installed along the route where pipeline renewal by the project will be carried out.

Table 2.2.32 shows the design plan for fire hydrants based on the above.

Table 2.2.32 Design plan for fire hydrants

Item	Design condition	Remarks
Location	<World Heritage Site> Install fire hydrants within 50 m of the registered buildings (in black in Figure 2.2.24).	− When hydrant plug is opened, water pressure of approx. 10 m will be secured. Therefore, it is possible to extinguish fires within the range of 50 m by connecting two 20 m hoses (40 m hose + 10 m pressure)
	<Outside the World Heritage Site> Install fire hydrants approx. 500 meters apart.	− Fire hydrants will be installed above ground along a wide road along the pipeline renewal route and where the fire engine can park easily.
Water Distribution Pipe Diameter at Fire Hydrant Installation Location	Distribution pipe diameter of ≥150 mm	− Fire hydrants will be installed along the route of the distribution pipeline with a diameter of ≥150 mm, considering the water pressure needed for firefighting.
Installation Method	Above ground or underground	− Fire hydrants which may interfere with the visual aesthetics of the surrounding area shall be installed below ground, and others will be installed above ground.
Design	To reduce cost, off the shelf products will be used. Only color can be specified.	—
Coupling	Coupling shall be specified to meet the fire department specifications.	—

As shown in Table 2.2.32, fire hydrants will be installed near registered world heritage buildings (in black in Figure 2.2.24). Thus, the registered buildings will have facilities which enable prompt firefighting. For buildings where there are no fire hydrants in the vicinity, firefighting capability will mainly depend on the fire engine.

Photo 2.2.6 and Photo 2.2.7 show how fire hydrants are planned to be installed either above or below ground. Where the fire hydrants can be inconspicuous, above ground type will be used, otherwise they will be installed below ground to preserve the landscape. The standard drawing of a fire hydrant is shown in Figure 2.2.25. Below ground installations must take into consideration possible obstruction of access by parked cars. This will be discussed in the detailed design phase.

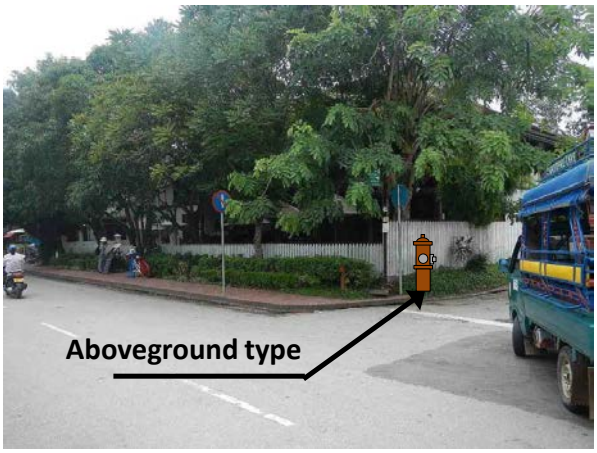
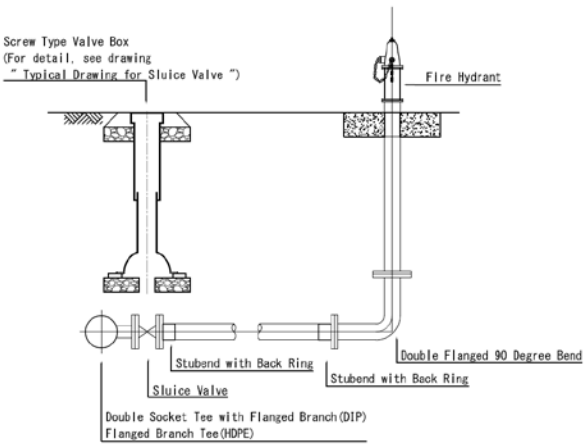
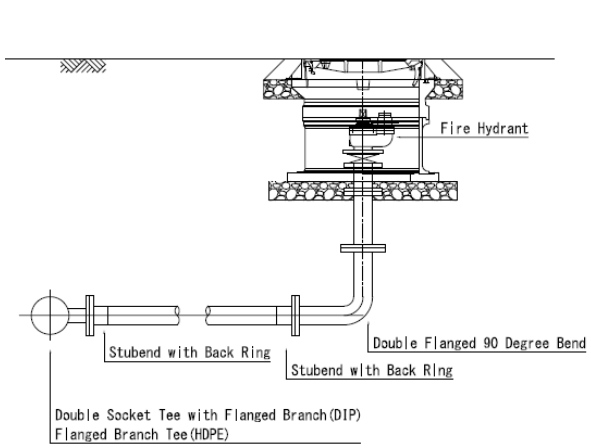


Photo 2.2.6 Installation of fire hydrants above ground

Photo 2.2.7　Installation of underground fire hydrants



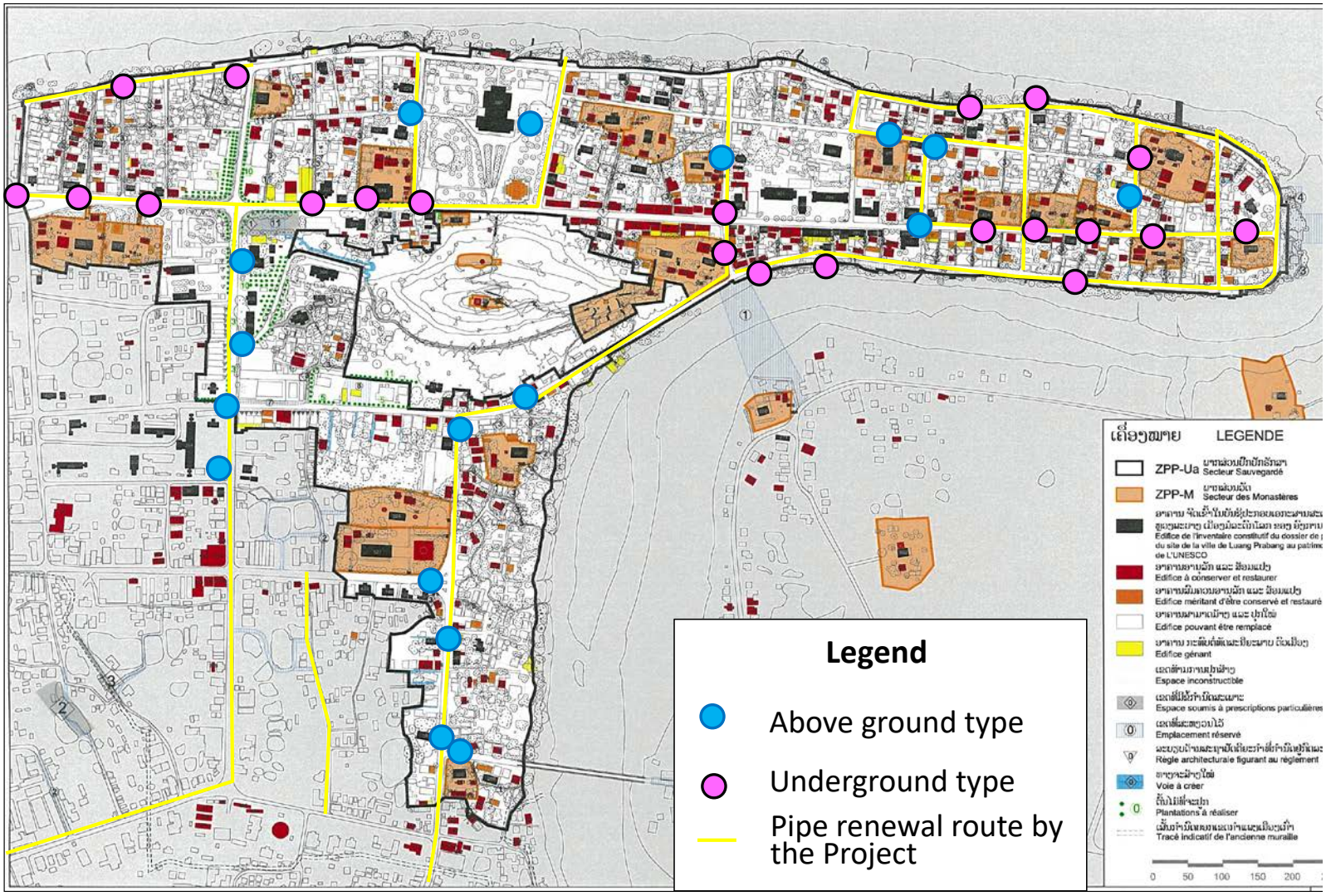
Aboveground Type



Underground Type

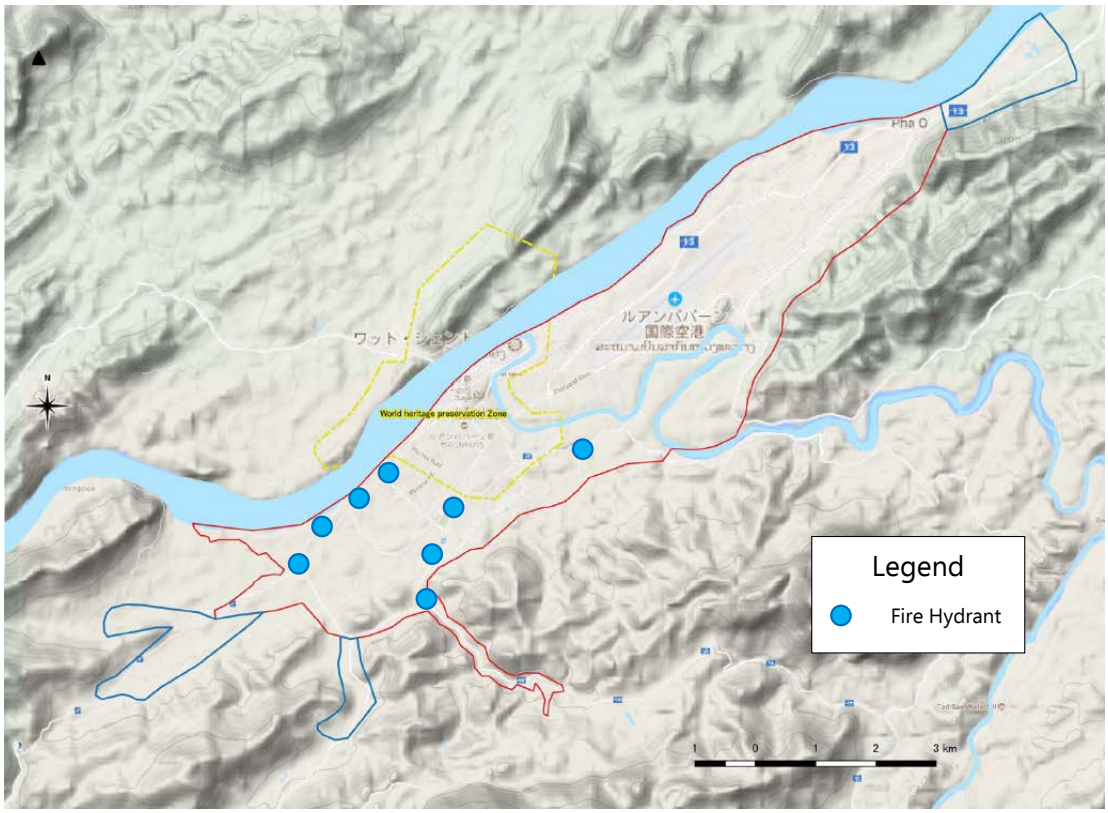
Figure 2.2.25 Standard design of fire hydrant

The proposed locations of fire hydrants for the World Heritage Site are shown in Figure 2.2.26 and the locations of those outside of the area are shown in Figure 2.2.27. A total of 45 fire hydrants are planned by the project.



Source: Prepared by JPST based on “Plan de sauvegarde et de mise en valeur（2001）

Figure 2.2.26　Proposed fire hydrant locations for the World Heritage Site



Map data: Google, Digital Globe

Figure 2.2.27 Proposed fire hydrant locations outside the World Heritage Site

(7) Water Supply System Design

1) Hydraulic Analysis (Pipeline Network Calculation)

A) Design Minimum Dynamic Pressure

The Lao regulations require minimum dynamic pressures (Table 2.2.33**)** to be maintained during daily maximum flow and for firefighting. Luang Prabang is classified as a large town. Therefore, 10~15 meters of dynamic pressure must be provided.

Table 2.2.33 Proposed minimum dynamic pressure (daily maximum demand with firefighting capability)

No	Category	Population	Min. Dynamic Pressure	Applicability in the project
I	Big City	Greater than 100,001	15 m	
II	Large Town	50,000 ~ 100,000	10 ~ 15 m	Applicable
III	Medium Town	20,000 ~ 50,000	10 m	
IV	Small Town (high potential)	5,000 ~ 20,000	10 m	
V	Small Town (low potential)	2,000 ~ 5,000	5 ~ 10 m	
VI	Community	Less than 2,000	5 m	

Source: The Lao Standard (MPWT (2009) Management and Technical Guidelines Water Supply)

Water requirement for firefighting specified in the Lao standard is summarized in Table 2.2.34. Hydraulic analysis was performed to calculate the water pressure for 12 L/s required at the end of distribution pipe.

Table 2.2.34 Firefighting demand

Category[1)]	Supply Population	Firefighting Demand	Applicability in the project
II and I	> 50,000	30 L/s (1.8 m^3/min)	
III and II	20,000 ~ 100,000	12 L/s (0.72 m^3/min)	Applicable
IV	5,000 ~ 20,000	6 L/s	
VI and V	< 5,000	Decided by designer	

1) same as the category of Table 2.2.33

Source: Lao Standard (MPWT (2009) Management and Technical Guidelines Water Supply)

The project will be designed to provide a minimum water pressure of 10-15 meters to meet the maximum daily demand with a simultaneous firefighting demand of 12 L/s.

B) Maximum Static Pressure and Dynamic Pressure

The Lao and Japanese standards for maximum static and dynamic pressure are summarized in Table 2.2.35.

Table 2.2.35 Maximum static pressure

Standards	Maximum Static Pressure	Maximum Dynamic Pressure
Lao	―	40 ~ 45 m
Japanese	Not exceed 0.74 MPa (approx. 74 m)	Desirable to limit to 0.50 MPa (approx. 50 m)

Lao Standard: (MPWT (2009) Management and Technical Guidelines Water Supply)

Japanese Standard: JWWA (2012) Design Criteria for Waterworks Facilities

According to the above requirements, the maximum static pressure should be 74 m and the dynamic pressure should not exceed a maximum of 40~45 m. Efforts will be made to keep the static pressure below 50 m to minimize the risk of developing excessive leakages in the system. However, static pressure more than 50 m will be unavoidable in certain locations.

C) Conditions for Hydraulic Analysis

Conditions for the hydraulic analysis are summarized in Table 2.2.36.

Table 2.2.36 Hydraulic analysis conditions

Item	Condition	Comments
Calculation	Hazen Williams Equation $H=10.666\times C^{-1.85}\times D^{-4.87}\times Q^{1.85}\times L$	H: Friction Loss (m) C: Pipe Roughness Coefficient (C value) D: Internal Diameter (m) Q: Flow Rate (m^3/s) L: Pipe Length (m)

Item	Condition	Comments
C Value	110	JWWA (2012) Design Criteria for Waterworks Facilities

D) Results

The results of the hydraulic analysis are shown below. The details of the hydraulic analysis are shown in **Appendix 7-1**.

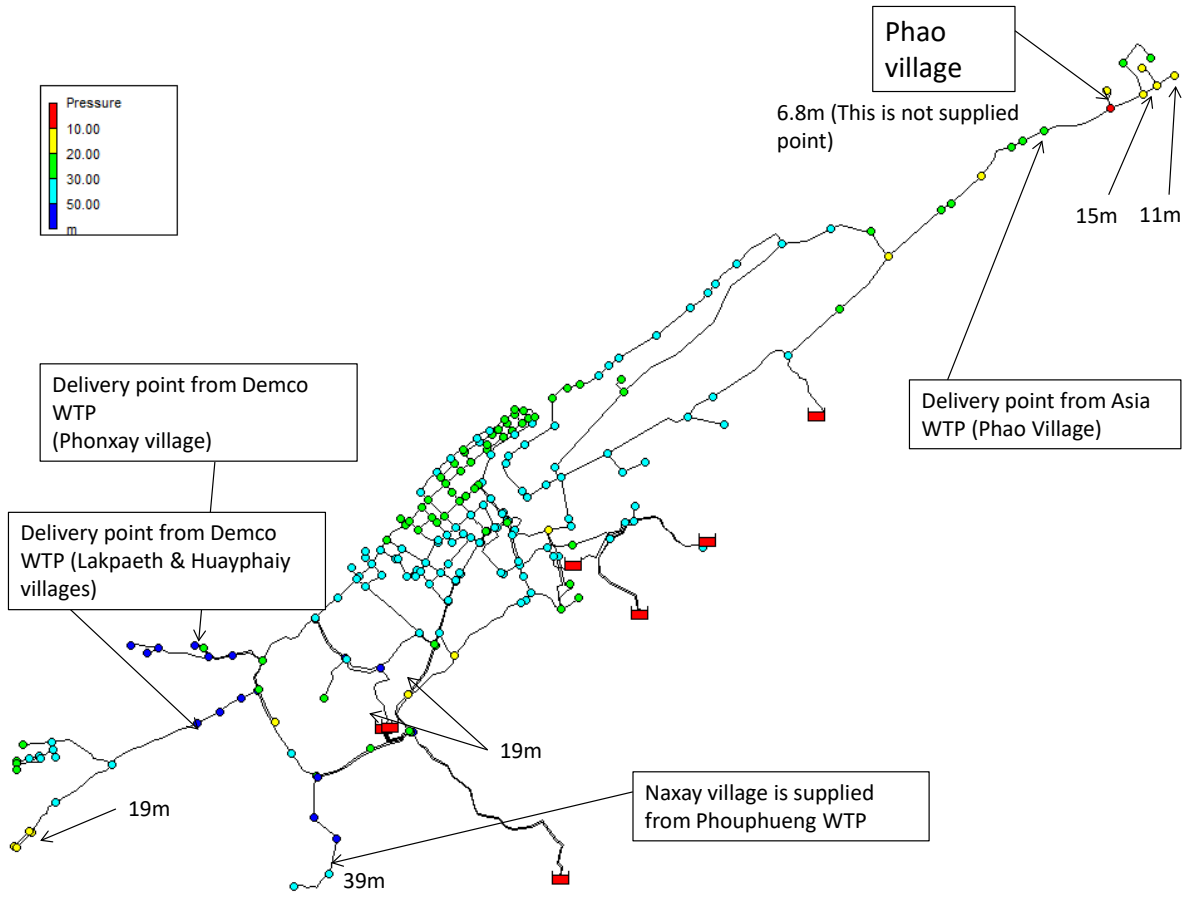


Figure 2.2.28 Results of hydraulic analysis

The villages shown in Table 2.2.37 will be supplied by Asia and Demco WTPs via WSSE-LPB distribution networks connected to Asia and Demco distribution mains. The WSSE-LPB networks must be able to deliver the bulk supply pressures at the delivery points.

Table 2.2.37 Pressure required at connection points to Asia/Demco networks

Area	Company	Bulk Supply Pressure	Comments
Phao Village	Asia	30 m	Satisfied (calculated)
Phonxay Village	Demco	25 m	Satisfied (calculated)
Lakpaeth, Huayphaiy Village	Demco	50 m	Satisfied (calculated)

The area which has the biggest water pressure is located around the delivery point by Demco, and the dynamic and static pressure in the area are about 59 m and 68 m respectively (see Figure 2.2.29).

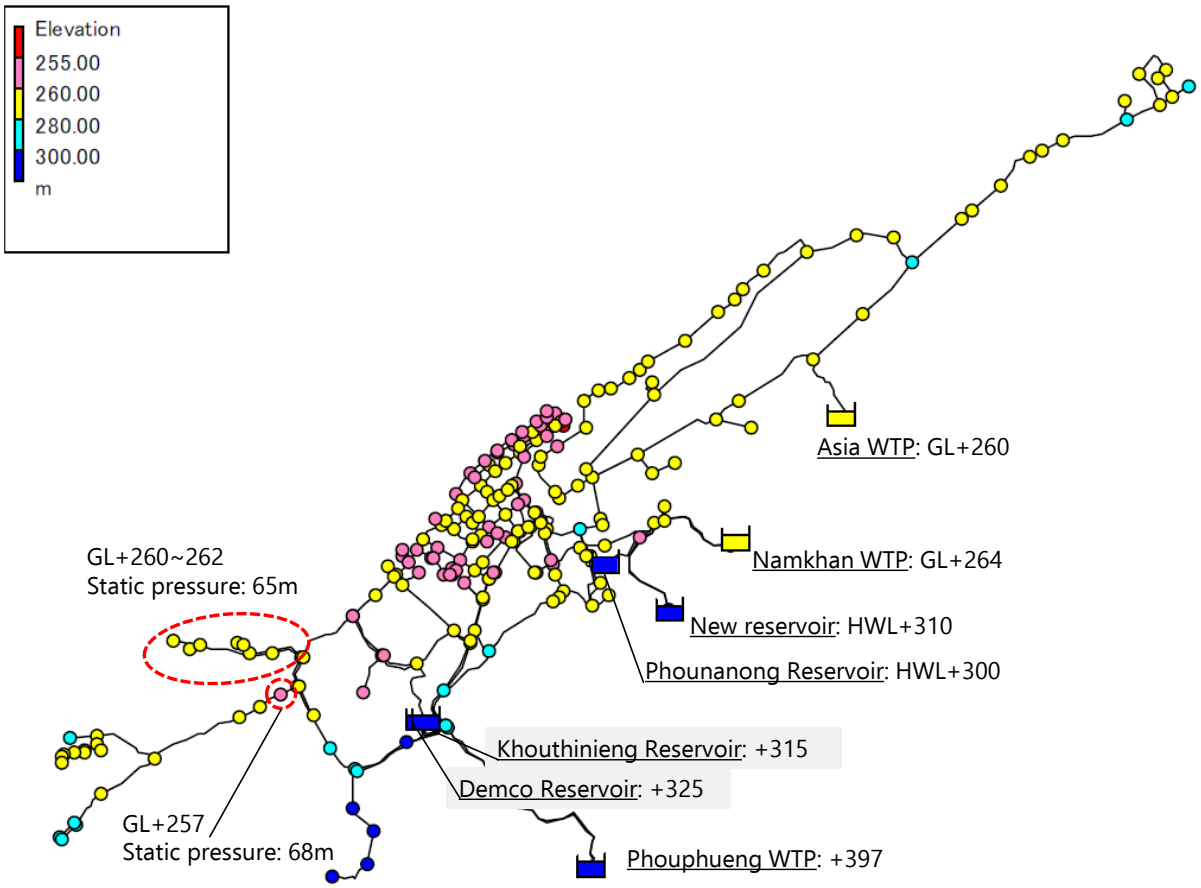


Figure 2.2.29 Elevation map

2) Results of surge analysis

The studies on the surge analysis were carried out to confirm the impact on the transmission pipelines from Namkhan WTP to new reservoir and from Phouphueng to Khouthinieng Reservoir. The results of the studies are shown below.

A) Namkhan to new reservoir by the transmission pump

A)-1 Without any countermeasures

- Significant impacts to the pipeline were confirmed, and there were the possibilities to occur water hammer.

A)-2 Application of flywheel

- Application of the flywheel makes the impacts small, and there were no possibilities to occur water hammer.

According to the above studies, the application of the flywheel, which is the cheapest measure, is enough for the surging. Thus, the flywheel is applied to the transmission pump. The details of the analysis are shown in **Appendix 7-2**.

B) Phouphueng to Khouthinieng Reservoir by gravity

The transmission system from Phouphueng WTP to Khouthinieng Reservoir is shown in Figure 2.2.30.

B)-1 In case of closing the either valve① or valve②

- The water hammer will not occur, since the water pressure escapes to the direction of the opened valve.

B)-2 In case of closing the both valve① and valve②

- There are the possibilities to occur water hammer. The velocity of pressure wave happened by closing valve is about 1,000 m/sec. The water hammer could be prevented, if the time to close the valve would be more than 70 seconds, which was more than 10 times of the round trip of the pressure wave in the transmission system.

According to the above studies, it is necessary to take more than 70 seconds to close the valves to prevent the water hammer. The guidance for the valve operation will be implemented by the soft component (technical assistance).

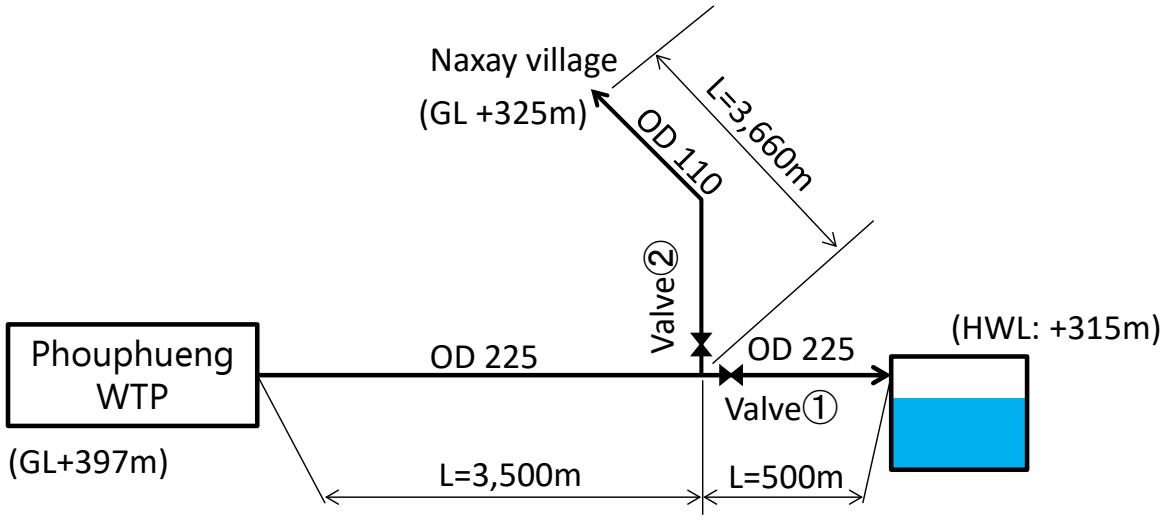


Figure 2.2.30 Schematic drawing of transmission system from Phouphueng WTP to Khouthinieng Reservoir

3) Pipe Material Selection

Comparison of materials considered for the transmission and distribution pipelines and yard piping for the Namkhan WTP and the new reservoir are summarized in Table 2.2.38.

Table 2.2.38 Pipe material comparison and selection

Material	DIP (Ductile Iron Pipe)	HDPE (High Density Polyethylene)	u-PVC (Un-plasticized Polyvinyl Chloride)
Durability	− High strength − High UV resistance	− High corrosion resistance − High UV resistance	− High corrosion resistance − Low UV resistance − Low impact resistance (easily damaged by road construction)

Material	DIP (Ductile Iron Pipe)	HDPE (High Density Polyethylene)	u-PVC (Un-plasticized Polyvinyl Chloride)
Workability	− Good workability push-on type connection, but not as much as HDPE or u-PVC	− Light, and good workability (especially with straight sections) − Workability for specially shaped fittings is not good.	− Light, and good workability
Past application	Used in older pipes in Luang Prabang city	Recently started to be used in Luang Prabang city	− Most commonly used pipe material in Luang Prabang city
Maintenance	Used in older pipes, spare parts are available. Maintenance can be performed easily.	Recently introduced to Luang Prabang city, logistic issues for spare parts may still exist. Also used by private water treatment plants, so the issue is not expected to be serious.	− Commonly used, issues with spare parts are not expected.
Cost	High	Moderate	Low Cost
Others	− Flexible within allowable bending angle − High reliability due to high strength	− High flexibility − Joints are fused. Risk of leakage is reduced.	− Joints tend to leak
Selection	Selected (for facility piping)	Selected (for transmission line)	Not Selected

u-PVC is the most common pipe material used in Luang Prabang city. It has low impact resistance and tends to develop leaks around connections. The use of HDPE pipes is on the rise in recent years.

HDPE will be selected for transmission and distribution pipelines in the project. The transmission and distribution pipes excluding the transmission line from Phouphueng WTP to Khouthinieng Reservoir will have the water pressure of 0.59MPa (59m) by dynamic pressure and 0.68MPa (68m) by static pressure at a maximum and 0.95MPa (95m) by consideration of water hammer pressure which is 40% of maximum static pressure. Therefore, pipes that can withstand approximately 1 MPa (100 m) will be selected for the project.

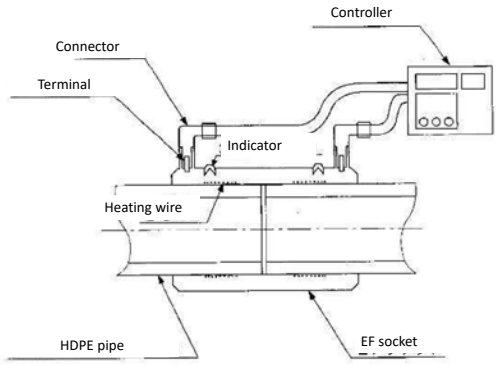
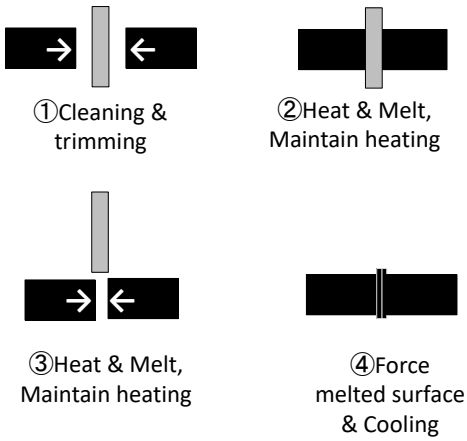
The transmission line from Phouphueng WTP to Khouthinieng Reservoir and branching points of the transmission lines to the distribution lines experience static pressures of up to 0.95 MPa (95 m) in some sections. For these lines, pipe with a strength of approximately 1.6 MPa (160 m) will be selected.

A lot of pipe fittings are required for the yard piping at the WTP and reservoir site. DIP pipes will be used for all yard piping because workability of HDPE fitting is low.

4) Joints for HDPE pipe

Electro-fusion (EF) and butt-fusion (BF) methods for jointing polyethylene pipes are compared in Table 2.2.39. Electro-fusion will be used for the project.

Table 2.2.39 Comparing jointing methods for HDPE pipes

Item	Electro-Fusion (EF)	Butt-Fusion (BF)
Steps for making pipe joints		
Method	After inserting the pipe into a joint (EF socket) in which a heating wire is embedded, electricity is supplied from a controller to generate heat, and the resin of the pipe and the joint is melted to make the connection.	After melting the end faces of the pipes by heating, the end faces are crimped and welded together.
Degree of Difficulty	◎ The task of inserting the pipe into the EF socket and activating the controller is relatively simple and time required is short.	△ Properly melting, aligning, and joining is difficult and requires high skill level. For this reason, EF bonding is generally recommended in Japan.
Cost	○ Construction cost is lower than for BF, but material costs are higher.	◎ Construction cost is higher than for EF, but material costs is cheaper.
Applicability for this project	◎ Simple task makes it easy to ensure quality. Quality control of joints is important because it directly relates to leakage prevention. Short construction time is an advantage in the World Heritage Site.	△ Since skill is required, it is more difficult to control construction quality. Construction time is also increased. So, it is not as attractive as EF.
Selection	Selected	Not Selected

5) Conditions for Pipe Laying

A) Earth Cover

Earth cover will be 0.8 ~ 1.4 meters depending on pipe diameter and whether the installation is along the road, sidewalk or road shoulder.

B) Installation Location.

Pipelines will be installed along road-shoulders and under sidewalks as much as possible. However, if

this is not possible because of waterways or other buried utilities, the pipes will be installed under roadways.

The general plan for pipe installation is shown in Figure 2.2.31.

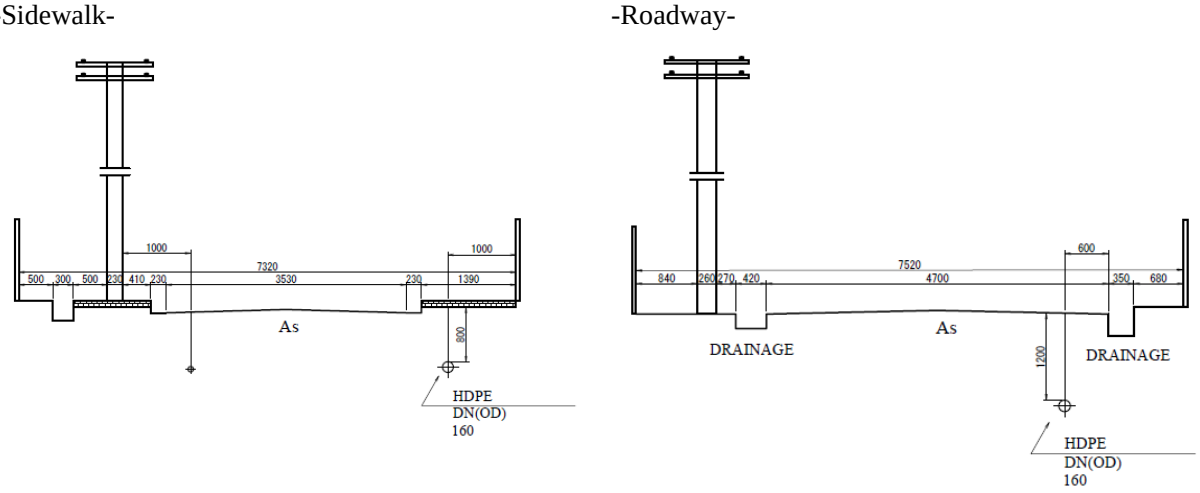


Figure 2.2.31 Cross section of pipe laying

6) Related Equipment

A) Gate Valves (Transmission Line)

To facilitate maintenance in sections, gate valves will be installed at 3 km intervals along the transmission line. Gate valves will also be installed around inverted siphons to avoid obstructions such as streams, at drain outs downstream, and pipe bridges.

B) Gate Valves (Distribution Line)

To facilitate maintenance, gate valves will be installed at all connection points of the network.

C) Air Valves

Air release valves will be installed at all high points in pipelines and at pipe bridges.

D) Drainage Facilities

After construction and installation of new equipment, pipes need to be flushed clear of turbid and contaminated water. Drainage facilities will be installed for this purpose at low points of the network, close to existing drainage channels, canals or rivers.

(8) Overview of the Transmission and Distribution Plan

Facility planning for water transmission and distribution is shown in Table 2.2.40.

Table 2.2.40 Facility planning for transmission and distribution

Facility			Details
Transmission Facilities	Transmission Lines		Total Length: approx. 5.0 km • From Phouphueng WTP to Khouthinieng Reservoir: 3.4 km (OD 225) • From Namkhan WTP to new reservoir (using existing transmission line): 1.6 km (OD 400)
Distribution Facilities	Reservoirs	New Reservoir	Reinforced concrete, flat slab construction Foundation: Direct foundation Count: 2 reservoirs Effective volume: V=1,500 m^3 (750 m^3×2 reservoirs) Effective depth: H = 5.00 m Retention time: 4.5 hours Dimensions: W 12.40 m × L 12.40 m × H 5.70 m
	Facility Piping	Inlet Pipe	DIP DN350, DN300
		Reservoir Connection Pipe	DIP DN300
		Outlet Pipe	DIP DN350, DN300, DN200
		Overflow Pipe	DIP DN300, DN200
		Drainage Pipe	DIP DN100
		Related Facilities	Water Meter Room: Reinforced Concrete, W 2.20 m × L 5.60 m × H 2.20 m
	Distribution Network	Piping	Total Length: approx. 60.2 km • From new reservoir to distribution branch: 1.6 km (OD 400) • Lines for service expansion area: 14.3 km (OD 80~225) • Renewal of old pipes: 44.3 km (OD 80～225)
Fire Hydrants			45

2.2.2.3 Namkhan WTP

(1) Basic Policy for Facility Planning

Although the existing WTPs in Luang Prabang city has capacity to meet the water demand of 2025, it still has deficiencies that need to be resolved. The facility plan for the Namkhan WTP will determine the improvements needed to achieve the delivery of safe, stable, sustainable supply.

(2) Operational Issues

The treatment capacity of the existing sedimentation process (from mixing well to sedimentation basin) is 6,000 m^3/day, while the capacity of the existing rapid sand filters is 12,000 m^3/day (refer to Figure 2.2.32). The following operational issues are considered:

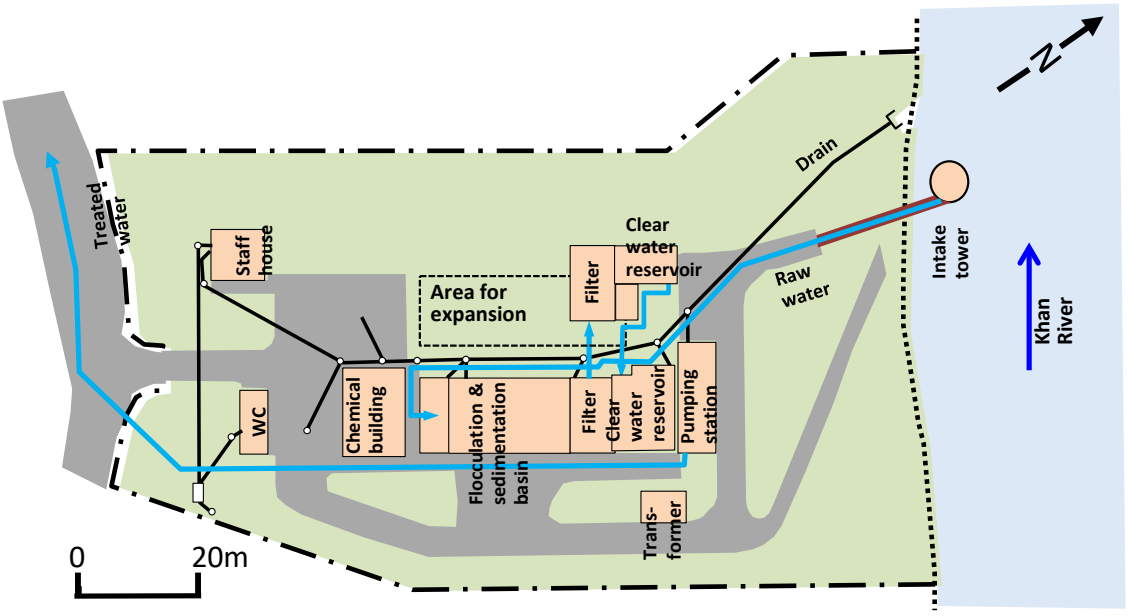


Figure 2.2.32 Layout of Namkhan WTP

- It is necessary to treat an amount of water exceeding the capacity of the sedimentation process. Therefore, floc carryover occurs at the inlet to the filters. The quality of the treated water (turbidity) is not stable.
- Solids load on the filters becomes high due to carryover of floc, and it is necessary to perform backwash frequently. Since the backwash uses treated water, the treated water production rate decreases during backwashing and is not stable.
- Since the sedimentation process cannot cope with high turbidity, it is necessary to reduce the intake of raw water during the rainy season and other times when turbidity increases; water production becomes unstable.
- The WTP was flooded in 2016 (Photo 2.2.8). The flood level was about 3 m higher than the planned high-water level as shown in Figure 2.2.33.

Photo 2.2.8 Flooding damage

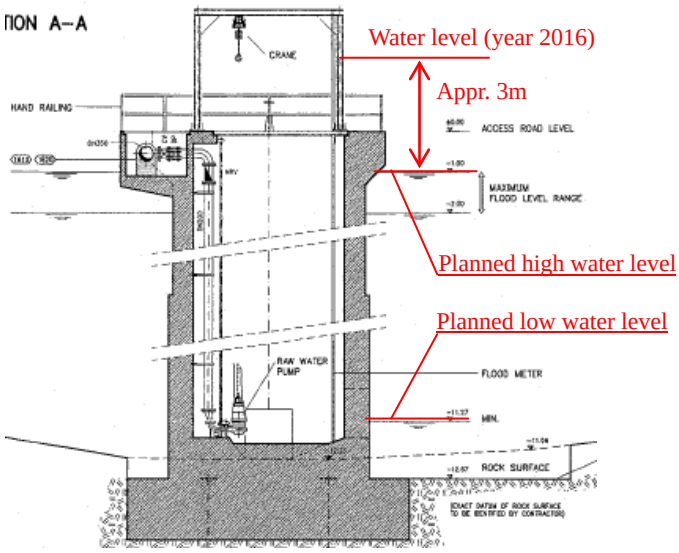


Figure 2.2.33 Section of intake tower

(3) Water Quality

1) Treated Water Quality

Table 2.2.41 shows the treated water quality of Namkhan WTP in 2017. The treated water quality in 2017 met the drinking water quality standard, but turbidity did not meet the standard in some cases. Turbidity data for the past 5 years are shown in "2) Water Quality ".

Table 2.2.41 Treated water quality of Namkhan WTP

Parameter	Unit	Permissible Limit	Monitoring Frequency			2017 Annual Report WSSE-LPB		Preparatory Survey Results
			Weekly	Monthly	Yearly	Raw water	Treated water	Raw water (Sampling date: April 25, 2018)
Microbial								
E. Coli	Units/100ml	0		✔		-	0	Detected
Chemical								
Aluminum (Al)	mg/l	<0.2		✔		0.015 to 0.03	0.027 to 0.091	-
Arsenic (As)	mg/l	<0.01			✔	-	-	ND (<0.005)
Chloride Cl^-	mg/l	<250			✔	3.0 to 4.0	5.0 to 8.0	4.3
Chlorine Cl_2 (free residual)	mg/l	0.1 - 2.0	✔			-	0.19 to 1.62	-
Copper)Cu)	mg/l	<2				-	-	-
Cyanide (Cn)	mg/l	<0.5			✔	-	-	-
Fluoride (F)	mg/l	<1.5			✔	0.04	<0.15	0.13
Iron (Fe)	mg/l	<0.3			✔	0.08	0.01	0.09
Lead (Pb)	mg/l	<0.01			✔	-	-	-
Manganese (Mn)	mg/l	<0.1			✔	-	-	ND (<0.01)
Mercury (Hg)	mg/l	<0.006			✔	-	-	-
Nitrate (NO_3^-)	mg/l	<50	✔			0.6 to 1.1	0.6 to 0.9	2.7
Nitrite (NO_2^-)	mg/l	<3	✔			0.005 to 0.006	0.004 to 0.005	ND (<0.05)
Sodium	mg/l	<200			✔	-	-	-
Sulfate ion (SO_4^{2-})	mg/l	<250			✔	-	-	-
Zinc (Zn)	mg/l	<3			✔	0.05	0.08	-
Taste	-	Acceptable	✔			-	-	-
Physical								
Color	TCU	<5	✔			0	0	9.0
pH	-	6.5 - 8.5	✔			7.39 to 8.20 7.85	7.26 to 8.10 7.74	8.3
Conductivity	μS/cm	<1000			✔	208 to 276	217 to 282	485
Turbidity	NTU	<5	✔			6.5 to 928 49	0.21 to 3.98 1.29	6.6
Total hardness as CaCo3	mg/l	<300			✔	112 to 168 128	98 to 166 119	124

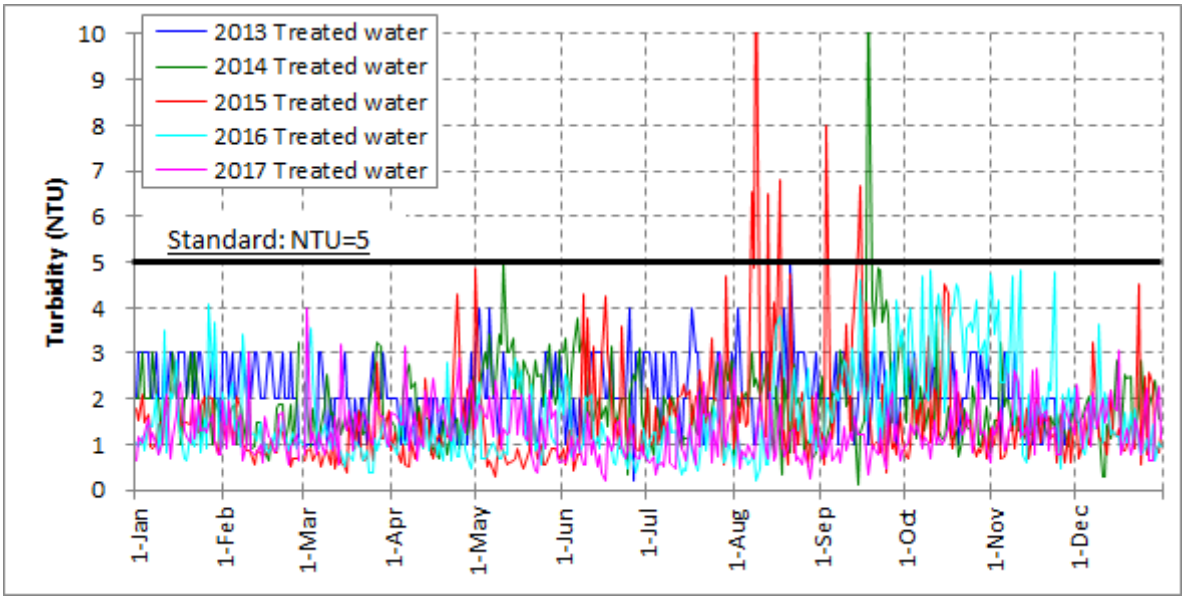
ND: Not detected Upper row: Lowest to Highest Lower row: Average

Source：Minister's Decision on Water Quality Standard Management for Drinking and Domestic Use (MOH, March 2014)

2) Water Quality

A) Turbidity (Namkhan WTP)

Figure 2.2.34 shows the turbidity of treated water at the Namkhan WTP over 5 years (2013-2017).



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.2.34 Turbidity of treated water (2013 to 2017)

The turbidity of treated water,

- in general, is lower than the drinking water quality standard of 5 NTU,
- exceeded the water quality standard 8 times over the past five years as shown in Table 2.2.42.

Table 2.2.42 Turbidity exceeding water quality standard (Unit: NTU)

Turbidity	**2014**	**2015**						
	9/18	**8/7**	**8/9**	**8/13**	**8/17**	**9/3**	**9/14**	**9/15**
Raw water	11,400	586	626	1,090	293	2,880	608	334
Treated water	11	6.56	12	6.48	6.82	8.00	5.37	6.67

Exceeding the water quality standard 8 times may not reflect the true extent of the turbidity problem if the frequency of measurement is considered. The WTP sometime reduces or stops the intake because of high turbidity. In other words, production amount is sacrificed in order to meet water quality standard. This aspect of the operation must be improved to secure stable water supply and quality considering the increase of water demands and impacts on the tourism which is a main industry of Luang Prabang city.

(4) Existing Water Treatment Facilities

1) Capacity Calculation

Table 2.2.43 shows the capacity calculations for Namkhan WTP.

Table 2.2.43 Capacity calculations

Facility	Shapes and Dimensions of the Existing Facilities	Design Standard and Evaluation
Raw water transmission pipe	DIP DN 300 mm, 140 m in length DN 200 mm electromagnetic flowmeter	Lao standard: - Flow velocity: 1.5 to 2.0 m/sec is recommended and less than 3.0 m/sec at maximum. Japanese standard: - Flow velocity: less than 3.0 m/s
	Treatment capacity with 6,000 m^3/day - Flow velocity: 0.98 m/sec	No problem
	Treatment capacity with 12,000 m^3/day: - Flow velocity: 1.96 m/sec	No problem
Mixing well	Type of mixing: hydraulic No. of wells: 1 Dimensions: W2.4 m x L4.35 m x D2.805 m = 29.28 m^3	Lao standard: not applicable Japanese standard: - Retention time: 1 to 5 min as a guide
	Treatment capacity with 6,000 m^3/day (4.17 m^3/min) - Retention time: 7.0 min	No problem
	Treatment capacity with 12,000 m^3/day (8.33 m^3/min): - Retention time: 3.5 min	No problem
Flocculation basin	Type of flocculation: hydraulic, up-and-down flow baffles No. of basins: 2 Dimensions: W0.6 m x L4.25 m x D2.78 m x 5 stages = 35.45 m^3/basin	Lao standard: - Flow velocity: 0.15 to 0.3 m/sec Japanese standard: - Retention time: 20 to 40 min - G value: 10 to 75 /sec - GT value: 23,000 to 210,000
	Treatment capacity with 6,000 m^3/day (2.08 m^3/min/basin) - Retention time: 17.0 min - Flow velocity: 0.10 m/sec - Designed G value: 19.6 sec-1 - Designed GT value: 19,961	Lower velocity Smaller GT value Affects good floc formation
	Treatment capacity with 12,000 m^3/day (4.16 m^3/min/basin) - Retention time: 8.5 min - Flow velocity: 0.19 m/sec - Designed G value: 51.7 sec-1 - Designed GT value: 260,100	Higher GT value Can shear floc and result in poor settling.
Sedimentation basin	Type: Horizontal flow No. of basins: 2 Dimensions: W5.5 m x L19.2 m x D2.879 m = 304.0 m^3/basin	Lao standard: - Width to length: 3 to 6 times - Overflow rate: 16.7 to 50 mm/min Japanese standard: - Width to length: 3 to 8 times - Overflow rate: 15 to 30 mm/min - Retention time: 20 to 40 min - Mean flow velocity in basin: less than 0.4 m/min
	Treatment capacity with 6,000 m^3/day	No problem

Facility	Shapes and Dimensions of the Existing Facilities	Design Standard and Evaluation
	(2.08 m^3/min/basin) - Overflow rate: 19.7 mm/min - Mean flow velocity：0.13 m/min (0.17 m/min at the end of basin)	
	Treatment capacity with 12,000 m^3/day (4.16 m^3/min/basin) - Overflow rate: 39.4 mm/min - Mean flow velocity：0.26 m/min (0.34 m/min at the end of basin)	Overflow rate is high compared to Japanese standard. Can cause carry over of sediment and floc.
Rapid sand filter (German aid in 2000)	Type: Gravity, single media constant rate filtration (cascade inflow, non-cascade outflow) No. of filters: 4 Dimensions: W2.4 m x L3.55 m x 2 filters (8.52 m^2/filter) W2.45 m x L3.55 m x 2 filters (8.70 m^2/filter) Total area: 34.44 m^2 Water backwashing and air scoring	Lao standard: - Filtration rate: 120 to 360 m/day Japanese standard: - Filtration rate: 120 to 150 m/day in general in single media
	Treatment capacity with 6,000 m^3/day - Filtration rate: 174 m/day (during one filter washing: 233 m/day)	No problem
Rapid sand filter (Lao government budget in 2011)	Type: Gravity, single media constant rate filtration (cascade inflow, non-cascade outflow) No. of filters: 4 Dimensions: W2.425 m x L4.52 m x 4 filters Total area: 43.84 m^2 Water backwashing and air scoring	Lao standard: - Filtration rate: 120 to 360 m/day Japanese standard: - Filtration rate: 120 to 150 m/day in general in single media
	Treatment capacity with 6,000 m^3/day - Filtration rate: 137 m/day (during one filter washing: 182 m/day)	No problem
Clear water reservoir (German aid in 2000)	No. of reservoirs: 1 Dimensions: W12.0 m x L9.0 m x D3.45 m = 373 m^3	Lao standard: Not applicable Japanese standard: - Retention time: more than 1 hour
	Treatment capacity with 6,000 m^3/day (250 m^3/hour) - Retention time: 1.5 hours	No problem
Clear water reservoir (Lao government budget in 2011)	No. of reservoirs: 1 Dimensions: W12.0 m x L9.0 m x D3.68 m = 397 m^3	Lao standard: Not applicable Japanese standard: - Retention time: more than 1 hour
	Treatment capacity with 6,000 m^3/day (250 m^3/hour) - Retention time: 1.6 hours	No problem

Lao standard: Management and Technical Guidelines Water Supply 2009, MPWT

Japanese standard: Design Criteria for Water Supply Facilities 2012, Japan Water Works Association

The raw water transmission pipe, mixing well and clear water reservoir satisfied both the Lao and Japanese standards. Some parts of the flocculation basin, sedimentation basin and rapid sand filter (year 2000) do not meet the Lao or Japanese standards. The flocculation basin and filter (year 2000)

can be used without problems as explained in the following paragraph. The capacity of the sedimentation basin is under sized and doubling the capacity of this unit process should be considered.

Flocculation basin

The design capacity of the existing basin is 6,000 m^3/day. Based on the operating conditions of the existing facilities, the floc is well formed at flow rates of 6,000 to 12,000 m^3/day. The GT (G: mixing intensity, T: mixing duration) value at 12,000 m^3/day is 260,100, which is higher than the Japanese standard and could lead to floc shearing and poor settling. At 6,000 m^3/day, the GT value is 19,961 which is slightly lower than the Japanese standard.

Since it can be confirmed that floc is formed in the actual operation, no change is required for the existing facility. The GT value can be increased by adjusting the height of the baffle plate.

Sedimentation basin

At the treatment capacity of 12,000 m^3/day, the overflow rate is 39.4 mm/min, which is higher than the Japanese standard (15 to 30 mm/min). Floc carryover is confirmed under actual operating conditions. Since the capacity of the existing sedimentation basin (6,000 m^3/day) does not match the capacity of the filter of 12,000 m^3/day, it is reasonable to say that the current facility is insufficient.

Rapid sand filter (year 2000)

Filtration rate is 174 m/day which is faster than the Japanese standard (120 to 150 m/day) but is consistent with the Lao standard. No problem would be expected at this range.

2) Water Treatment Structures

The results of field investigation of the existing facilities are shown in Table 2.2.44. Facilities to be rehabilitated or replaced by the project are underlined.

Existing facilities basically have no serious problems except for the concrete around the chemical solution tank.

Table 2.2.44 Survey of water treatment facilities of Namkhan WTP

Facility	Location of Investigation	Year of Commencement	Results of Investigation
Intake facilities	Intake tower	2000	• No cracking in concrete.
	Pump shed		• No loose rust and paint peeling on steel columns and tie beams.
	Access bridge		• Loose rust and paint peeling on steel lattice girders.
Raw water transmission facilities (Raw water pipe)	DN 300 mm on steel lattice guider	2000	• No water leakage found from flange joints. • No loose rust on the outside of pipe.
	Pipe hanging clamp		• No loose rust.
	Underground pipe		• No loose rust on the outside of pipe.

Facility	Location of Investigation	Year of Commencement	Results of Investigation
	Above ground pipe (flow meter and chemical feeding parts)		• No loose rust on the outside of pipe.
Water treatment facilities	Mixing well	2000	• No cracking in concrete.
	Flocculation basin		• No cracking in concrete.
	Walls of sedimentation basin		(Eastern side) • 12 cracks in concrete and 1 has efflorescence. • No trace of water leakage from the cracks. (Western side) • 13 cracks in concrete and 2 has efflorescence. • 7 cracks show traces of water leakage.
	Walls of filters		• No cracking in concrete on both side walls. • One efflorescence was found on the wall of the pipe gallery. (Although there is no problem in the short term, if left for a long time it will cause water leakage, so it should be repaired.) • No water leakage around pipe passage through the side wall of the pipe gallery.
	Walls of filters	2011	• One efflorescence on the right wall. • One efflorescence on the wall of pipe gallery.
Chemical feeding facilities	Chemical dosing station	2000	(External Surface) • Paint peeling. • Cracking in mortar plastering of brick walls. (Internal Surface) • Paint peeling on ceiling, wall and stair.
	Around chemical solution tank		• Leakage from the bottom of the second tank from the left. • Peeling of anticorrosion paint (all four tanks). • Chemical leakage from lower surface of the mixer motor grate (concrete). → Total repair of the tank is necessary.
	Piping trough		• Corrosion is severe (grating lid and frame).
Treated water transmission facilities	Clear water reservoir	2000	• One efflorescence on the wall of pump room.
	Pump room shed		(External surface) • Sound, no paint peeling. (Internal surface) • Paint peeling on ceiling and wall.
	Clear water reservoir	2011	• One efflorescence on the eastern side wall.
	Pump room shed		(External surface) • Sound, no paint peeling. (Internal surface) • Sound, no paint peeling.

3) Mechanical Equipment

Survey results of the existing mechanical equipment are shown in Table 2.2.45. Equipment to be

rehabilitated or updated by the project is underlined.

Table 2.2.45 Results of field investigation of mechanical equipment of Namkhan WTP

Equipment	Specification	QTY	Results of Investigation
Intake pump	Submersible motor pump		
	295 m^3/h x 36 m (7,080 m^3/d) (2011 year)	3	• Not a specification that can operate continuously for 24 hours • Running pump alternately. There is no standby pump. • The impeller is worn out. The material of impeller cannot cope with grit in high turbidity raw water. →Replace with new pumps that can cope with grit in high turbidity raw water.
	450 m^3/h x 36 m (10,800 m^3/d) (2008 year)	1	• Not a specification that can operate continuously for 24 hours. • The impeller is worn out. The material of the impeller cannot cope with grit in high turbidity raw water. • →Replace with new pumps that can cope with grit in high turbidity raw water.
Transmission pump (Namkhan WTP to Phousi Reservoir)	No. 1 to No. 4 240 m^3/h (5,760 m^3/d) x 50 m (year 2011)	4	• Running. →The Phousi Reservoir will be abandoned and a new reservoir will be constructed at a different location. The pumps must be replaced to match new discharge conditions.
	No. 5 390 m^3/h (9,360 m^3/d) x 49 m (year 2008)	1	• Pump capacity is too big relative to the required transmission flow, making operation inefficient and uneconomical. • Not running. →Abandon.
Transmission pump (Namkhan WTP to Phounanong Reservoir)	155.9 m^3/h (3,741.6 m^3/d) x 49 m (year 2011)	3	• Running. • The capacity of the pumps is appropriate.
Filter backwashing pump	Horizontal shaft single suction volute pump 200 m^3/h (3.33 m^3/min) x 9 m (year 2000 year)	2	• Running. • Backwashing speed: Filter (year 2011): 0.30 m^3/m^2/min (low) Filter (year 2000): 0.38 m^3/m^2/min • Backwashing speed for the filter (2011) is not enough.
Filter air scouring blower	Roots blower		• If the air scouring rate is 1 m^3/m^2/min, the requirements are as follows: Filter (year 2011): 10.96 m^3/m^2/min Filter (year 2000): 8.7 m^3/m^2/min
	16.96 m^3/min x 1,650 min^{-1} (2018 year)	1	• Capacity for required air volume is 1.7 times. →To be used continuously by changing the pulley to adjust the air volume.
	600 m^3/h (10 m^3/min)	1	• Faulty →The blower must be replaced.
Chemical feeding facility	Alum solution tank: RC made, Constant water level tank with mixer	2	• Used as PAC tank. • The inside of tank is corroded. →Replace with FRP tank.
	Lime solution tank:	2	• Used as PAC tank.

Equipment	Specification	QTY	Results of Investigation
	RC made, Constant water level tank with mixer		• The inside of tank is corroded. →Replace with FRP tank.
	Polymer solution tank: Polyethylene tank with mixer	2	• Functioning.
	Pre-chlorination facility: Calcium hypochlorite solution tank, Polyethylene constant water level tank	1	• Hypo scale on the internal surface of the tank. • Pre-chlorination is not implemented. →Replace according to location of the pre-chlorination facility
	Post-chlorination facility: Calcium hypochlorite solution tank, Polyethylene constant water level tank	2	• Post-chlorination facilities are installed on the slab of clear water reservoir. • Hypo scale on the inside of the tank.

4) Electrical Facility

The survey results for the existing electrical equipment are shown in Table 2.2.46. Equipment to be updated by the project is underlined.

Table 2.2.46 Results of field investigation for electrical equipment at Namkhan WTP

Equipment	Specification	QTY	Results of Investigation
Power receiving and transforming equipment			
No. 1 Transformer	500 kVA 22 kV/380 V 50 Hz oil-filled transformer	1	• This transformer is for transmission pump (Phousi Reservoir), 1 large intake pump and equipment for filter. • This is in the transformer room with no protection from electrical accident. • The room is not ventilated sufficiently and not cleaned. Electrical accident can occur. • No.1 and No.2 transformers are installed in 2 different locations making it difficult for maintenance.
No.2 Transformer	250 kVA 22 kV/380 V 50 Hz oil-filled transformer	1	• This transformer is for transmission pumps (Phounanong Reservoir), 3 small intake pumps. • Since this is installed on a utility pole outdoors, it is safe. • No.1 and No.2 transformers are installed in 2 different locations making it difficult for maintenance.
Operation equipment			
Monitoring panel	Indoor self-standing	1	• This panel is for monitoring and control of the entire WTP. • This panel includes power circuit and auxiliary relay for the entire WTP. • This is installed in the old control room. • Originally, this panel could monitor and control the entire WTP, but currently some parts of the panel are out of order. Therefore, it needs to control each panel of intake pump, transmission pump, and chemical feeding facility respectively. Therefore, the operability is not good.

Equipment	Specification	QTY	Results of Investigation
Intake pump control panel (large)	Indoor self-standing	1	• This panel is for 1 large intake pump and is installed in the old control room. • The power circuit is separated from the one for the small pumps. Operability is not good.
Intake pump control panel (small)	Indoor self-standing	1	• This panel is for 3 small intake pumps and is installed in the new control room. • The power circuit is separated from the one for the large intake pump. Operability is not good.
Chemical feed facility control panel	Indoor self-standing	1	• This panel is for the chemical feed facilities and is installed in the chemical building. • The ventilation is not enough in the building.
Transmission pump control panel (Phousi Reservoir)	Indoor self-standing	1	• This panel is for transmission pumps (Phousi Reservoir) and is installed in the old control room. • Pump operability is not good, since the control room is separated from the control panel room for Phounanong transmission pump.
Transmission pump control panel (Phounanong Reservoir)	Indoor self-standing	1	• This panel is for transmission pumps (Phounanong Reservoir) and is installed in the new control room. • Pump operability is not good, since the control room is separated from the control panel room for Phousi transmission pump.
Intake pump switch box	Outdoor	1	• This switch box is for local operation of intake pump and is installed in intake tower. • Rain and wind hit the box directly. Installation environment is not good.
Air scouring blower switch box	Indoor	1	• This switch box is for local operation of air scouring blower and it is installed in the old pumping station. • Pumping station is not ventilated. Installation environment is not good.
Backwash pump switch box	Indoor	1	• This switch box is for local operation of backwash pump and is installed in the old pumping station. • Pumping station is not ventilated sufficiently. Installation environment is not good.
Air scouring blower switch box	Outdoor	1	• This switch box is for local operation of air scouring blower and is installed on the upper side (outdoor) of the old filter basin. • Rain and wind hit the box directly. Installation environment is not good.
Backwash pump switch box	Outdoor	1	• This switch box is for local operation of backwash pump and is installed on the upside (outdoor) of old filter. • Rain and wind hit the box directly. Installation environment is not good.
Transmission pump switch box (Phousi Reservoir)	Indoor	2	• These switch boxes are for local operation of transmission pump (Phousi Reservoir) and are installed in the old pumping station. • Pumping station is not ventilated sufficiently. Installation environment is not good.
Aluminum sulfate solution tank switch box	Indoor	2	• These switch boxes are for local operation of aluminum sulfate tank mixer and are installed in the chemical building. • Building is not ventilated sufficiently and the switch boxes are installed near stored chemicals. Installation environment is not good.
Lime solution tank	Indoor	2	• These switch boxes are for local operation of lime tank

Equipment	Specification	QTY	Results of Investigation
switch box			mixer and are installed in the chemical building. • Building is not ventilated sufficiently and the switch boxes are installed near stored chemicals. Installation environment is not good.
Measuring equipment			
Intake flow meter	Electromagnetic type	1	• This is for measuring intake. • This is installed in the flow meter pit next to the sedimentation basin. • Installation environment is not good: − flow meter pit has no cover − rain and wind hit the flow meter directly.
Transmission flow meter (Phousi Reservoir)	Electromagnetic type	1	• This is for monitoring transmission (Phousi Reservoir). • This is installed in the old pumping station.
Transmission flow meter (Phounanong Reservoir)	Electromagnetic type	1	• This is for monitoring transmission (Phounanong Reservoir) • This is installed in the new pumping station.

(5) Design Plan for Raw Water Intake Facility

1) Existing Facility

Table 2.2.47 shows the issues of the existing intake facilities of Namkhan WTP

Table 2.2.47 Issues of existing intake facilities of Namkhan WTP

Item	Issue
Intake	The impeller is worn out. The impeller is damaged by sand in the high turbidity water.
Maintenance hoist crane of intake pump	The existing hoist is a single winding type. The hook moves laterally when the wire is wound. The lifted pump hits the inside of the intake tower when it is being hoisted.
Removal of sand in intake tower	Sand accumulates on the bottom of the intake tower. The pump will be damaged by sand.
Control equipment for intake water flow	Currently, intake flow control is not provided. Intake fluctuates depending on the water level of the Khan River. To stabilize the quality of treated water, it is important to control the raw water intake to match the constant chemical feed rate.

2) Facility Plan

A) Structure of Intake Tower

The existing concrete structures are in good enough condition and will not need to be replaced or rehabilitated.

B) Mechanical Equipment

The plan for mechanical equipment at the intake facility is shown in Table 2.2.48.

Table 2.2.48 Plan for mechanical equipment (Intake equipment of Namkhan WTP)

No.	Equipment	Specification	QTY	Purpose/Reason for installation
1	Intake pump	Submersible motor pump 9.2 m^3/min x 25 m x 75 kW 4.6 m^3/min x 25 m x 37 kW	 3 3	The existing pump is not suitable for high turbidity raw water.
2	Sand extraction pump	Submersible motor sand pump 0.5 m^3/min x 15 m x 5.5 kW	2	In order to protect the intake pump, the pump removes the accumulated sand from the bottom of the intake tower.
3	Pump handling hoist (intake pump)	Chain hoist (motor) 1.5 t	1	To make maintenance easier. The detailed explanations are shown below.
4	Jib crane (sludge extraction pump)	Manual chain hoist 360^o rotation and manual trolley with hook	1	For loading and unloading of the sludge extraction pump and change of operation position.
5	Intake water flow control valve	Toothed vane disc butterfly valve with worm gear operator	1	To control flow for stable water quality (No flow control valve now).

Further information on intake pump and pump handling hoist is shown below.

Intake pump

The same type of intake pumps with existing ones can be accommodated in the existing intake tower. The longest operating time for a pump is 12 hours and pumps are operated alternately. (Thus, two pumps with each capacity of 6,000 m3/day are equivalent to a pump of 6,000 m3/day with the function of continuous operations.)

Large and small pumps are required, since operation of one of two treatment systems is sometimes suspended for flow adjustment, cleaning and maintenance.

Given the above, three large and three small pumps will be installed, some of which will be on standby. Since the water level fluctuation is not so large, pumps will be fixed speed. The flow rate can be adjusted by controlling the number of pumps in operation.

Pump handling hoist (intake pump)

The existing hoist is a single winding type. The hook position shifts when winding up the wire. It is difficult to hoist and suspend the pump without lateral movement of the hook. The pump can hit the inside of the intake tower when it is being hoisted.

In the new chain type hoist, the hook stays in the same position when the pump is lifted or suspended.

C) Electrical Equipment

The plan for electrical equipment at the intake is shown in Table 2.2.49

Table 2.2.49 Electrical equipment plan (Intake equipment at Namkhan WTP)

No	Equipment/Instrument	Type	QTY	Purpose/Reason for installation
1	Control panel for intake pumps	Indoor self-standing	1	To match the new intake pumps. Installation of sludge extraction pump requires new power circuit.
2	Local control panel for intake pumps	Outdoor Post mounted	1	To match the new intake pumps.
3	Local control panel for sand extraction pump	Outdoor Post mounted	1	Installation of new sand extraction pump requires local control panel.

(6) Water Treatment Facilities Plan

1) Existing Water Treatment Process

The existing water treatment process at Namkhan WTP is shown in Figure 2.2.35. The Namkhan WTP started to operate in year 2000 with a treatment capacity of 6,000 m^3/day, taking raw water from the Khan River. The treatment facilities consist of mixing well, flocculation and sedimentation basins and rapid sand filters. Additional rapid sand filters were put into operation in 2011 to add a capacity of 6,000 m^3/day. At present, settled sludge and backwash wastewater from filters are discharged directly to the Khan River.

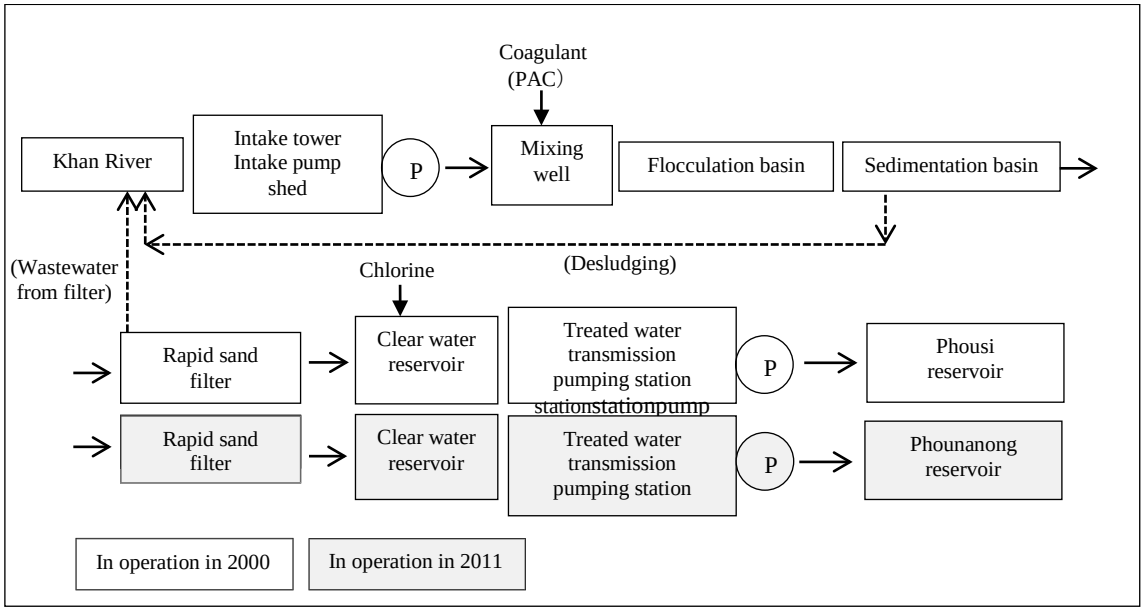


Figure 2.2.35 Existing water treatment process at Namkhan WTP

2) Existing Water Treatment Facilities

Table 2.2.50 summarizes the major issues of the existing water treatment facilities at the Namkhan WTP.

Table 2.2.50 Existing Operating Issues at Namkhan WTP

Facility/Equipment	Issues
Receiving and mixing well	The capacity of 6,000 m^3/day is insufficient and does not match filter capacity of 12,000 m^3/day. If the flocculation basin and the sedimentation basin are constructed for a capacity of 12,000 m^3/day, it will be impossible to distribute the flow evenly to each flocculation basin.
Flocculation basin, Sedimentation basin	The capacity of 6,000 m^3/day is insufficient and does not match filter capacity of 12,000 m^3/day. There is floc carryover from the sedimentation process to the filters.
Rapid sand filter	Floc carryover from the sedimentation basin clogs of the filters, which need more frequent backwashing and causes a reduction in production capacity. Algae grows on the sand.
Water supply structures	Cracks (with trace leakage) in sedimentation basin and filters.
Filter backwashing pump	Small capacity.
Filter air scoring blower	One of the two existing blowers is out of order.
Connection between clear water reservoirs	There is no connection between the 2 clear water reservoirs. Filter backwashing operations can only access the water from one reservoir and this can have a negative impact on the amount of water available for distribution. Therefore, a pipe connecting the two reservoirs is needed to simplify operations and provide more flexibility.
Treated water transmission pump (for new distribution reservoir)	The existing water transmission pump for the Phousi Reservoir is not suitable for the different discharge conditions imposed by the new reservoir location.
Wastewater treatment facilities	Currently there are no such facilities and the wastewater is discharged to the Khan River without treatment.
Chemical feeding facilities	The coagulant is fed to the raw water transmission pipe. When the intake water amount is large, the feeding volume is increased using a temporary hose. The control of chemical feed rate is not efficient.

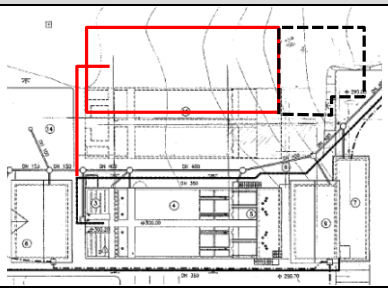
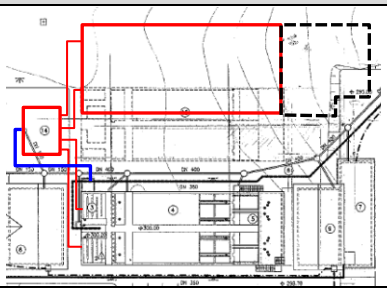
3) Design Plan of Water Treatment Facilities

A) Water Treatment Process

The existing mixing well cannot evenly distribute the flow of raw water to stabilize the quality of treated water. The design of the receiving and mixing wells is reviewed to improve this situation.

Table 2.2.51 shows the options for the receiving and mixing well design.

Table 2.2.51 Options for receiving/mixing well design

	Option 1	**Option 2**
Outline		
Explanation	Utilize the existing raw water transmission pipe to connect to the newly constructed receiving/mixing well, flocculation basin and sedimentation basin.	Construct the receiving/mixing well to evenly distribute raw water to each process train.
Advantages	• It can make use of the existing raw water transmission pipe. • It is simple facilities.	• Chemical mixing becomes efficient, better floc formation can be expected, contributing to stabilization of treated water quality. • It can evenly distribute the flow to each flocculation and sedimentation process train and the chemical feed rate can be made constant, thereby providing stable quality of treated water. • Improved floc formation reduces the load on the filters.
Disadvantages	• It is difficult to evenly distribute the flow to each process train. • The chemical is injected into the raw water pipe, and the efficiency of chemical mixing is inferior to case 2.	• It is necessary to use a part of the parking lot.
Selection	Not selected	Selected

Option 1 is simple to maintain, but Option 2 can provide equally distributed flow, thereby stabilizing the quality of treated water. Option 2 also improves the chemical feeding process. Option 2 is selected.

B) Water Treatment Structures

B)-1 Receiving/Mixing Well

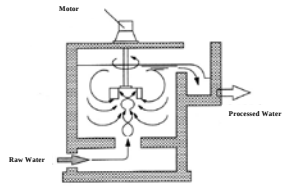
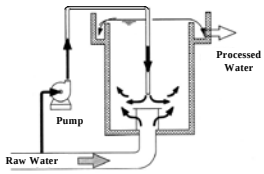
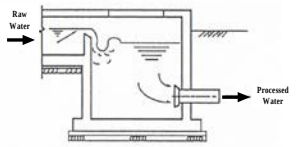
A receiving/mixing well will be constructed with a capacity of 12,000 m^3/day.

In the mixing well, turbulent or vortex flow can be generated by mechanical mixing such as rapid mixer or pump, or by energy of the water flow itself (hydraulic mixing).

Hydraulic mixing has no mechanical operation, and therefore is easier to maintain and cheaper in terms of construction and O & M.

The receiving well will be the hydraulic mixing type. Figure 2.2.36 shows a schematic design of the receiving/mixing well.

Table 2.2.52 Mechanical and hydraulic mixing

Mechanical mixing by rapid mixer	Mechanical mixing by pump	Hydraulic mixing by water flow
		

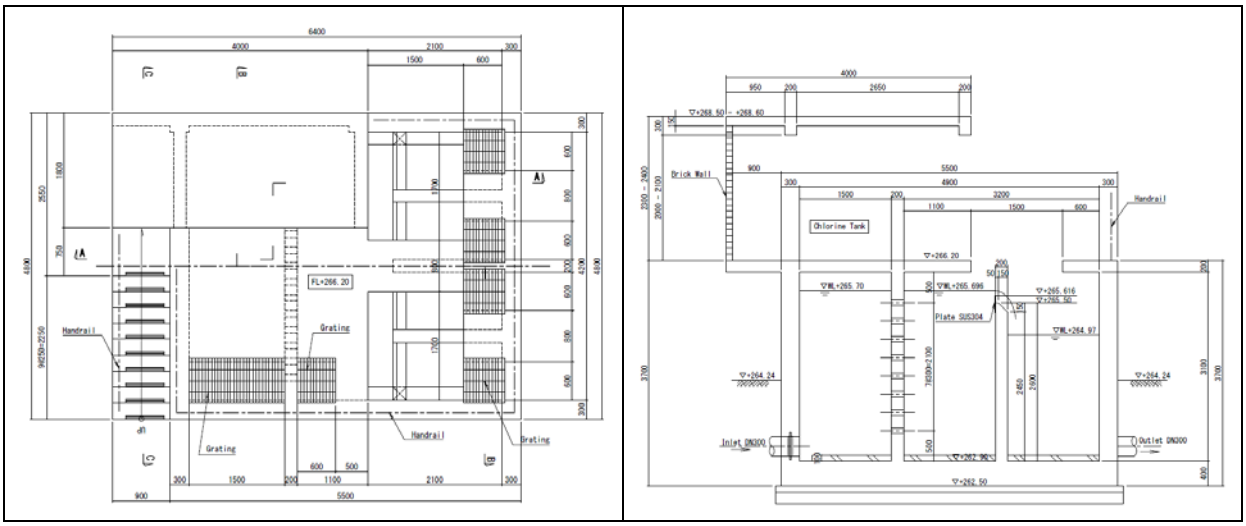


Figure 2.2.36 Schematic design (Receiving/mixing well)

B)-2 Flocculation Basin and Sedimentation Basin (New)

A new flocculation basin and sedimentation basin are needed to address the deficit capacity of 6,000 m^3/day, to achieve stable treated water quality and quantity. The formulation of the new flocculation and sedimentation basins is adjusted with the existing facilities.

B)-3 Foundation of Facilities

The foundation of new facilities will be the direct type judging from the result of soil investigation and from the foundation type of existing facilities.

B)-4 Existing Facilities

No change will be made.

B)-5 Connecting Pipe

A pipe will be installed connecting the two clear water reservoirs, using the existing drain valves (φ200 and φ250), without having to drain water from the reservoirs.

B)-6 Repair

The cracks observed in the existing sedimentation basin should be repaired. As this can be carried out by WSSE-LPB, the work is included in the Lao responsibilities.

C) Mechanical Equipment Plan

C)-1 Existing Facilities

The mechanical equipment plans for the existing water treatment facilities are shown in Table 2.2.53

Table 2.2.53 Mechanical equipment plan for the existing facilities at Namkhan WTP

Equipment	Specification	QTY	Purpose/Reason for installation
Sedimentation drainage equipment	Siphon drain pipe and vacuum pump	2	To drain the supernatant from the sedimentation basin at the time of sludge extraction.
Filter backwash pump	4 m^3/min x 10 m	2	To properly operate the existing filters.
Filter air scouring blower	11 m^3/min x 40 kPa	1	To replace the existing old blower. (The other existing new one will be modified as shown below.)
Transmission pump	4.5 m^3/min x 55 m with flywheel	2	To transfer required amount of water to the new reservoir.
Transmission flow control valve	Toothed vane disc butterfly valve with worm gear operator	1	To control transmission flow to the new reservoir.

Further explanations are shown below.

Sedimentation drainage equipment

There is only a drain valve at the bottom of the existing sedimentation basin. With this equipment, the supernatant is drained separately from the sludge, thus improving the sedimentation efficiency of the backwash wastewater treatment facility.

Filter backwash pump

The new pumps will provide the optimal backwash rate.

Filter air scouring blower

A recently installed belt type blower has 1.7 times of the required air scouring rate. By changing the belt drive pulley it is possible to lower the rotation speed and the air volume to save energy. The other blower installed in 2000 will be replaced before it starts to expensive maintenance issues.

Transmission pumps

There are 4 existing pumps manufactured by PACO with discharge rate of 4.0 m^3/min and 50 m head and 1 pump made in China with discharge rate of 6.5 m^3/min and 49 m head. These pumps do not meet the requirement of 4.5 m^3/min and 55 m head for transmission to the new reservoir. New pumps must be installed. The new pumps should be able to prevent pressure surge (water hammer) when the pumps stop suddenly in case of emergency or loss of power. Pumps with flywheels resist changes in rotational speed by their moment of inertia and keep spinning after a sudden stop thereby slowly ramping down and preventing water hammer. Therefore, pumps with flywheels will be installed.

Transmission flow control valve

The flow control valve is needed to optimally control the water transmission to the new reservoir. It is also important for extending the service life of the transmission pumps by operating without frequent stops.

Intermediate chlorine equipment

Intermediate chlorination can suppress algae growth on filters. It is not installed by the project for the following reasons:

- The moderate amount of algae growth can be suppressed by cleaning.
- The equipment may not be necessary if the problem is not serious.
- The equipment is not expensive and can be installed by WSSE-LPB if the need arises.

C)-2 New Water Treatment Facilities of the Namkhan WTP

The mechanical equipment plans for the new water treatment facilities are shown in Table 2.2.54.

Table 2.2.54 Mechanical equipment plan for the new facilities at Namkhan WTP

Equipment	Specification	QTY	Purpose/Reason for installation
PAC flow proportion and dilution tank	PVC 150 liters	1	Necessary for PAC injection
Pre-chlorination feeding equipment	500 liters calcium hypochlorite dissolution feed tank with mixer	2	Inhibit bacterial growth in flocculation basin and sedimentation basin
Sludge extraction valve	DN 150 mm Resilient seat gate valve (OS&Y) with extension stem and floor stand operator	6	Drain sludge from sedimentation basin
Sedimentation drain valve	DN 200 mm Resilient seat gate valve with T wrench operation	2	Drain supernatant when cleaning sedimentation basin
Sedimentation basin wash pump	Horizontal end suction top vertical discharge volute pump 0.75 m^3/min x 60 m Washing pipe including sprinkler	1	Secure proper pressure when cleaning sedimentation basin

PAC flow proportion and dilution tank

PAC is split into 4 raw water streams and diluted so that there is even distribution in the new receiving/mixing well with rapid mixing as the flow falls over the weir.

C)-3 Chemical Feed Equipment

Chemical feed equipment plan is shown in Table 2.2.55

Table 2.2.55 Chemical equipment plan for Namkhan WTP

Equipment	Specification	QTY	Purpose/Reason for installation
Preparation tank (PAC)	Round shape FRP tank 2.5 m^3	4	Shown below
Mixing air blower	0.32 m^3/min x 20 kPa	2	Shown below

Equipment	Specification	QTY	Purpose/Reason for installation
(PAC)			
Constant level tank (PAC)	PVC 250 Liters	2	Feed PAC by gravity
Flow control piping unit (PAC)	PVC pipe and control valve	2	Feed PAC at optimal flow
Preparation tank (Polymer)	500 Liters tank Polyethylene (with mixer)	2	Store polymer
Polymer feed pump	Diaphragm meter pump 1.2 - 0.12 L/min	4	Weigh polymer

PAC preparation tank

Almost all the inner lining is peeled off in the RC tank. According to MaWaSU experts, the peeled materials flow into pipes and cause clogging. After concrete surface repair, it is technically possible to carry out surface treatment, dry thoroughly, install wall-embedded piping, and re-line. However, if the surface treatment and the drying process are not done properly, the lining will not last regardless of the type of re-lining material used. Re-lining at the site is not recommended because it will be difficult to optimally perform the surface treatment and drying process. Factory manufactured FRP and polyethylene tanks are lighter in weight, superior in chemical resistance as well as durability, compared to RC tanks. It is easy to repair damages on FRP tanks with local products.

PAC mixing air blower

Usually one mechanical mixer is installed in a PAC solution tank. If the mixer fails, the dissolution tank cannot be used. If there are a lot of solution tanks, many mixers will be needed. This is not economical. If air is used for circulation, only two blowers will be needed (one for regular use + one on standby). Only part of the air pipe which is submerged contacts the solution and this reduces the problem of corrosion.

PAC constant level tank

The FRP solution tank can be installed at an elevated position in the existing chemical feed room. The coagulant can be introduced by gravity (using the flow rate control valve and the areal flow meter). A constant level tank (level controlled by float valve) can be installed for accurate injection.

Polymer preparation tank

Polymer solution is stored and allowed to mature in the preparation tank.

Polymer feed pump

The matured polymer is viscous and measurement error by use of areal flow meter can become large. Therefore, flow meter with manual control using flow control valve and areal flow meter is not suitable for polymer feed pump. Since the feed volume is very small about 10% of PAC, a diaphragm type metering infusion pump is used for accurate flow control.

A) Electrical Equipment

A)-1 Power Receiving and Transforming Equipment

The plan for electrical equipment at Namkhan WTP is shown in Table 2.2.56.

Table 2.2.56 Electrical equipment plan (incoming service) at Namkhan WTP

No.	**Equipment**	**Specification**	**QTY**	**Purpose/Reason for installation**
1	Transformer	500 kVA 22 kV/380 V Outdoors oil-filled transformer	1	A new transformer will match the increase in load because of new mechanical equipment. 1 new transformer will be installed outdoors to improve ease of maintenance.
2	Distribution panel	3φ 380V	1	A new power distribution panel will match the change in the structure of the control panel.

Currently there are 2 transformers used to service the plant. The first transformer was installed in the transformer room in 2000. A second transformer was installed when the filter basin and transmission pump for Phounanong Reservoir were installed in 2011. The latter was installed outdoors because there was no space for it in the transformer room. The first transformer does not have a protective cover. The transformer room is not sufficiently ventilated and not maintained in a clean state. The dust in the room can cause an electrical failure.

The 2 existing transformers will be replaced by a transformer suitable for the planned capacity of the mechanical equipment at the upgraded plant. It will be installed outdoors for safety, easy access and maintenance.

A portable generator is needed when power failure occurs. Power failure does not happen frequently, and past incidents were adequately handled by the existing portable generator. Therefore, the existing generator will continue to be used.

A)-2 Electrical Equipment for Operation and Control

The plan for electrical equipment is shown in Table 2.2.57.

Table 2.2.57 Electrical equipment plan (control panels) at Namkhan WTP

No.	**Equipment**	**Specification**	**QTY**	**Purpose/Reason for installation**
1	Control panel filter facility	Indoor self-standing	1	Power for filter facility
2	Control panel for transmission facility (New reservoir)	Indoor self-standing	1	Power for transmission pump (new reservoir)
3	Control panel for chemical feed facility	Indoor self-standing	1	Power for chemical feed facility
4	Local control panel for intake pump	Outdoor pole standing	1	For operation of intake pump

No.	Equipment	Specification	QTY	Purpose/Reason for installation
5	Local control panel for intake sludge extraction pump	Outdoor pole standing	1	For operation of intake sludge extraction pump
6	Local control panel for transmission pump (new reservoir)	Indoor pole standing	1	For operation of transmission pump (new reservoir)
7	Local control panel for washing pump of sedimentation basin	Indoor pole standing	1	For operation of sedimentation basin washing
8	Local control panel for back wash pump	Indoor pole standing	1	For operation of back wash pump
9	Local control panel for air scouring blower	Indoor pole standing	1	For operation of air scouring blower
10	Local control panel for sludge pump	Outdoor pole standing	1	For operation of sludge pump
11	Local control panel for chemical feed facility	Indoor self-standing	1	For operation of chemical feed facility

The layout of the control panel and local control panel needs to be changed to match the new process flow, capacity, and number of mechanical equipment.

The control panel should accommodate the load configuration for the intake pumps, washing equipment, transmission pumps and chemical feed equipment. The control panel should be installed in the control room in the same place as the current monitoring panel.

The control board for existing transmission pumps for Phounanong Reservoir stays where it is, because the mechanical equipment is not changed.

The layout of the local control panel is designed for the new mechanical equipment, the number of units, and the operation control system. For better protection from the external elements (such as water and dust), the local control panel should be the board type, not the switch box type currently used.

(7) Wastewater Treatment Facility Plan

1) Purpose of Wastewater Treatment Facility

Namkhan WTP must comply with the wastewater standard as stated in the "Wastewater standard value from general factory" (Government Decree No. 81, 2017/2/21 concerning approval / promulgation of national environmental standards). The relevant parameter in the standard for wastewater is total suspended solids with the following allowable limit:

TSS (Total Suspended Solids)	Less than 50 mg/L

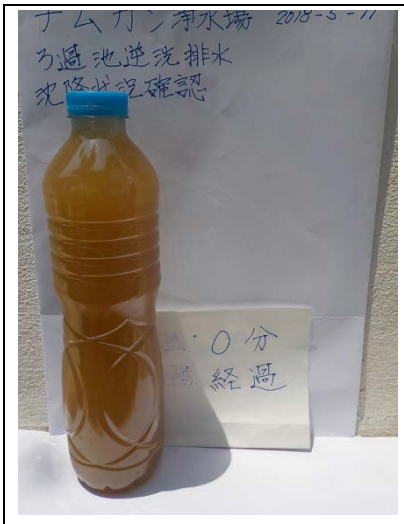
There are 2 kinds of wastewater from the Namkhan WTP:

A) Desludging from the sedimentation basin, drainage from cleaning operations and,
B) Backwash wastewater from filter cleaning operations.

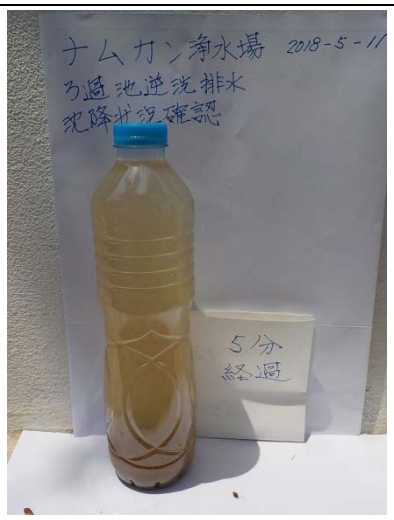
The TSS in backwash wastewater samples taken during the survey was 2,668 mg/L, which is significantly higher than the allowable value. It is therefore necessary to have wastewater treatment facilities.

2) Wastewater Settling Time

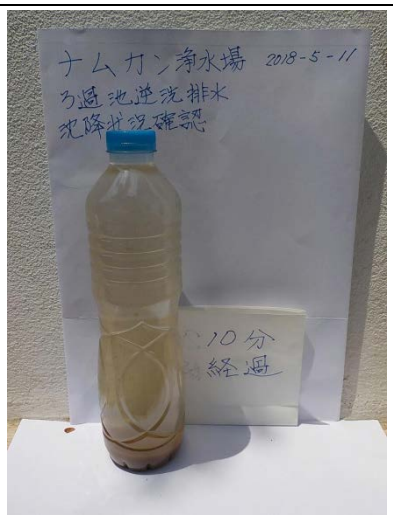
The settling time of a sample of backwash wastewater from filters is determined by letting the sample stand undisturbed for 2 hours as shown in Photo 2.2.9 and recording the change in turbidity at regular intervals.



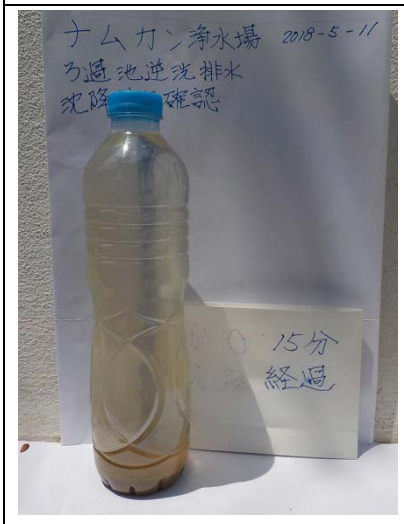
0 minutes after settling



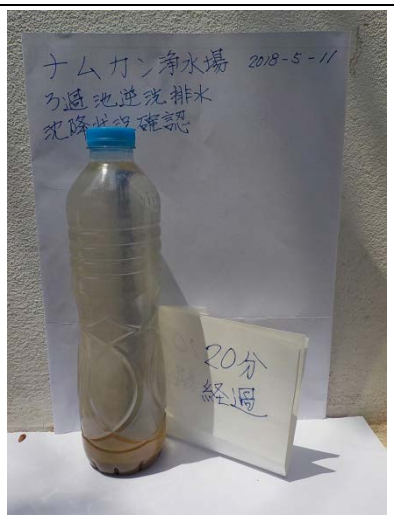
5 minutes after settling



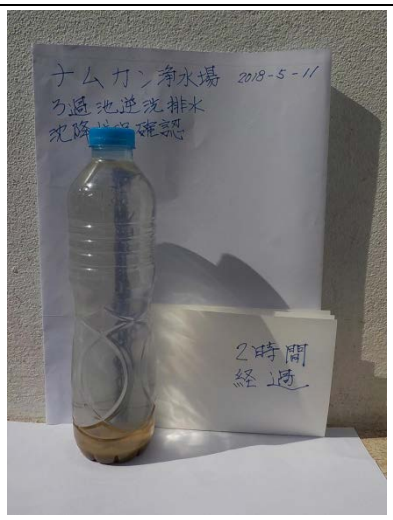
10 minutes after settling



15 minutes after settling



20 minutes after settling



2 hours after settling

Photo 2.2.9 Settling time of backwash wastewater from filters (May 11, 2018)

The TSS of the supernatant was measured for settling intervals of 0, 30, 60, 90, and 120 minutes. The results are shown in Table 2.2.58.

After 60 minutes of settling the TSS in the supernatant of the backwash wastewater falls below the allowable limit. The higher value after 120 minutes is considered within the range of measurement error. It is confirmed that the TSS in supernatant meets the standard of less than 50 mg/L after one hour.

Table 2.2.58 TSS and settling time of supernatant from backwash wastewater

	After 0 minutes	**After 30 minutes**	**After 60 minutes**	**After 90 minutes**	**After 120 minutes**
Total Suspended Solids (TSS)	2,668	60	34	18	33

3) Design Plan

A) Retention Time

Based on the settling times determined above, the retention time is expected to be 2 hours or more.

B) Components of Treatment Facility

The wastewater treatment facility shall be composed of wastewater/sludge basins, and a lagoon.

Wastewater basin : Storing the backwash wastewater from filters to allow settling before discharging the supernatant to the Khan River by operating stop logs.

Sludge basin : Storing the sludge from the sedimentation basin to allow settling before discharging the supernatant to the Khan River by operating stop logs.

Lagoon : The settled sludge transported from the bottom of the wastewater basin and sludge basin will be concentrated and dried further in the lagoon. The supernatant in the lagoon is discharged to the Khan River by operating stop logs.

C) Foundation of Facilities

Direct foundation same as the existing facilities will be used.

D) Yard Piping

The following yard piping is planned.

Sludge pipe (1) : From sedimentation basin to sludge basin

Sludge pipe (2) : From sludge basin to lagoon

Wastewater pipe : From rapid sand filters to wastewater basins

4) Wastewater Treatment Method

Figure 2.2.37 shows the sludge treatment, and Table 2.2.59 shows the stages of the treatment process.

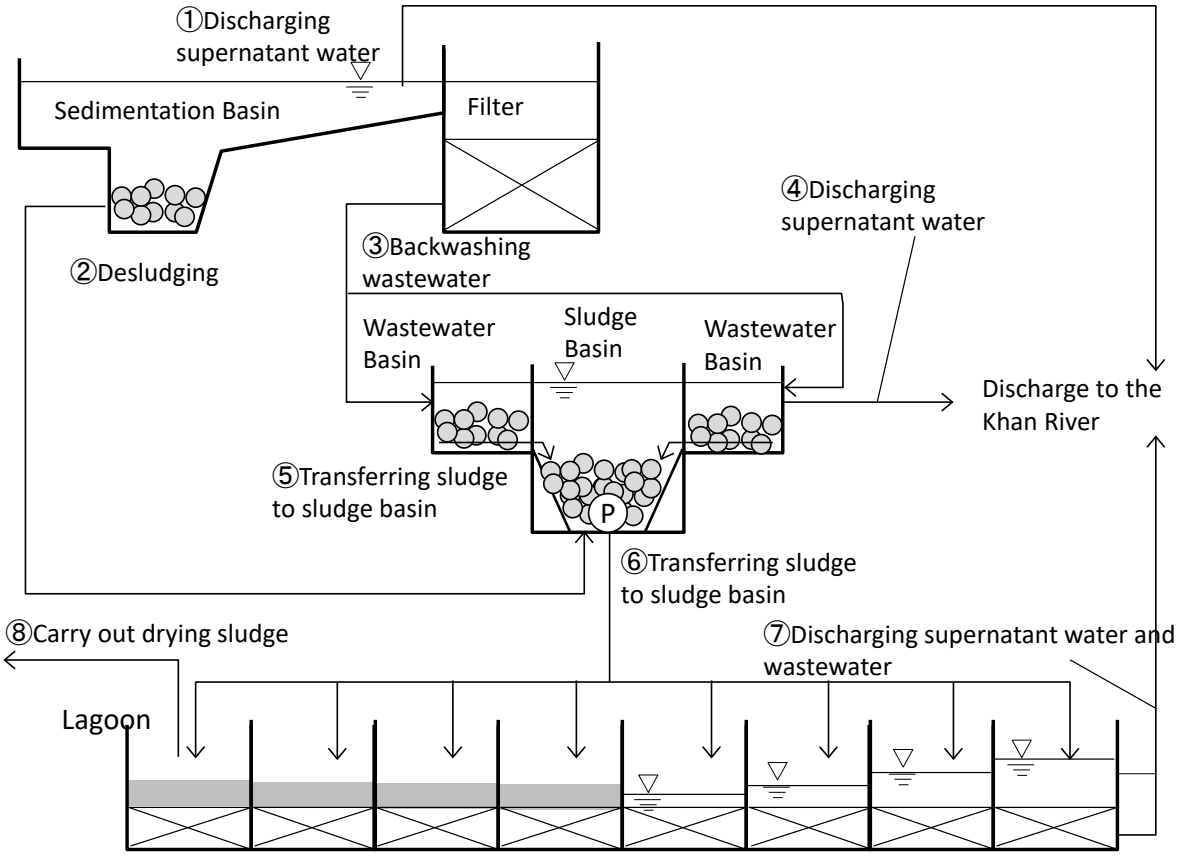


Figure 2.2.37 Wastewater treatment process

Table 2.2.59 Wastewater treatment process

Treatment Stage	Tasks	Remarks
① Discharging supernatant	Operate valves (new sedimentation basin) ・ Supernatant flows to the existing drainage chamber and then to the Khan River. Operate vacuum pump (existing sedimentation basin) ・ Supernatant is pumped to the existing drainage chamber and discharged to the Khan River.	Only for washing sedimentation basins
② Extracting sludge	Operate valves ・ Transfer sludge from sedimentation basin to sludge basin.	
③ Filter washing wastewater	Operate valves ・ Transfer wastewater from filter washing to one of two wastewater basins.	
④ Discharging supernatant	Operate valves ・ Allow settling in the wastewater basins, discharge supernatant to the Khan River.	Target is supernatant of wastewater basin and sludge basin
⑤ Transferring sludge to sludge basin	Operate valves ・ Sludge which settles after wastewater from filter washing is left to flow down to the sludge basin through the perforated pipe.	
⑥ Transferring concentrated sludge to lagoon	Operate Pump ・ Move the settled sludge to the lagoon by a pump.	
⑦ Discharging supernatant and filtered wastewater from lagoon	Operate stop log weir gate ・ After leaving the concentrated sludge to stand, release the supernatant to the Khan River by opening the stop log gate. ・ After the concentrated sludge is left to stand, the wastewater that seeps in the lower part of the lagoon is collected through a perforated pipe and discharged to the Khan River through the existing drainage chamber.	
⑧ Carrying out dried sludge	Scrape and remove ・ After decrease of moisture content of the sludge by drying , the dried sludge is scraped and carried by a belt conveyor out of the lagoon for transportation to waste disposal site. ・ The disposal site (Lak 8) is in the southern part of Luang Prabang (The private WTPs transport sludge to the same disposal site.)	

(8) Yard Piping Plan

Figure 2.2.38 shows a drawing of yard piping layout in the Namkhan WTP.

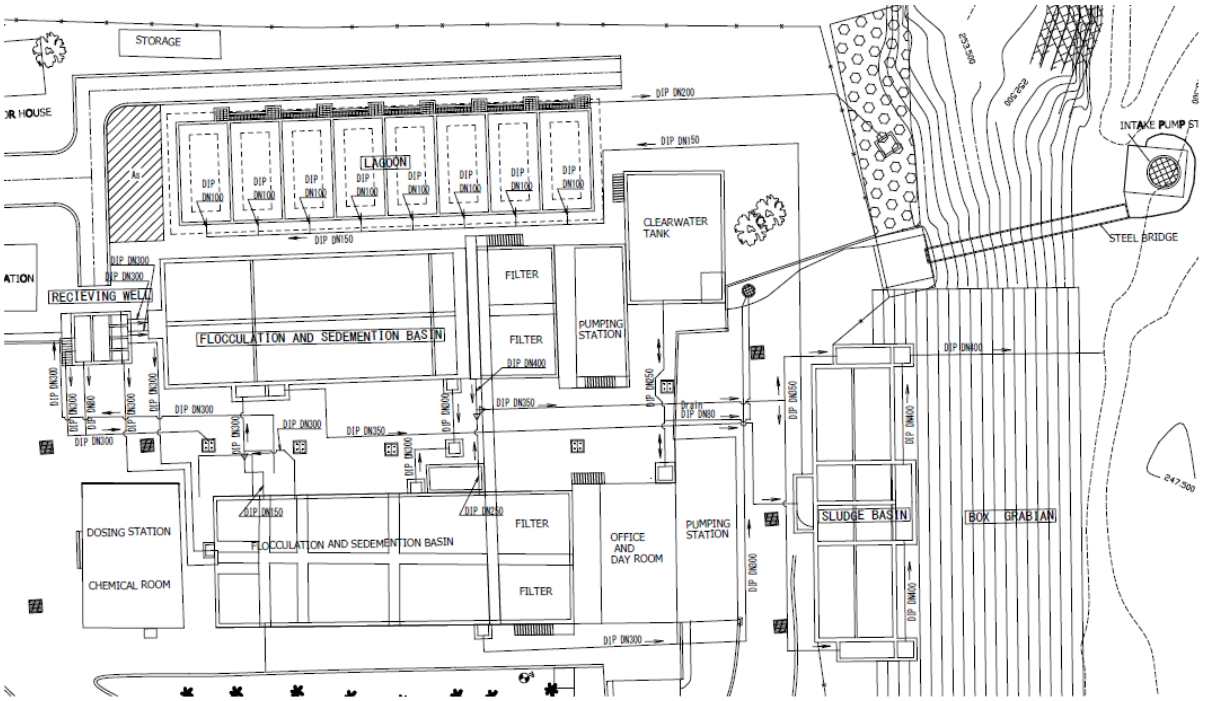


Figure 2.2.38 Yard piping at Namkhan WTP

(9) Flood Prevention

As discussed in "1.2.4 History of Precipitation and Flood Damage", no special flood prevention measures, such as constructing an embankment around the Namkhan WTP will be implemented. Nevertheless, some simple measures will be considered given the flood event in 2016.

Generally, civil structures will become usable even if they were submerged, but mechanical and electrical equipment is likely to become unusable when submerged, so it is desirable to move mechanical and electrical equipment to a location with a high ground. Therefore, regarding the electrical equipment to be updated in this project, all the power control boards are installed in the existing control room where the ground height is rather high. However, the transmission pumps should be installed in the current location, since the existing pump room cannot be moved.

(10) Water Treatment Facility Plan

Table 2.2.60 shows the water treatment facility plan in the Namkhan WTP and Figure 2.2.39 shows the general layout of Namkhan WTP.

Table 2.2.60 Facility plan for Namkhan WTP

Facility/Equipment			Details
Intake facilities	Pump equipment	Intake pump	13,200 m3/day No. of pumps: 6 (Large pumps: 3 including 1 standby, Small pumps: 3 including 1 standby)
Water treatment facilities	Receiving well		12,000 m3/day Structural details: RC, Direct foundation (integral structure with

Facility/Equipment			Details
			mixing well) Internal dimensions: W4.20 m x L3.00 m x D2.80 m = 35.28 m^3 Retention time: T = 35.28 / 9.17 = 3.8 min (Check against "Design Criteria for Water Supply Facilities 2012": T ≧ 1.5 min)
	Mixing well		12,000 m3/day Structural details: RC, Direct foundation (integral structure with receiving well) Type of mixing：Hydraulic mixing by water fall Internal dimensions: W0.90 m x 4 distribution tanks, L1.50 m x D2.00 m = 10.80 m3 Retention time: T = 10.80 / 9.17 = 1.2 min (Design criteria: T ≧ 1.0min)
	Flocculation basin		6,000 m3/day Structural details: RC, Direct foundation (integral structure with sedimentation basin) No. of basins: 2 Type of flocculation: Up-and-down flow Internal dimensions per basin: 1^{st} & 2^{nd} compartments: W0.60 m x L5.40 m 3^{rd} & 4^{th} compartments: W0.70 m x L5.40 m 5^{th} & 6^{th} compartments: W0.96 m x L5.40 m Retention time: T = 27min (Design criteria: T ≧ 20 to 40 min) G value: 13 to 73 /s (Design criteria: 10 to 75 /s) GT value: 64,270 (Design criteria: 23,000 to 210,000)
	Sedimentation basin		6,000 m3/day Structural details: RC, Direct foundation (integral structure with flocculation basin) No. of basins: 2 Type: Horizontal flow Internal dimensions per basin: W5.40 m x L16.20 m x D2.95 to 3.85 m) (mean water depth: 3.10 m including sludge accumulation depth 0.3 m) Overflow rate: 6,600 / (5.40 x 16.20 x 2 x 24) = 1.57 m/hr = 26.2 mm/min (Design criteria: 15 to 30 mm/min) Mean flow velocity: 6,600 / (5.40 x 3.10 x 2 x 24) = 8.21 m/hr = 0.14 m/min (Design criteria: 0.40 m/min)
Wastewater treatment facilities	Wastewater & sludge basin		Effective volume: 450 m3 (225 m3/basin x 2 basins) Structural details: RC, Direct foundation No. of basins: 2 Internal dimensions per basin: W10.00 m x L7.80 m x D3.00 m
	Lagoon (sludge drying bed)		Effective volume: 324 m3 (40.5 m3 x 8) Structural details: RC, Direct foundation No. of beds: 8 Bed area: 9.00 m x 4.50 m x 8 = 324 m2
Mechanical facility	Pump equipment	Treated water transmission pumps	6,000 m3/day Treated water transmission pump with flywheel No. of pumps: 2 including 1 standby
		Filter backwash pumps	No. of backwash pump: 2
	Blower	Filter air scouring blower	No. of blowers: 1
	Chemical feed facility		PAC feed facility (injection rate: 2.5-4.0 mg/L) Polymer feed facility (injection rate: 0.02-0.2 mg/L) Chlorine feed facility (injection rate: 0.2-1.0 mg/L)
Electrical facility	Power receiving and transforming facility		Outdoor oil-filled transformer 500kVA 22kV/380V 50Hz
	Operation	Control panel	Indoor self-standing×4

Facility/Equipment			Details
	facility		3φ 380V 50Hz
	Operation facility	Local control panel	Indoor pole standing×4, Outdoor pole standing×3 Outdoor self-standing×1

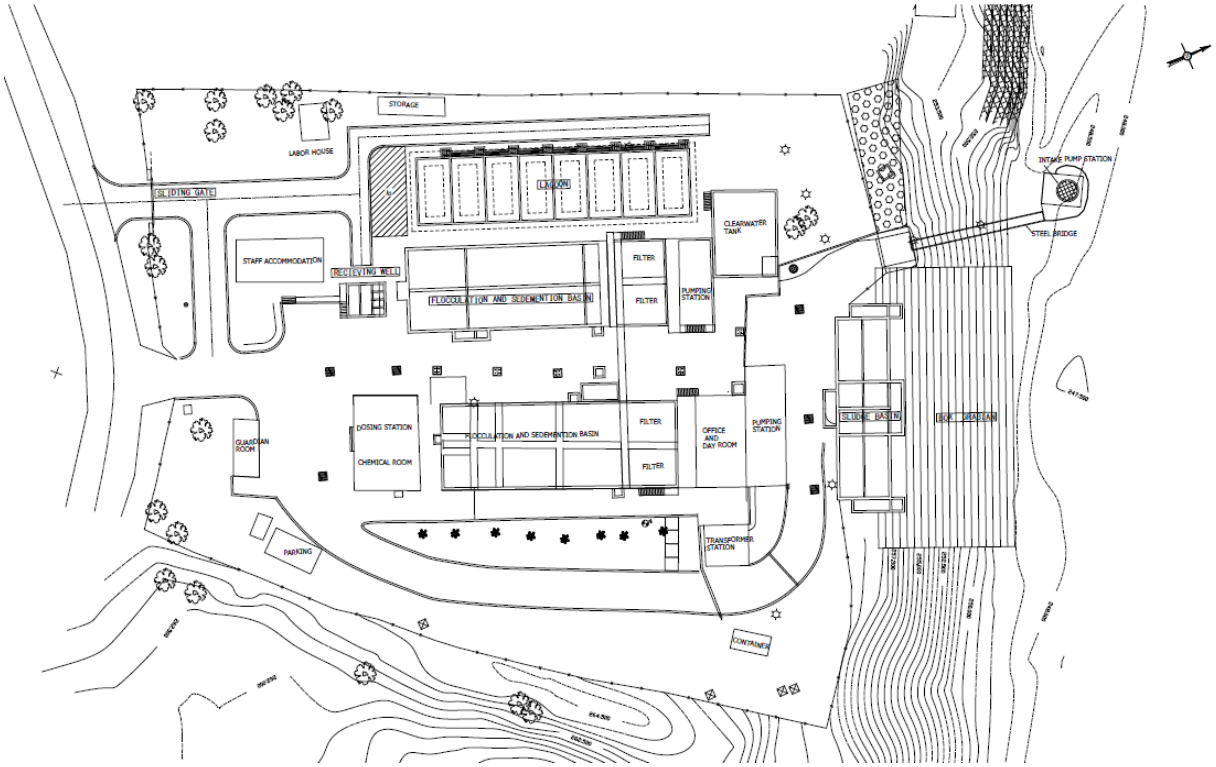
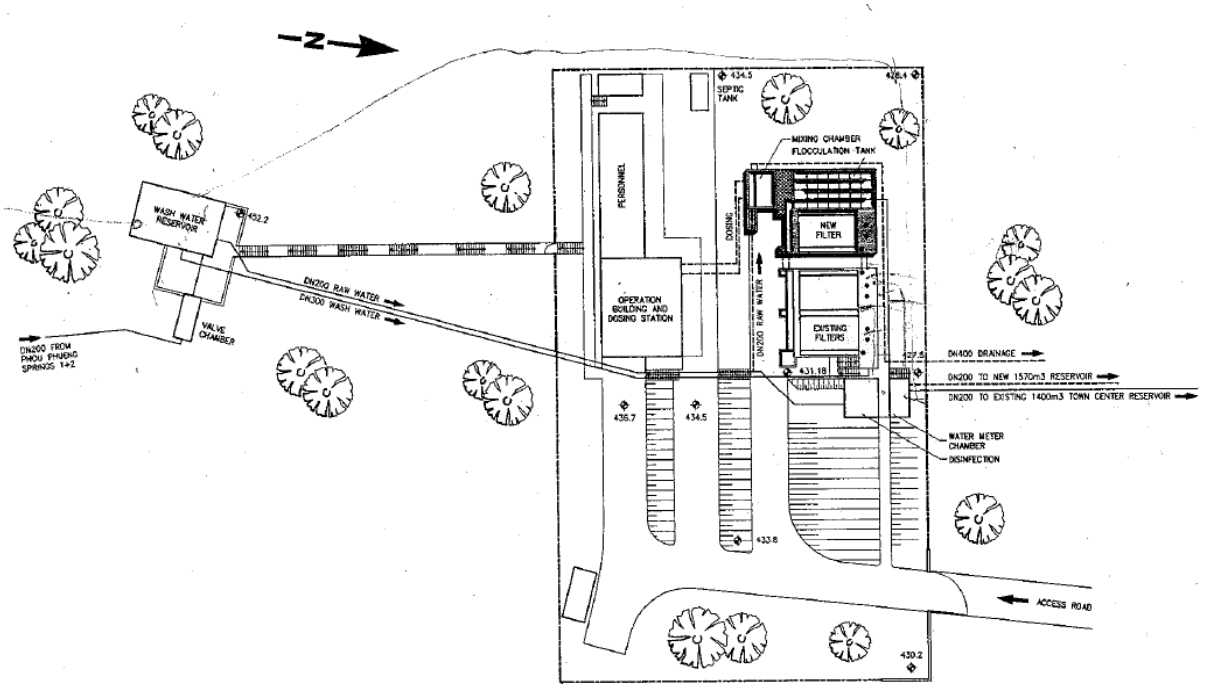


Figure 2.2.39 General layout of Namkhan WTP

2.2.2.4 Phouphueng WTP

(1) Present Plant Layout

Figure 2.2.40 shows the present plant layout of the Phouphueng WTP.



Source: WSSE-LPB

Figure 2.2.40 Present plant layout of Phouphueng WTP

(2) Basic Policy for Facility Planning

Phouphueng WTP has a problem with raw water hardness. From the comparative study shown in Table 2.2.61, it is decided not to introduce any facility to treat hardness by the project. Therefore, the only upgrade to be implemented at the Phouphueng WTP is the installation of the monitoring system described in "2.2.2.5 Monitoring System".

Table 2.2.61 Options to cope with water hardness at Phouphueng WTP

Item	1) Continue maintenance of water meters	2) Introduction of hardness treatment
Action	Customer water meter maintenance will continue as usual.	Introduce chemical treatment facilities to reduce water hardness.
Initial cost	None	About 3.2 million USD
O&M cost	2,500 USD/year	330,000 USD/year
Consequence	・ Maintenance of water meters is continued in the same manner as before. ・ Treated water is mixed with the treated water from the Demco WTP at the Khouthinieng reservoir. The hardness is diluted.	・ More O&M staff is required. ・ Scaling has also occurred in other distribution areas. The problem remains even if the issue is dealt with at the Phouphueng WTP. ・ Ultimately, it may be necessary to raise the water tariff to address the issue in a comprehensive manner.
Decision	Selected	Not selected

(3) Existing Water Treatment Facilities

1) Treatment Process

The water treatment facility commenced operation in 1970. Only a rapid sand filter was used to treat

spring water, the source of raw water. In 2000, a mixing well and a flocculation basin and an expanded rapid sand filter were put into operation as shown in Figure 2.2.41.

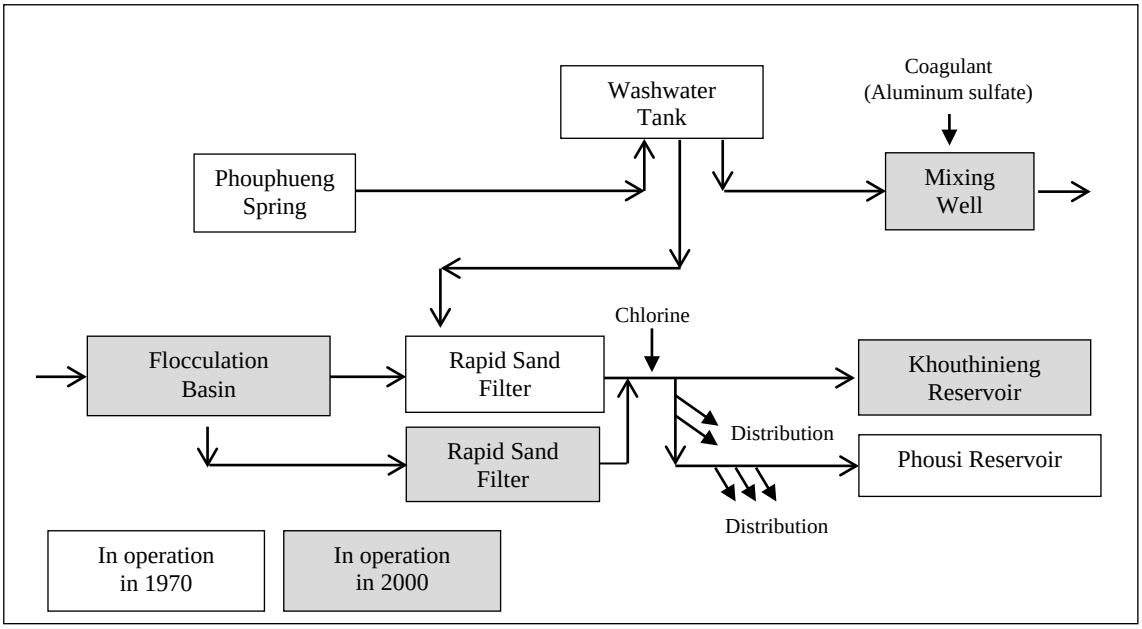


Figure 2.2.41 Existing water treatment process at Phouphueng WTP

2) Treatment Facilities

The existing facilities and their conditions are shown in Table 2.2.62.

Table 2.2.62 Results of field survey of water supply structures at Phouphueng WTP

Facility	Location of Inspection	Year of Commencement	Results of field survey
Raw water transmission facilities	Wash water tank	1970	(External surface) • Cracking in mortar plaster. • No breakage and no water leakage. (Internal surface) • No issues. • No loose rust on footsteps.
Water treatment facilities	Mixing well	2000	• No cracks in concrete.
	Flocculation basin		• No cracks in concrete.
	Filter	1970	• Five cracks in concrete inflow channel. The crack on the upper part is penetrating. • One crack on each side wall.
	Filter	2000	• No cracks in concrete.
Operation building and chemical dosing station	Dosing station	2000	• No issues with steel stairs and gratings.

3) Mechanical Equipment

The existing mechanical equipment and their conditions are shown in Table 2.2.63.

Table 2.2.63 Results of field survey of mechanical equipment at Phouphueng WTP）

Equipment	Specification	QTY	Results of field survey
Backwash pump	Vertical axis line pump	1	• No issues.
Air scouring blower	Root type rotary blower 13.58 m^3/min x 1470 min^{-1} (2014 year)	1	• If the air scouring rate is 1 m^3/m^2 /min, the filtration area is 24.3 m^2, the required wash air volume is 24.3 m^3/min. • Although the capacity of the blower is small, JPST confirms that the amount of scouring air is enough in terms of the actual operation.
Aluminum sulfate feed facility	Solution tank Constant water level tank	2 1	• Feed by gravity. • No issues.
Hypochlorite feed facility	Solution tank Constant water level tank	4 2	• Feed by gravity. • The ball tap is broken due to scaling but still operates.

4) Electrical Equipment

The existing electrical equipment and their conditions are shown in Table 2.2.64.

Table 2.2.64 Results of field survey of electrical equipment at Phouphueng WTP

Equipment	Specification	QTY	Results of field survey
Transformer	100kVA 22kV/380V 50Hz oil-filled transformer	1	• Installed outdoors. • No issues.
Control panel	Indoor self-standing	1	• Installed in the control room. • No issues.
Intake flow meter	Electromagnetic type	1	• Intake water is spring water. • Flow meter is installed in front of mixing well. • Flow indicator is hard to make out due to installation place. Air bubbles are formed in the inflow pipe.
Transmission flow meter	Electromagnetic type	2	• Faulty.

5) Existing Structures

The building structures and basins at the Phouphueng WTP are generally as sound as those at the Namkhan WTP. It is necessary to repair the cracks in the filter structures which were built in 1970 to prevent water leakage.

(4) Design Plan

This project will not include the repair of cracks in the filters. WSSE-LPB will do this and the repair of the other concrete structures.

The project will replace the flow meter for the monitoring system, as explained in “2.2.2.5 Monitoring System”.

2.2.2.5 Monitoring System

(1) Status of Flow Measurement

Table 2.2.65 shows the flow meters managed by WSSE-LPB. Many flow meters installed at the WTPs and reservoirs are out of order and the working ones are likely not accurate.

It is important to implement efficient distribution control when there are multiple WTPs and water distribution reservoirs in a service area such as Luang Prabang city. It is necessary to have accurate information on water transmitted and distributed to manage the service properly. Table 2.2.66 shows the water production/purchase cost at each WTP in Luang Prabang city. The production cost is lower than the purchase cost from private WTPs (Asia / Demo), with the exception for 2017. The purchase amount from private WTPs can be adjusted by knowing the precise amount of water transmitted and distributed.

Table 2.2.65 Status of existing flowmeters

Facility	Location	Remarks
Phouphueng WTP	Inflow	
	Outflow (Phousi Reservoir)	not functioning
	Outflow (Khouthinieng Reservoir)	not functioning
Namkhan WTP	Inflow	All operating but the difference between inflow and outflow is 20%. Therefore, accuracy is not good.
	Outflow (Phousi Reservoir)	
	Outflow (Phounanong Reservoir)	
Phousi Reservoir	Outflow	not functioning
Khouthinieng Reservoir	Outflow	not functioning
Phounanong Reservoir	Outflow	not functioning

Table 2.2.66 Production and purchase cost

Location	Cost of production／Purchase cost	Remarks
Phouphueng WTP	2015：236 kip/m^3 2016：224 kip/m^3 2017：240 kip/m^3	Maintenance expenses, repair expenses, chemicals expenses, electricity expenses, labor costs
Namkhan WTP	2015：1,608 kip/m^3 2016：1,699 kip/m^3 2017：1,742 kip/m^3	Maintenance expenses, repair expenses, chemicals expenses, electricity expenses, labor costs
Asia WTP	2014：1,797 kip/m^3 2015：1,817 kip/m^3 2016：1,778 kip/m^3 2017：1,735 kip/m^3	Bulk water purchase cost
Demco WTP	2017：1,818 kip/m^3 2018：1,987 kip/m^3	Bulk water purchase cost

Source: WSSE-LPB

(2) Monitoring Control for Flow Rate

WSSE-LPB requested the installation of a SCADA system for better monitoring and control of flow rate.

It is cheaper to treat water at the WSSE-LPB's WTPs than to purchase water from the private companies. It is necessary to measure transmission and distribution flow accurately so WSSE-LPB can systematically adjust the purchase amount from the private WTPs.

Three monitoring methods are compared in Table 2.2.67, and the data logger is considered to be the preferred. Hereinafter, a monitoring method using data loggers is referred to as a monitoring system.

Table 2.2.67 Comparison of monitoring methods

	Monitoring by Data Logger	Monitoring with Communication Network	Monitoring and Control with communication network
Description	Data taken at site or via internet and reviewed in the monitoring room. The system does not have control capability.	A communication network is established from the various monitoring locations to a centralized computer system and graphic user interface at monitoring room. The system does not have control capability.	A communication network is established from the various monitoring locations to a centralized computer system and graphic user interface at the monitoring system. The system has control capability.
Cost	low	medium	high
Pros and Cons	Data can be confirmed in monitoring rooms via internet. In case of power failure, there is no loss of data, since data are stored on site.	Data can be confirmed in monitoring rooms and is available instantaneously. The data logger has the same function. Therefore, monitoring with a communication network will not be chosen this time.	Data can be confirmed in monitoring rooms. Some control functions can be automated. Adding control functionality increases cost. Control functions can be handled manually, so automatic control is not necessary.
Selection	○	―	―

(3) Outline of Monitoring System

1) Monitoring Locations

WTPs need to check the water level and flow rate of the reservoir. Monitoring devices are installed at the headquarter office of WSSE-LPB, Namkhan WTP and Phouphueng WTP.

New bulk metering stations to be managed by the WSSE-LPB on the downstream side (see Figure 2.2.42 and Figure 2.2.43) of the private WTPs have also been considered to confirm the amounts that are billed.

Bulk metering stations are not included in the project for the following reasons:

- The contracts WSSE-LPB has with Asia and Demco require that the accuracy of bulk meters, which are integrating type, be verified by both parties every 3 months. WSSE-LPB should have high confidence in the accuracy of the amount of water purchased.

- The flows at the private bulk meter stations are measured by flow meters. It is possible to check and record the flow at each bulk meter station manually.

- The flow rates measured in the WSSE-LPB WTPs and reservoirs and the records taken at the private bulk meter stations can be used to plan the purchase volumes.

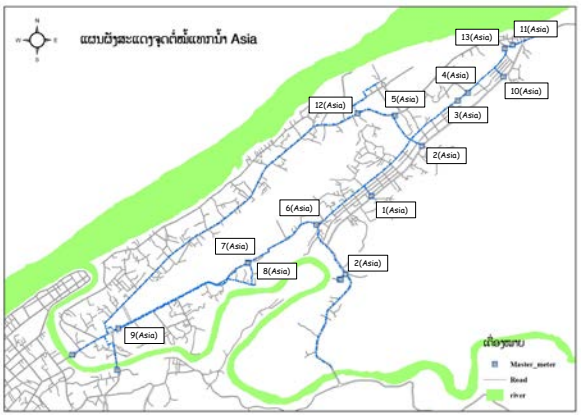


Figure 2.2.42 Metering stations (Asia)

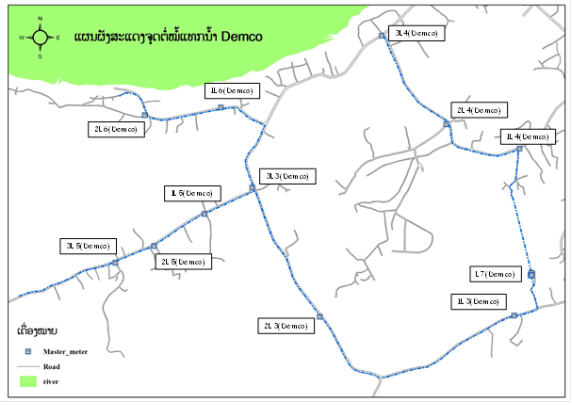


Figure 2.2.43 Metering stations (Demco)

Source: WSSE-LPB

2) Monitoring System

General-purpose software is applied to set up the monitoring system and normal personal computers are applied to set up monitoring devices to be installed at monitoring locations.

3) Monitoring Targets

The items for monitoring are shown in Table 2.2.68.

Table 2.2.68 Monitoring targets

Location	Monitoring Targets
Namkhan WTP	Pump operation, Khan River water level, water level in sludge basin, intake water flow rate, transmission flow rate
Phouphueng WTP	Intake water flow rate, transmission flow rate
Each Reservoir	Reservoir water level, distribution flow rate

4) Monitor Signals

Monitoring can be done via the internet, using data that are transmitted from mobile phones. 3G mobile broadband internet is selected, because the service area for 4G is limited.

5) Design Plan

Table 2.2.69 shows the monitoring system plan.

Table 2.2.69 Monitoring system plan

No.	Item	Details	QTY	Monitoring Target
1	Data logger monitoring device （WSSE-LPB）	personal computer, internet connection device 3 G or better	1	Conditions at the WTPs and reservoirs
2	Data logger monitoring device (Namkhan WTP, Phouphueng WTP)	personal computer, internet connection device 3 G or better	2	Storing data on intake and transmission flow rate, and water level of the Khan River and sludge basin
3	Khan River water level gauge (Namkhan WTP)	Suspended water level gauge	1	Water level of the Khan River
4	Intake flow meter (Namkhan WTP)	Electromagnetic type	1	Intake flow rate
5	Transmission flow meter (Namkhan WTP)	Electromagnetic type	1	Transmission flow rate (New reservoir)
6	Water level gauge (Sludge basin at Namkhan WTP)	Ultrasonic type	1	Water level of sludge basin Drain sludge pump operation
7	Intake flow meter (Phouphueng WTP)	Electromagnetic type	1	Intake flow rate
8	Transmission flow meter (Phouphueng WTP)	Electromagnetic type	1	Transmission flow rate (Khouthinieng Reservoir)
9	Distribution flow meter (Phounanong Reservoir, Khouthinieng Reservoir, New Reservoir)	Electromagnetic type	3	Distribution flow rates
10	Reservoir water level gauge (Phounanong Reservoir, Khouthinieng Reservoir, New Reservoir)	Suspended water level gauge	3	Water level of the reservoirs
11	Data logger panel (Phounanong Reservoir, Khouthinieng Reservoir, New Reservoir)	Outdoor Self-standing Internet connection device 3 G or better	3	Storing data on water level and distribution flow rates

(4) Summary of Monitoring System

Table 2.2.70 shows the summary of the monitoring system

Table 2.2.70 Summary of the monitoring system

Equipment			Details
Monitoring system	Data logger monitoring device		Personal computer x 3, Printer x 3 (WSSE-LPB, Namkhan WTP, Phouphueng WTP) Paperless recorder x 1 (Namkhan WTP: about 20 digital, analog about 5), paperless recorder (Phouphueng WTP: about 2 analog) Internet connection router (3 G or better) x 3, UPS (Uninterruptible Power Supply) x 3
	Data logger panel		Paperless recorder (approximately 2 digital and 2 analog) x 3, Internet connection router (3 G or better) x 3, UPS x 3
	Instrumentation equipment	Khan River water level gauge	Suspended water level gauge 0～15m (Namkhan WTP)
		Intake flow meter	Electromagnetic flow meterφ200, 0～700 m^3/h (Namkhan WTP)
		Transmission flow meter	Electromagnetic flow meterφ200, 0～400 m^3/h (Namkhan WTP)
		Drain sludge basin water level gauge	Ultrasonic type water level 0～5m (Namkhan WTP)
		Intake flow meter	Electromagnetic flow meterφ200, 0～500 m^3/h (Phouphueng WTP)
		Transmission flow meter	Electromagnetic flow meterφ300, 0～500 m^3/h (Phouphueng WTP)
		Distribution flow meter	Electromagnetic flow meterφ200, 0～300 m^3/h (Phounanong Reservoir)
		Reservoir water level gauge	Suspended water level gauge 0～10 m (Phounanong Reservoir)
		Distribution flow meter	Electromagnetic flow meterφ300, 0～600 m^3/h (Khouthinieng Reservoir)
		Reservoir water level gauge	Suspended water level gauge 0～10 m (Khouthinieng Reservoir)
		Distribution flow meter	Electromagnetic flow meterφ200, 0～600 m^3/h (New Reservoir)
		Reservoir water level gauge	Suspended water level gauge 0～10 m (New Reservoir)

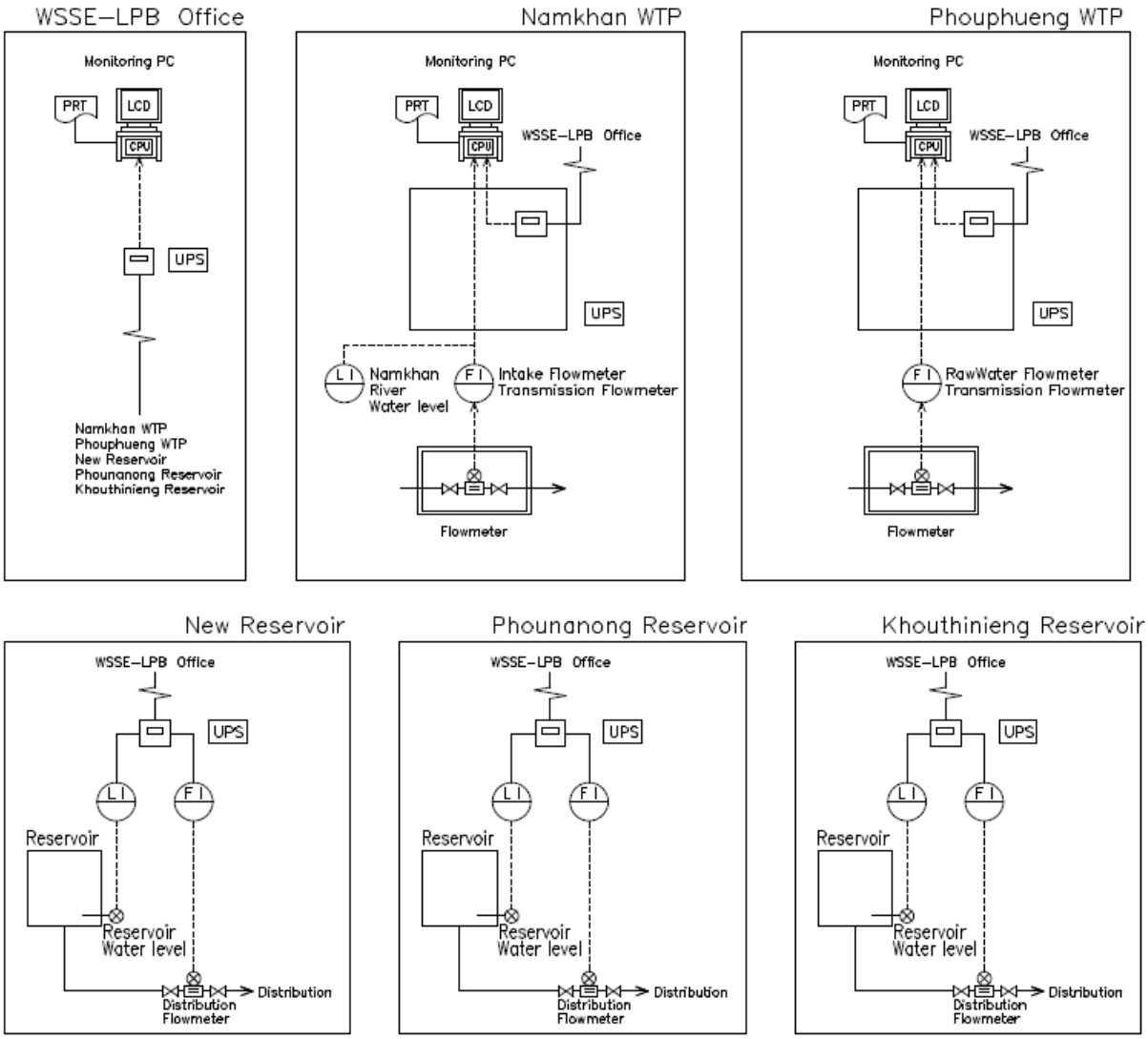


Figure 2.2.44 System diagram of monitoring system

2.2.3 Outline Design Drawing

Table 2.2.71 shows the list of design drawings for the project. The drawings are attached in the **Appendix 7-4**.

Table 2.2.71 List of outline design drawings

Site	Title of Drawings	Drawing No.	Scale
Pipeline Network	General Map for Pipeline Network	LPB-P-001	None
	Keymap Locations	LPB-P-002	None
	Pipeline Plan (1)～(28)	LPB-P-011～028	1:3000
	Typical Drawing for Pipe Laying (1) Earthwork	LPB-P-TYP-001	1:200
	Typical Drawing for Pipe Laying (2) Sluice Valve	LPB-P-TYP-002	1:200
	Typical Drawing for Pipe Laying (3) Air Valve	LPB-P-TYP-003	1:200
	Typical Drawing for Pipe Laying (4) Fire Hydrant	LPB-P-TYP-004	1:200
	Typical Drawing for Pipe Laying (5) Service Connection	LPB-P-TYP-005	None
Water Reservoir	General Layout of Water Reservoir Facility	LPB-C-R-001	1:250
	Ground Reservoir Structure (1)	LPB-C-R-002	1:100
	Ground Reservoir Structure (2)	LPB-C-R-003	1:100
	Flow Meter Chamber Structure	LPB-C-R-004	1:50
	General Plan of Water Riservoir Pipe Installation	LPB-C-R-005	1:250
Nam Khan Water Treatment Plant - Civil	General Layout of Nam Khan Water Treatment Plant	LPB-C-W-001	1:500
	Recieving and MixingWell Structure (1)	LPB-C-W-002	1:50
	Recieving and MixingWell Structure (2)	LPB-C-W-003	1:50
	Flocculation Basin, Sedimentation Basin Structure(1)	LPB-C-W-004	1:100
	Flocculation Basin, Sedimentation Basin Structure(2)	LPB-C-W-005	1:100
	Flocculation Basin, Sedimentation Basin Structure(3)	LPB-C-W-006	1:100
	Flocculation Basin, Sedimentation Basin Structure(4)	LPB-C-W-007	1:100, 1:20
	WWW Basin and Sludge Basin Structure (1)	LPB-C-W-008	1:100
	WWW Basin and Sludge Basin Structure (2)	LPB-C-W-009	1:100
	Lagoon Structure (1)	LPB-C-W-010	1:150
	Lagoon Structure (2)	LPB-C-W-011	1:50
	Lagoon Structure (3)	LPB-C-W-012	1:50
	General Plan of Nam Khan Water Treatment Plant Pipe Installation	LPB-C-W-013	1:300
Nam Khan Water Treatment Plant - Mech.	Nam Kham Water Treatment Plant Process Flow Diagram	LPB-M-W-01	None
	Layout of Raw Water Intake Tower Pump & Sludge Estraction Pump	LPB-M-W-02	1:100
	Raw Water Pump & Sludge Drain Pump Pipng Schematic	LPB-M-W-03	None
	Recieving and Mixing Well Hypo Tank & PAC Feed Piping Detail	LPB-M-W-04	1:50
	Layout of Transmission Pump Station	LPB-M-W-05	1:100
	Filter Air Scouring Blower Piping Plan	LPB-M-W-06	1:100
	Transmission Pump & Air Scouring Blower Pipng Schematic	LPB-M-W-07	None
	Chemical Building Tank Layout Plan & Section	LPB-M-W-08	1:100
Nam Khan Water Treatment Plant - Elec.	System Configuration Diagram for Monitoring System	LPB-E-01	None
	Single Line Diagram of Equipment for Power Receiving	LPB-E-02	None
	Single Line Diagram of Raw Water Control Panel and Transmission Pump Control Panel	LPB-E-03	None
	Single Line Daigram of Wash Pump Control Panel	LPB-E-04	None
	Single Line Daigram of Chemical Feed Control Panel	LPB-E-05	None

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

(1) Project Implementation Organization

The project will be executed according to the scheme for Japanese Grant Aid. After signing the Exchange of Notes between two governments, the Government of Lao PDR will select the consultant and contractor who are Japanese corporations, for the implementation of the project. Figure 2.2.45 shows the conceptual organization of the project.

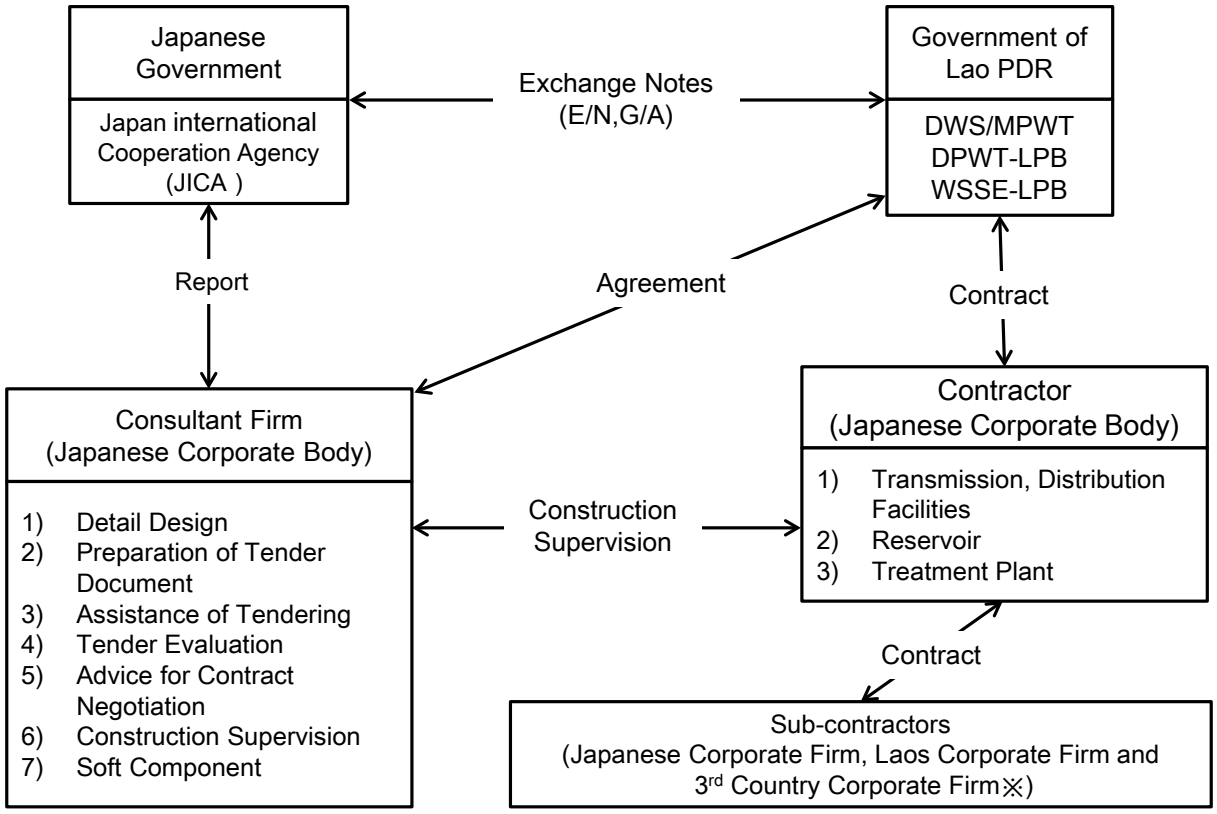


Figure 2.2.45 Organization for project implementation

(2) Project Implementation Agency

The executing agency of the project is Department of Water Supply, Ministry of Public Works and Transport (DWS/MPWT) and coordinates mainly with central government agencies concerned to implement the project smoothly.

The implementing agencies are Department of Public Works and Transport in Luang Prabang Province (DPWT-LPB) and Luang Prabang Water Supply State Enterprise (WSSE-LPB). They are responsible for supporting the executing agency and coordinate with all relevant organizations in the project area to facilitate the project. They are also responsible for operation and maintenance of the facilities by the project.

(3) Consulting Firm

The detailed design and construction supervision for the project including construction of transmission and distribution pipelines, the new reservoir, and WTP will be carried out by a Japanese consulting firm. A Japanese consulting firm with enough experiences will be selected.

(4) Construction Contractor

The construction works borne by Japanese Grant Aid are carried out by a Japanese contractor. The project includes construction of transmission and distribution pipelines, reservoir, improvement of water treatment facilities, as well as procurement/installation of mechanical and electrical equipment. A general construction company that has enough capacity and experiences will be selected. The general construction company is required to control construction qualities including construction of watertight concrete structure and to procure mechanical and electrical equipment in good quality.

(5) Necessity of Dispatching Experts

It is necessary to dispatch experts with specialized experiences in the construction of transmission and distribution pipelines, reservoirs and water treatment facilities, installation of electrical and mechanical equipment, conducting test operations and confirming the water tightness of structures and pipelines. The following engineers are needed:

・One representative in charge of overall construction work (Project Manager)
・Chief Engineer
・Civil Engineer
・Mechanical Engineer
・Electrical Engineer
・Safety Management Engineer

2.2.4.2 Implementation Conditions

The following conditions need to be considered for the construction and procurement.

(1) General

- Contractor and consultant will coordinate with Lao side closely and clarify means of information sharing such as regular meetings.
- No other UXO has been found since the one discovered at a construction site near the airport in Luang Prabang city. Therefore, a UXO survey will not be implemented for pipe laying. A topographical survey and soil investigation were carried out at the candidate site for the new reservoir after a UXO survey was carried out by the Lao side. During construction, UXO surveys will be carried out by the Lao side when the need arises.

(2) Transmission and Distribution Pipelines

- Construction along main street where there is a night market, should be conducted with the following considerations according to the discussions with administrator of the night market:
  - Discussion with the administrator of the night market should be done prior to construction.
  - Construction should be done during the rainy season to reduce the impact on tourism.

- Construction activities should be limited to less than 50 m stretches at one time.

- In addition to the night market, there are many restaurants and hotels in the World Heritage Site. It is necessary to inform the construction schedule to the hotels, restaurants and residents through stakeholder meetings and other means before construction starts.
- Safety measures should be taken to prevent accidents involving resident or tourists around excavations.

(3) Service Pipe

- It is necessary to re-connect existing service pipes to the new distribution lines.
- Concerned customers who need the re-connect works by the renewal of distribution pipelines can be assumed from site conditions. However, it is impossible to find all the concerned customers. Therefore, customer surveys are necessary to compile the list of households with service pipes connecting to pipelines targeted for renewal.
- Water supply interruptions may affect households not on the above list. Therefore, the contractor must announce the possibility of water supply interruptions in advance to all residents near the construction site, with the help of the implementing agencies.
- Steps for conversion of service pipes are described as follows.
  - ① Construct new distribution lines, ② Supply water to network of old and new distribution pipes, and ③ Connect existing house connections to the new distribution pipe.
  - Before ③Connect existing house connections to the new distribution pipe, it is necessary to conduct customer survey to ascertain the status of existing house connections.
- It is important to minimize water supply interruptions (by using self tapping saddle, etc.) as much as possible.

(4) Reservoir

- It is important to ensure maximum water tightness.

(5) Namkhan WTP

- It is important to ensure maximum water tightness.
- Construction will take place while the treatment plant continues to operate. It is necessary to minimize the impact on water supply operations. Therefore, the construction schedule should be coordinated through adequate discussions with WSSE-LPB.
- JPST confirmed with WSSE-LPB that the operation of the WTP can be stopped for 3 weeks at the longest for one suspension.
- The disruption to production will only happen when
  - installing the pipe connecting the new water receiving well and the existing flocculation basin (2-3 weeks for concrete curing);
  - installing the pipe between the 2 clear water reservoirs (2-3 weeks for concrete curing);
  - switching water intake pipes during replacement of intake pumps (approx. one day);
  - replacing water intake pump (approx. one day);
  - replacing transmission pump (2-3 days for supply to Phousi Reservoir);

During these suspensions, water shortfall can be supplied from private WTPs.

2.2.4.3 Scope of Works

The Japanese side will be responsible for the construction of transmission and distribution pipelines, WTP facilities and reservoir, and installation of monitoring system (see Table 2.2.72). The Lao side will take care of site preparation in the Namkhan WTP and clearing of the new reservoir site (tree trimming and removal of rocks).

House connections must be made when aging pipes are renewed in the existing service area and for new customers in the expansion area. Japanese side is responsible for the former and Lao side for the latter (see Table 2.2.73). The list and details of the responsibilities of Lao side are also shown in "2.3 Obligations of Recipient Country".

Table 2.2.72 Scope of work

Responsible party	Construction	Remarks
Japanese side	• Transmission and distribution lines for renewal and expansion • Construction of facilities at Namkhan WTP • Site preparation including cutting land and leveling for the new reservoir site • Construction of the new reservoir • Installation of monitoring system	Connecting service pipes to renewed pipes, is included in the construction of distribution lines.
Lao side	• Site clearing such as tree trimming and removal of rocks at the new reservoir site • Access road to the new reservoir site	

Table 2.2.73 Supplementary explanation on service pipe

Service pipe	Supplementary explanation
Reconnecting existing service pipes to renewed pipes	to be carried out by the Japanese side.
Connecting new service pipes to new distribution line (expansion area)	to be implemented by the Lao side with material procurement. Practically, residents will pay the cost for house connection based on their applications.

2.2.4.4 Consultant Supervision

(1) Detailed Design and Construction Supervision

The consultant will organize the following engineers including a project manager and carry out the following tasks.

-Detailed design
-Tendering-1 (preparation of tender document, and approval of tender document)
-Tendering-2 (public announcement, tendering, and evaluation of bid submissions)
-Construction supervision

1) Detailed Design: Japanese Engineers

Table 2.2.74 Staffing plan for detail design (Japanese engineers)

Positions	Scope of work
Project manager	For entire design ・meetings with relevant authorities ・preparing, editing and reviewing reports ・reporting detailed design to relevant authorities
Treatment plant	For treatment plant and reservoir design ・detailed design, calculations, drawings ・specifications
Transmission and distribution lines 1	Designing transmission and distribution facilities ・detailed design, calculations, drawings ・specifications ・topographical survey, soil investigation
Transmission and distribution lines 2	Designing transmission and distribution facilities ・detailed design, calculations, drawings ・specifications ・topographical survey, soil investigation
Mechanical equipment	Designing mechanical equipment ・detailed design, calculations, drawings ・specifications
Electrical equipment	Designing electrical equipment ・detailed design, calculations, drawings ・specifications
Construction plan/Cost estimation	Responsible for implementation plan and cost estimation ・collecting unit price of material and machinery ・estimation for project cost

2) Detailed Design: Lao Engineers and an interpreter

Lao engineers and a local interpreter support Japanese engineers.

Table 2.2.75 Staffing plan for detailed design (Lao engineers and an interpreter)

Positions	Scope of work
Civil engineer (Transmission and distribution 1)	Supporting engineering tasks and interpretation
Civil engineer (Transmission and distribution 2)	Supporting engineering tasks and interpretation
Interpreter	Interpretation in Lao and English

3) Tendering-1

This involves the preparation and approval of tendering documents.

Table 2.2.76 Staffing plan for tendering -1 (Japanese engineers)

Positions	Scope of work
Project manager	Overall project responsibilities: ・meetings with relevant authorities ・preparing, editing and reviewing reports ・reporting detailed design to relevant authorities
Tendering expert	Preparing tendering documents
Agreement on rates	Preparing of materials for agreement on construction unit rates with a contractor

Table 2.2.77 Staffing plan tendering-1 (a Lao interpreter)

Position	Scope of Work
Interpreter	・Interpreting in Lao and English

4) Tendering-2

This involves public announcement, tendering, and evaluation of bid submissions.

Table 2.2.78 Staffing plan for tendering-2 (Japanese engineers and an interpreter)

Positions	Scope of Work
Project manager	Overall project responsibilities ・meeting with relevant authorities ・preparing, editing and reviewing reports ・reporting detailed design to relevant authorities ・meetings with a contractor to agree on unit price
Tendering expert	Assisting followings for a tender ・tender announcement ・tender ・tender evaluation
Agreement on rates	Preparing materials for agreement on construction unit rates with a contractor
Interpreter	Interpreting in Lao and Japanese

5) Construction Supervision: Japanese Engineer

The consultant will perform the following supervisory tasks:

1. Check and approve shop drawings prepared by a contractor
2. Inspect major equipment and materials
3. Supervise construction activities and schedule
4. Safety management, quality control, and progress management
5. Advise on environmental protection
6. Report on construction progress to Japanese and Lao sides
7. Assist the Lao side on the necessary procedures and responsibilities in the execution of Japanese Grant Aid project
8. Test facility operations and evaluate performance
9. Inspect completed structures
10. Inspect for defects

The project consists of improvement of the water treatment facilities and construction of the reservoir, as well as installation of transmission and distribution pipelines. In order to conduct consistent construction supervision for these mutually related works, a resident engineer is necessary from the beginning of construction to the commissioning and handover of the facilities.

In addition to improvement of the water treatment facilities and construction of the reservoir as civil structure, the project installs pipelines of 65.2 km which includes renewal of pipelines of 45.9 km. The

renewal of pipelines, which covers implementation of re-connecting renewed pipelines and existing service pipes, has to be carried out while continuously supplying water to existing customers, and the most of renewal works will be carried out in World Heritage Site. Considering these working conditions, a lot more consultation and adjustment will be needed compared to general new pipelines installation work. As it is difficult to conduct the construction supervision for quality control and progress management of civil engineering structures and installation of pipelines by one resident engineer, an additional engineer for pipe laying shall be deployed during the following construction phases.

- Beginning of construction
- When the resident engineer can not take care all the sites due to increase of office works during transition period of fiscal year,
- Construction in the World Heritage Site

The following engineers are also required for construction supervision at various stages of the construction of each facility.

Table 2.2.79 Staffing plan for construction supervision (Japanese engineers)

Position	Scope of Work
Project manager	Overall project responsibility ・meetings with relevant authorities before construction ・inspection at completion ・reporting progress and at completion of construction ・supporting Lao side for handover of the facilities at the completion of constructions
Resident engineer	・supervising all construction and related activities ・meetings with relevant authorities ・quality control, schedule and safety measures ・approving drawings and construction plans and related documents ・preparing documents for repot to Lao side and JICA ・providing technical advice and training for the contractor
Engineer to inspect facilities at completion	・Assisting with inspection at completion
Civil engineer (treatment facilities)	・advising on treatment facilities and reservoir ・supervising construction on treatment plant and reservoir ・approving drawings, construction plans and related documents ・Progress control of WTP and reservoir
Civil engineer (transmission /distribution facilities)	・advising on pipe installation ・supervising pipe installations ・approving drawings, construction plans and related documents ・Progress control of pipe installations
Mechanical engineer	・supervising installation of mechanical equipment, test operation and preparation of maintenance manual ・approving drawings, construction plans and related documents
Electrical engineer	・supervising installation of electrical equipment, testing operation and preparation of maintenance manual ・approving drawings, construction plans and related documents

Position	Scope of Work
Defect inspector	・inspecting for defects

6) Construction Supervision: Lao Engineers and others

Following staffs are required for the construction supervision.

Table 2.2.80 Staffing for construction supervision (Lao engineers and others)

Position	Scope of Work
Civil engineer	・supervising all construction activities ・inspecting construction sites ・supporting Japanese engineers
Mechanical engineer	・supervising installation of mechanical equipment ・inspecting construction sites ・supporting Japanese engineers
Electrical engineer	・supervising installation of electrical equipment ・inspecting construction sites ・supports Japanese engineers
Pipe laying engineer	・supervising pipe laying including yard piping ・inspecting construction sites ・supporting Japanese engineers
Secretary	・administrative tasks
Office boy	・miscellaneous tasks

7) Soft Component (technical assistance): Japanese Engineers

The consultant will dispatch experts to provide training for WSSE-LPB staffs on:

- Operation and maintenance of treatment plant,
- Management of monitoring system

Table 2.2.81 Staffing for training and capacity building (Japanese engineers)

Staff in charge	Scope of Work
Operation and maintenance (WTP)	・Training on flow control, water purification technology and sludge management
Distribution control using the monitoring system	・Training on management of water production amount, water pressure and cost-effective operations

8) Soft Component (technical assistance): Lao Interpreters

Local interpreters will be assigned for the soft component (technical assistance).

Table 2.2.82 Staffing for training and capacity building (Lao interpreters)

Training Component	Scope of Work
Operation and maintenance (WTP)	・Preparing training materials in Lao ・Liaising and coordinating between Japanese expert and WSSE-LPB staff
Distribution control using the monitoring system	・Preparing training materials in Lao ・Liaising and coordinating between Japanese expert and WSSE-LPB staff

(2) Construction Management by the Contractor

1) Construction Management: Japanese Engineers

Japanese engineers will be assigned to positions as described below to construct the facilities for the project.

Table 2.2.83 Construction management (Japanese engineers)

Person in Charge	Scope of work
Project manager	Resident engineer responsible for ・negotiations ・technical management ・safety management ・management of materials and equipment
Chief engineer	Overall supervision of treatment plant and reservoir construction: ・allocating workers ・procurement of machinery ・procurement of materials ・safety management ・civil works and shop drawings
Civil engineer	Overall supervision of pipeline construction ・pipe installation ・Installation of house connection ・preparation of shop drawings
Mechanical engineer	Responsible for pumps and equipment of treatment plant ・procurement of materials, and installation ・preparation of shop drawings ・general administration of mechanical installation
Electrical engineer	Responsible for electrical equipment ・procurement of materials, and installation ・preparation of shop drawings ・testing operation of monitoring system ・general administration of electrical installation
Safety management engineer	Responsible for safety management in pipe construction sites ・ensuring safety of visitors to construction sites
Office manager	Accounting and supporting the project manager ・management of workers ・procurement of materials ・accounting and miscellaneous related tasks

2) Construction Management: A Lao Interpreter

A local interpreter will be assigned for the Japanese contractor’s project manager.

Table 2.2.84 Staffing plan for construction management (a Lao interpreter)

Position in charge	Scope of work
Interpreter	・Interpreting in meetings

2.2.4.5 Quality Control Plan

Quality control during construction consists mainly of ensuring conformance to management items and design specifications. The major items to be scrutinized are listed in Table 2.2.85 together with material/equipment, contents of control, control methods, and standards etc., to be complied with. In principle, Japanese Industrial Standard (JIS) or other equivalent international standards will be used.

Table 2.2.85 Quality control and standards

Category	Material/ Equipment	Contents of Control	Control Method	Applicable Standards	Frequency of Test	Records	Remarks
Pump Facilities	Pump	Conforms to Standards	Observation Shop-Drawings Test Report	JIS B 8301 JIS B 8302	When Received Factory Inspection	Record Test Results Table Approval Drawings	In the presence of Consultant
Pipe Material	Ductile Cast Iron Pipe	Conforms to Standards	Shop-Drawings	JIS G 5526 JIS G 5527	For each pipe laying section	Approval Drawings	
		Type	Observation		For each type、when received	Record	In the presence of Consultant
	High Density Polyethylene Pipe	Conforms to Standards	Shop-Drawings	ISO4427	For each pipe laying section	Approval Drawings	
		Type	Observation		For each type、when received	Record	In the presence of Consultant
Pipe Laying	Joint	Joint condition	Observation	－	During jointing	Report	In the presence of Consultant
			Pressured Leakage Test	No leakage observed	For each pipe laying section	Test Result Table	In the presence of Consultant
			Ultra Sonic Test		At one time for every 10 joints	Test Result Table	
Concrete Material	Reinforcing Bars	Type of re-bar (deformed, round)	Observation	JIS G 3112 JIS G 3117	When received for each type		In the presence of Consultant
		Conforms to standards	Test Report			Test Result Table	
	Cement	Type of cement	Observation	JIS R 5210	When received.	Record	In the presence of Consultant
		Conforms to standards	Test Report			Test Result Table	
	Water	Piped water or clear river water	Observation	－	When mixed	Concrete Mixture Table	In the presence of Consultant
		Water quality (river water)	Water Quality Test	JIS A 5308 Appendix 9	Before mixture design	Test Result Table	
	Aggregates	Maximum diameters of aggregates	Observation	Reinforced concrete: 25 mm	When Received.	Record	In the presence of Consultant
		Grain size	JIS A 1102	JIS A 5005	Before mixture design	Test Result Table	
	Concrete mixture	Conforms to standards	Test Report	JIS A 6201-6207	When received	Test Result Table	When necessary.
	Storage of materials	Place and storage conditions	Observation	－	When necessary.	Report	In the presence of Consultant

Category	Material/ Equipment	Contents of Control	Control Method	Applicable Standards	Frequency of Test	Records	Remarks
Concrete pouring	Concrete design mixture (major structures)	Test mixture	Confirmation of Quality	28-day strength:21N/mm^2 Slump:10.0±2.5cm Air Content: ±1.5% W/C Ratio: less than 65% (less than 55% for water retaining structure) cement: more than 270 kg/m^3	1 time before pouring	Test Result Table	In the presence of Consultant
	On-site concrete mixture	Water content of small aggregate surface	JIS A 1111, 1125	—	Each mixing	Test Result Table	In the presence of Consultant
		Grain size of aggregate	JIS A 1102	JIS A 5005	When received	Test Result Table	
		Temperatures of water and aggregates	Temperature Measurements	—	Each mixing	Test Result Table	In the presence of Consultant
		Water and cement volumes		Error: less than1%			
	Slump	Conforms to the specifications	JIS A 1101	10.0±2.5 cm	Each placing	Test Result Table	In the presence of Consultant
	Air	Conforms to specifications	JIS A 1128	±1.5%	Each placing	Test Result Table	In the presence of Consultant
	Compressive strength	Laboratory	—	Approval of consultant	Prior to the test	—	
		Sampling	JIS A 1132	7-day strength: 3 pcs 28-day strength: 3 pcs	Every 50 m^3 placing or 1 time per day 1time for one consecutive placing work	—	In the presence of consultant
		Conforms to specifications	JIS A 1108	Design strength= 21 N/mm^2	Every 50 m^3 placing or 1 time per day 1 time for 1 consecutive placing	Test result table	
	Leakage test (reservoir and others)	Conforms to specifications	Water Level Measurement, Observation	No water level draw-down after 24 hours	After the structure is constructed	Test result table	In the presence of consultant

2.2.4.6 Procurement Plan

(1) Procurement of Equipment

Table 2.2.86 shows procurement list of equipment for the project.

Table 2.2.86 Procurement list for machinery

No	System/Facility	Details	Application	Source
1	Data logger monitoring device （WSSE-LPB）	personal computer, internet connection device 3 G or better	Monitor flow and water level	Japan

No	System/Facility	Details	Application	Source
2	Data logger monitoring device (Namkhan WTP)	same as above	same as above	Japan
3	Data logger monitoring device (Phouphueng WTP)	same as above	same as above	Japan
4	Data logger panel (new reservoir)	Outdoor, Self-standing Internet connection device 3 G or better	Measure flow and water level	Japan
5	Data logger panel (Phounanong Reservoir)	Same as above	same as above	Japan
6	Data logger panel (Khouthinieng Reservoir)	same as above	same as above	Japan
7	Belt Conveyor	7 m long, 350 mm wide	Carry out sludge	Japan

(2) Workers and Materials

1) Labor

A) Employment of Engineers and Laborers in Lao PDR

Laborers are basically employed in Lao PDR.

B) Working Conditions in Lao PDR

According to labor laws by Ministry of Labor and Social Welfare, working hours and holidays are regulated as follows:

・8 hours per day (6 days per week), not exceed 48 hours per week
・Overtime: less than 30 hours per month
・Breaks/day: 1 hour including lunch

2) Construction Materials

A) Procurement of Materials and Equipment

In principle, construction materials and equipment will be procured in Lao PDR and Japan. If it is difficult to procure from these countries, procurement from third country will be allowed. The sources of procurements were decided considering the following conditions:

・Quality of materials and equipment has to meet requirements.
・Easy to operate and maintain, and spare parts are readily available
・Available after-sale service
・Appropriate price

The procurement plan for construction materials is shown in Table 2.2.87.

Table 2.2.87 Procurement plan for construction materials and equipment

Name of Materials	Source of Procurement			Remarks
	Laos	Japan	Other Countries	
1. Construction Materials				
Ready Mix Concrete, Sand, Gravel, Cement, Steel Bar	○			
Plywood for Molding, Wood	○			
H-shaped Steel Beam and Steel Materials	○			
Paints, Lubricant, Fuel	○			
Materials for Water Stops	○			
Scaffolding and Support	○			
2. Mechanical and Electrical Equipment				
Pumps		○		
Overhead traveling crane	○			
Water Treatment Equipment including Chemical Feeding Equipment		○		
Electrical Equipment and Panels		○		
Lighting Equipment, Cables and Cable Conduits	○			
Instrumentation and Control Devises		○		
Monitoring System for Transmission and Distribution Flow		○		
3. Pipe Materials				
Pipe Material (DIP)			○	Assumed to be from Taiwan
Pipe Material (HDPE)			○	Assumed to be from Thailand
Valves and Fittings			○	Assumed to be from Thailand
Fire Hydrant			○	Assumed to be from Thailand
4.Equipment				
Belt conveyor		○		

A)-1 Construction Materials

Reasons for selecting procurement source of construction material are provided in Table 2.2.88.

Table 2.2.88 Reasons for procurement source of construction material

Construction Material	**Source of Procurement**	**Reasons for choice**
Cement	Laos	Portland cement produced in both Thailand or Vietnam can be purchased in local markets and used for construction works in Lao PDR.
Ready Mixed Concrete	Laos	There is a ready mixed concrete factory which has two plants in north of Luang Prabang city and its capacity is 120 m^3/h. There is no problem on quality control of plant facilities and concrete.
Steel Materials	Laos	Products made in Thailand, Vietnam and China are available in local markets.
Wood	Laos	Produced in Lao PDR
Asphalt	Laos	Imported production is available in local market.
Oils and fuel	Laos	Imported production is available in local market.

A)-2 Pipe Materials (Ductile Iron Pipe, High Density Polyethylene Pipe)

Ductile iron pipes (DIP) are assumed to be procured from Taiwan and high-density polyethylene pipes (HDPE) from Thailand. Fitting equipment for service pipe is procured locally. Local procurement is preferable for future repair and maintenance. Thus, specification adopted by WSSE-LPB is applied to the equipment of service pipe.

3) Construction Machinery

A) Procurement of Construction Machinery

There are several companies holding general-purpose construction machines in Lao PDR. While the varieties of construction machinery owned by the local lease companies are not so much, necessary machinery for the project can be procured from those companies. The procurement plan for construction machinery is shown in Table 2.2.89.

Table 2.2.89 Procurement plan for construction machinery

Name of Machinery	Specification	Lease(L)/Purchase(P)	Source of Procurement			Remarks
			Japan	Laos	Other countries	
Backhoe (with large-sized breaker)	1,300 kg	(L)		○		Excavation
Bulldozer	15 t, 21 t	(L)		○		Banking, back filling
Backhoe	0 .45, 0.8 m^3	(L)		○		Excavation, loading, back filling
Truck crane	5, 15 t, 25 t	(L)		○		Concrete placement, pipe laying
Crawler crane	35 t, 50 t	(L)		○		Pilling of H-shape steel
Truck with crane	4 t, crane capacity 2.9t	(L)		○		Moving materials and equipment, pipe laying
Mobile concrete pump	100 m^3/h	(L)		○		Concrete placement
Vibration roller (with hand guide)	0.5 t, 1.0 t	(L)		○		Back filling and rolling compaction for roadbed and asphalt paved
Dump truck	2 t, 4 t, 10 t	(L)		○		Soil carrying
Generator	150 kVA	(L)		○		Drainage
Motorized grader	3.1 m	(L)		○		Subgrade, Roadbed
Tire roller	8-20 t	(L)		○		Roadbed, Asphalt paved

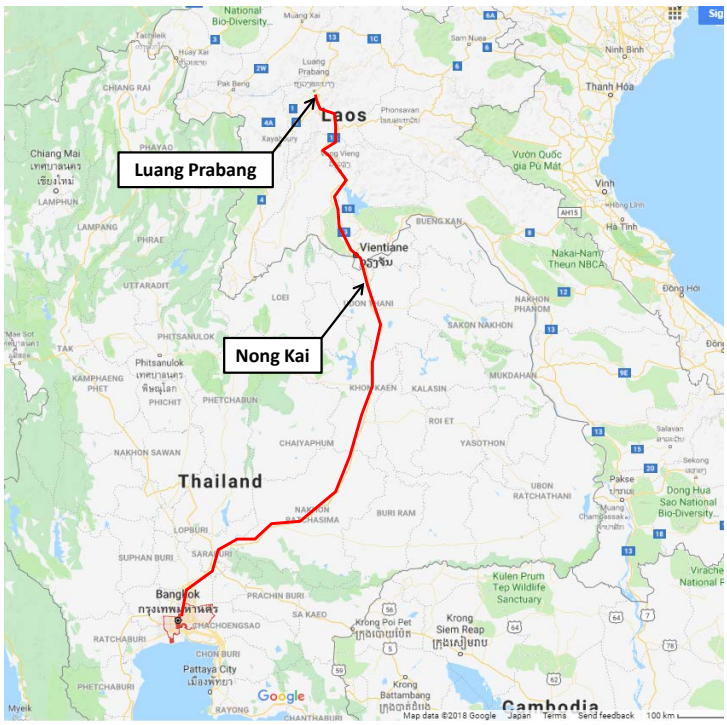
(3) Transportation Plan

1) Transportation Plan

Transportation is necessary for equipment and materials procured from Japan and other countries.

2) Transportation Route

The assumed transportation route, from Bangkok harbor to Luang Prabang, is shown in Figure 2.2.46



Map source: Google, DigitalGlobe

Figure 2.2.46 Transportation route (inland)

Materials and equipment procured in Japan will be shipped to Thailand by sea, then transported through land routes from Thailand to Luang Prabang via Vientiane.

i) Shipment transportation begins from Yokohama harbor.

ii) By sea from Yokohama to Bangkok

iii) By truck from Bangkok to Nong Khai

iv) By truck from Nong Khai in Thailand to Vientiane in Lao PDR

v) After going through import custom, by truck to stockyard in Luang Prabang city

Materials and equipment procured in other countries will be transported from a major port in each country to Thailand by sea, then from Thailand to Luang Prabang via Vientiane, as described above.

The route to Luang Prabang via National Route 13 is approximately 300 km from Vientiane. It is paved and wide enough for transportation trucks. However, it goes through steep terrain in a mountainous area.

Information on the transportation route is shown in Table 2.2.90.

Table 2.2.90 Transportation route

Route	Goods	Condition of roads	Distance	Time
Bangkok ～ Nong Khai	steel, steel sheet pile, and HDPE etc.,	asphalt paved national roads	800 km	13 hours
Nong Khai ～ Vientiane		Mekong bridge No.1	1 km	1 hour (with a custom stop)
Vientiane ～ Luang Prabang	scaffolding, cables and lighting equipment etc.,	asphalt paved national roads	350 km	10 hours
Luang Prabang ～ Construction sites	goods that can be procured in Luang Prabang	asphalt and concrete paved national roads	around 5 to 20 km	< half an hour

2.2.4.7 Training on Initial Operation and Maintenance

The contractor will provide initial training on operation and maintenance for each equipment such as pump and valve etc. Comprehensive training on operation and management of new and existing facilities such as control of treated water amount, chemical dosage rates, and transmission flow rates are implemented by the consultant through the soft component (technical assistance) program. It will be the same for the monitoring system.

2.2.4.8 Soft Component (technical assistance) Plan

(1) Objective

This project will install pipelines, construct treatment facilities and reservoirs, and set up a monitoring system. The consultant will provide training to local staff on operation and maintenance of these facilities to ensure that they can operate them effectively and sustainably.

This training will focus on the operations that are different from the existing ones and on the new monitoring system.

(2) Training Outcome

At the end of training, staff of WSSE-LPB will be able to:

- properly operate and maintain the facilities constructed under this project, and conduct water quality management at the Namkhan WTP.
- control water transmission and distribution properly using the new monitoring system.

(3) Training Outputs:

Following two outputs are set for the soft component.

1) Operation & Maintenance and Water Quality Management of the Namkhan WTP (Technical Staff in WSSE-LPB)

a) Improved understanding of the water treatment process

b) Improved capacity for preparing standard operation procedures (SOPs)

c) Improved operation and maintenance of the Namkhan WTP to provide customers with stable and

safe water which meets drinking water quality standards

2) Distribution Control Using the Monitoring System (Staff of Administration Planning Division and related WTPs in WSSE-LPB)

a) Improved capacity for operating the flow monitoring system

b) Improved capacity in controlling water distribution effectively

(4) Training Evaluation

Evaluation methods and indicators for each output are summarized in Table 2.2.91.

Table 2.2.91 Evaluation of training achievement

Sector	Output	Evaluation Method	Indicator
O/M and Water Quality Management in Namkhan WTP	Staff of WSSE-LPB can operate and maintain the WTP and provide customers with safe and stable water following manuals and SOPs	1. Stable treated water quality, with intake controlled by observing river water level (gauge), and injecting the appropriate amount of chemicals.	・Proper revision of SOP ・Constant intake flow rate, regardless of river water level ・Controlled chemical injection rate by using manuals developed by JICA's grass root project ・Appropriate input of operation data for intake flow etc. in record formats ・Operation method on the site
		2. Proper operation of new wastewater facilities. - Proper operation of the supernatant drainage in the sedimentation basins. - Sludge collected in wastewater and sludge basins move to lagoons. After drying the sludge, the sludge is carried out by a belt conveyor. - Supernatant discharge from wastewater and sludge basins and lagoon to the Khan River.	・Establishment of proper SOP for wastewater treatment facility ・Preparation of record formats for operation of the wastewater facility ・Appropriate input of operation data for wastewater and sludge treatment in the record format ・Operation method on the site
Distribution Control Using the Monitoring System	Staff of WSSE-LPB can control water distribution effectively	1. Implementation of effective water distribution based on actual water supply record.	・Records of water transmission and distribution as well as water levels of reservoirs ・Supplied water volume based on the above records. ・Water production plan based on the supplied water volume.

(5) Training Activities

The details of the training program are shown in Table 2.2.92. Two Japanese experts will go to Lao PDR twice with a total man month of 2.94 M/M. Between the visits, the staff will conduct on-site training on their own.

Table 2.2.92 Training program

Training	Output	Activities	Staff Input
O/M and Water Quality Management of the Namkhan WTP	Staff of WSSE-LPB can operate and maintain the WTP and provide customers with	1. Preparation of training and lecture materials on new facilities at Namkhan WTP 2. Confirming O/M records of existing WTP 3. Lectures and on-the-job training (OJT) on performance evaluation and monitoring method	WTP O/M Expert (Japanese consultant) 1 person×1.47M/M (Dispatch twice:1.During

Training	Output	Activities	Staff Input
	safe water stably by following manuals and SOPs	for each process (Flush Mixing→ Flocculation→Sedimentation→Filtration), including performance comparison of new flocculation basin with existing one, methods for examination and training if necessary. 4. Lectures and OJT training on O/M of drainage and sludge treatment for sedimentation basin and filter. 5. Updating the operation recording formats for flow rate (intake and transmission), dosage of chemicals, filter backwashing, drainage and sludge discharge, pump operation time and number by considering information flow. Preparation of revised record format. 6. Training on recording the above. 7. Updating O/M manuals and SOPs of the WTP (utilizing MaWaSU project outcomes). 8. Lectures and OJT training on above manuals and SOPs.	trial operation 2.After handover of the facilities) Interpreter/local support staff 1 person×1.47M/M
Distribution Control by Using the Monitoring System	Staff of WSSE-LPB can control water distribution effectively	1. Lectures on distribution control monitoring system (preparation of training materials and lectures). 2. Confirmation of transmission and distribution volume of existing 4 WTPs. 3. Lectures on effective water distribution (preparation of training materials and lectures). 4. Updating the recording formats for the flow rate and water level in each reservoir. 5. Training on record keeping using the above formats. 6. Lectures for preparation of water distribution plan based on measured data (preparation of training materials and lectures). 7. Preparation of O/M manuals for water distribution system (SOPs of pump, valve[1)] and flow meter etc., O/M schedule of transmission pump). 8. Lectures and OJT training on the above manuals.	Expert in distribution control (Japanese consultant) 1 person×1.47 M/M (Dispatch twice:1.During trial operation 2.After handover of the facilities) Interpreter/support staff (local) 1 person×1.47 M/M

1) Including valve operation to prevent surging.

(6) Implementation of Training Program

The draft implementation plan for the soft component is shown in Table 2.2.93.

Two Japanese experts in O/M of WTP and distribution control will be dispatched to Lao PDR twice. After the first training session, WSSE-LPB staff will study various operation recording formats and discuss the contents to be described in the SOPs by themselves. During the second training session, the Japanese experts will provide additional training on recording formats and preparation of SOPs.

Table 2.2.93 Implementation plan for the soft component

No.	Activities	2022		
		May	June	July
1.	Operation/Maintenance and Water Quality Management of the Namkhan WTP			
1-1	Lecture for new facilities at Namkhan WTP (preparation of training materials and lecture)			
1-2	Confirming O/M records of existing WTP			
1-3	Lecture and on-the-job training (OJT) on performance evaluation and monitoring method of each process (Flush Mixing→ Flocculation→Sedimentation→Filtration) including performance comparison of new flocculation basin with existing one, improvement methods examination and training if necessary			
1-4	Lecture and OJT training on O/M of drainage and sludge treatment for sedimentation basin and filter			
1-5	Updating the operation recording formats for flow rate (intake and transmission), dosage of chemicals, filter backwashing, drainage and sludge discharge, pump operation time and number by considering			
1-6	Training on recording the above formats			
1-7	Updating O/M manuals and SOPs of the WTP (Utilizing MaWaSU project outcomes)			
1-8	Lecture and OJT training on above manuals and SOPs			
2.	Distribution Control by Using the Monitoring System			
2-1	Lecture for distribution control monitoring system (preparation of training materials and lecture)			
2-2	Confirming transmission and distribution volume of existing 4 WTPs			
2-3	Lecture for water distribution method based on above volume (preparation of training materials and lecture)			
2-4	Updating the recording formats for the flow rate and water level in each reservoir			
2-5	Training on recording the above formats			
2-6	Lecture for preparation of water distribution plan based on measured data (preparation of training materials and lecture)			
2-7	Preparation of O/M manuals for water distribution system (SOPs of pump, valve and flow meter etc., O/M schedule of transmission pump)			
2-8	Lecture and OJT training for the above manuals			
	Submission of progress report for soft component implementation		▲	
	Submission of complement report for the soft component			▲

(7) Responsibilities of the Lao Side

1) Assignment of Staff for Training

The Lao side should assign the relevant staff from the water treatment and water supply sections to receive the training.

2) Arrangement of Meeting Rooms for Training

The Lao side will provide the meeting rooms and A/V equipment for the technical sessions.

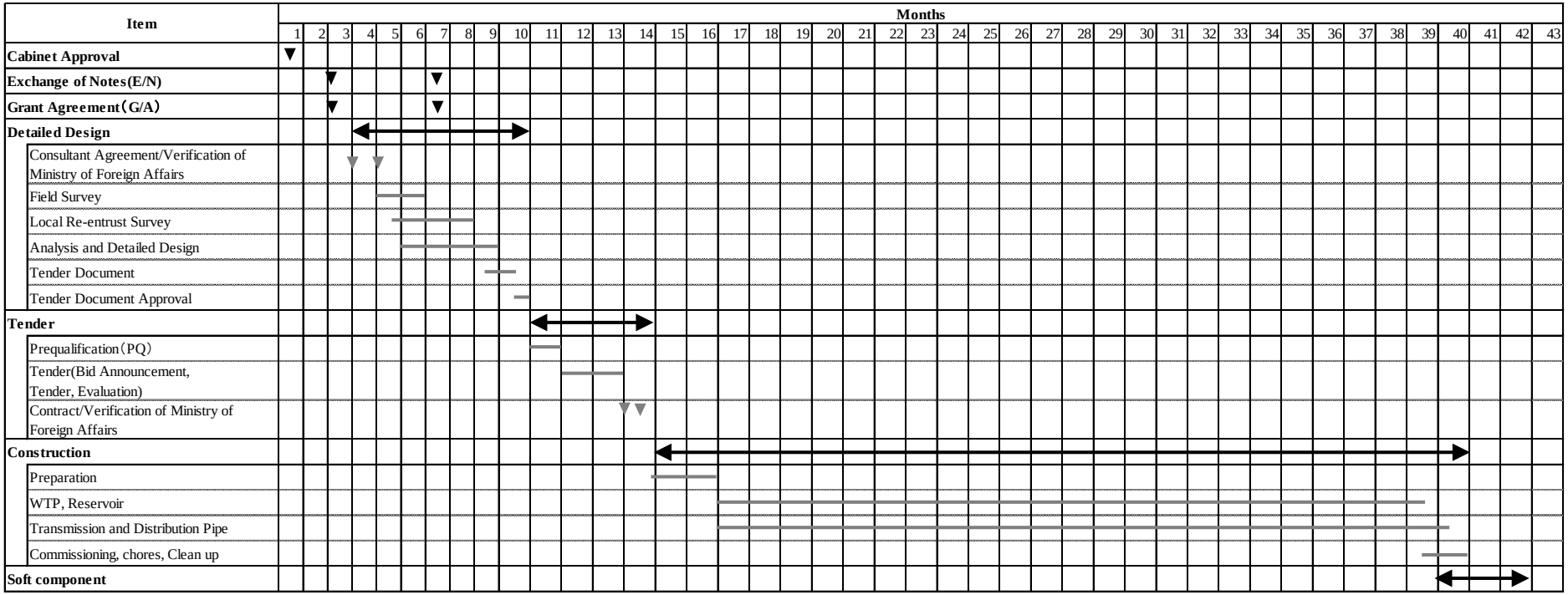
3) Preparation and Installation of Baffle Plates

During the training on “O/M and Water Quality Management of the Namkhan WTP”, improvement in mixing intensity of the existing flocculation basin may be implemented. If so, the Lao side will install baffle plates in the flocculation basin for adjusting mixing intensity.

2.2.4.9 Implementation Schedule

The project will be implemented for multi years. Detailed design will be carried out in the first year and construction and procurement in the second year. The design period is 5.0 months (7 months: from the signing of consultant agreement to the approval of tender documents), bidding and finalizing arrangement with contractor is 4.0 months, construction and procurement is 26 months. The implementation schedule is as shown in Table 2.2.94.

Table 2.2.94 Implementation schedule



2.3 Obligations of Recipient Country

2.3.1 List of Responsibilities

Table 2.3.1 lists the main obligations of the Lao side.

Table 2.3.1 List of major obligations of recipient country

Responsibility	Tasks	Remarks
Bank Arrangement	• Opening bank account • Issuing Authorization to Pay (A/P)	Including banking fees
Land Acquisition	• Acquire land for the reservoir site	Details are shown in 2.3.2 Land Acquisition".
Clearing (Reservoir site)	• Clear site for reservoir construction including tree trimming and removal of rocks	—
Access road construction	• Construct access road to reservoir site	—
Drainage from reservoir site	• Secure drainage from the reservoir site	Details are shown in 2.3.3 Drainage from Reservoir Site".
Environmental and social considerations	• Implement IEE • Monitoring during construction	Details are shown in "2.3.4 Response to Environmental and Social Considerations".
Namkhan WTP	• Make adjustments for WTP operation suspension • Repair civil structures • Remove the following – hut in the area for the sedimentation basin – shrine and a hut in the area for the lagoon – tree (or just trim) in the area for the new facilities	Details are shown in "2.3.5 Adjustment to WTP operation during construction".
House connection	• Connect service pipe to new network in the expanded supply area	Details are shown in "2.3.6 House Connection".
Power supply	• Arrange service for the reservoir site	Details are shown in "2.3.7 Power Supply".
Preparation of stockyard	• Prepare stockyard for the contractor	
UXO	• Conduct UXO survey before construction when the need arises • Remove UXO when the need arises	Details are shown in "2.3.8 UXO".
Coordination with residents	• Coordinate and respond to residents, restaurant and hotel owners, mainly around the construction site during pipeline installation	—
Soft component	• Assign staff for training • Arrange meeting rooms for training • Prepare and install baffle plates	Details are shown in "2.2.4.8(7) Responsibilities of the Lao Side".
Tax exemption	• Arrange for tax exemption	—

2.3.2 Land Acquisition

The Lao side needs to acquire the site for the new reservoir.

The detailed process for land acquisition is as shown in "1.3.12 Land Acquisition". The land acquisition has been completed on 25 December, 2018.

2.3.3 Drainage from Reservoir Site

Rain water and overflow from the reservoir is discharged to the valleys. As shown in Figure 2.3.1, the project will install about 10 meters of drainage pipe from the site. There is a stream after the valleys.

The Lao side is responsible for drainage downstream of the drainage pipe.

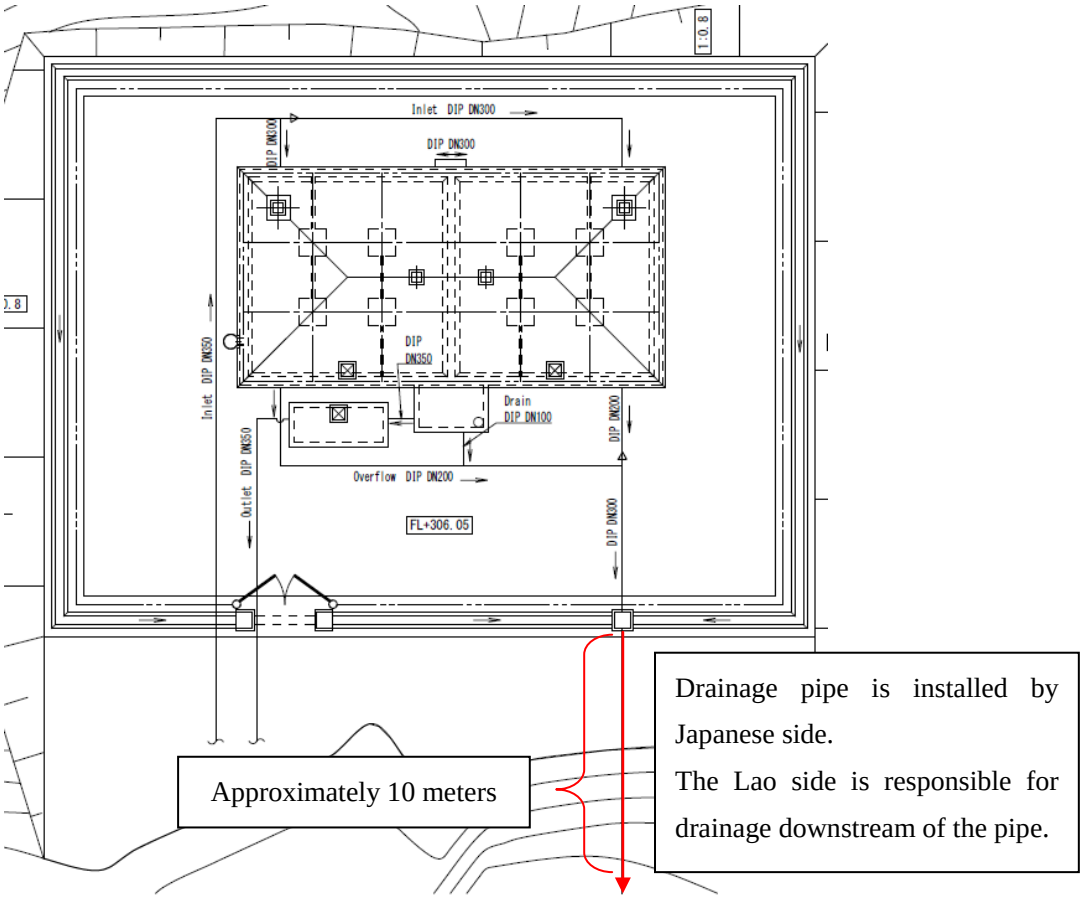


Figure 2.3.1 Drainage pipe at the reservoir site

2.3.4 Response to Environmental and Social Considerations

2.3.4.1 Acquisition of Environment Compliance Certificate (ECC)

This project is obliged to conduct the initial impact assessment (IEE) and acquire the ECC according to the laws of Lao PDR. DPWT-LPB and WSSE-LPB, the implementing agencies hold a stakeholder meeting on the draft IEE report. The feedback from the meeting is incorporated in the final IEE report and submit to DONRE for acquiring the ECC.

DPWT-LPB submitted the IEE report to DONRE in October 2018 and obtained the ECC on 22

November, 2018.

2.3.4.2 Heritage Impact Assessment (HIA)

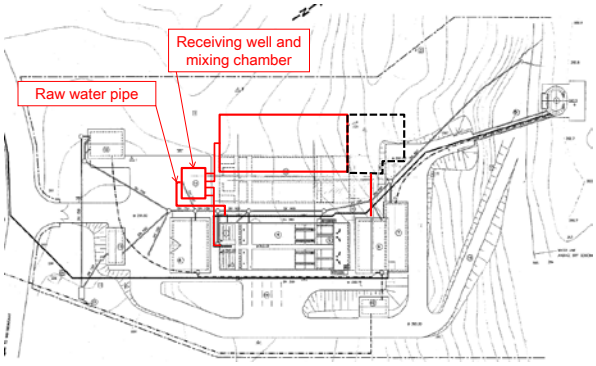
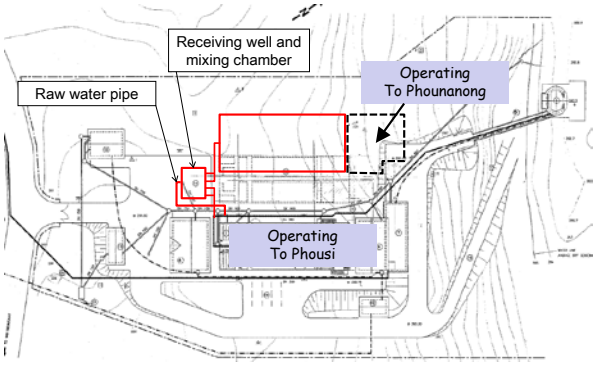
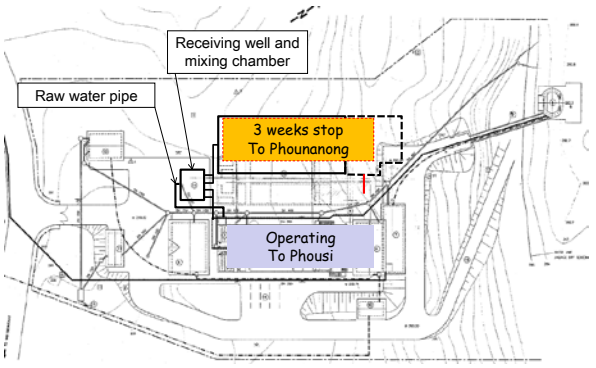
After a meeting with DPWT-LPB on this project in the World Heritage Site, the Luang Prabang Heritage Office determined that there is no potential negative impact and that further survey (Heritage Impact Assessment: HIA) is not required. The official letter on this decision was issued by the head of Luang Prabang World Heritage Office on 30 November 2018.

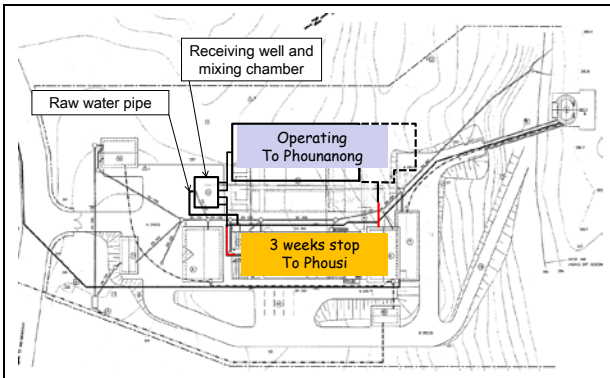
2.3.5 Adjustment to WTP operation during construction

It will be necessary to empty the existing flocculation basin and clear water reservoir and suspend plant operation for about 3 weeks each during construction at Namkhan WTP to conduct the following tasks:

No.1 install pipeline to connect the two clear water reservoirs

No.2 install pipeline to connect the new mixing well to the existing flocculation basin

	The red line shows the pipeline connections to be installed for: − receiving and mixing wells − flocculation basin and sedimentation basin − mixing well and flocculation basin − joining two reservoirs
	Stage 1 − Pipeline installation between receiving and mixing well, flocculation basin and sedimentation basin. − WTP can operate normally.
	Stage 2 (first 3-week suspension is necessary) − Wall of the reservoir is opened to install the pipe to connect the two reservoirs (red line). − Phounanong Reservoir will be emptied, water cannot be sent from Phounanong Reservoir for about 3 weeks.

	Stage 3 (second 3-week suspension is necessary) − installing pipeline from mixing well to existing flocculation basin. − Wall of the clear water reservoir is opened to install a connection pipe. − The reservoir to supply water to Phousi Reservoir will be emptied for about 3 weeks. Water cannot be sent to Phousi Reservoir during the 3 weeks.

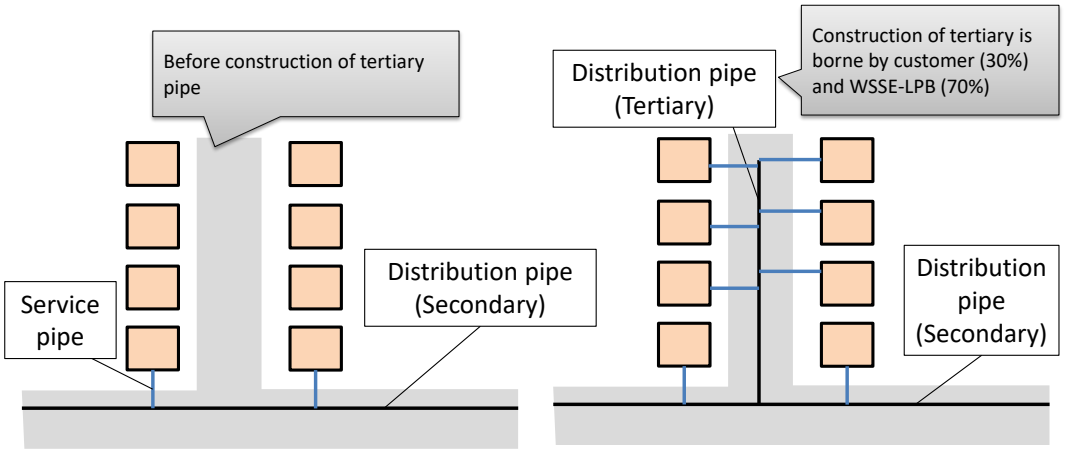
In order to continue water supply service, water supply from the Asia and Demco WTPs will be increased to cover the shortfall of 6,000 m^3/day during the each 3-week supply suspension according to the construction stages shown in the above. Previous supply suspensions at the Namkhan WTP for routine cleaning and other operations had gone smoothly with similar arrangement.

2.3.6 House Connections

Table 2.3.2 shows the details related to house connections to the distribution network as confirmed with WSSE-LPB.

Table 2.3.2 Detailed situations on house connections

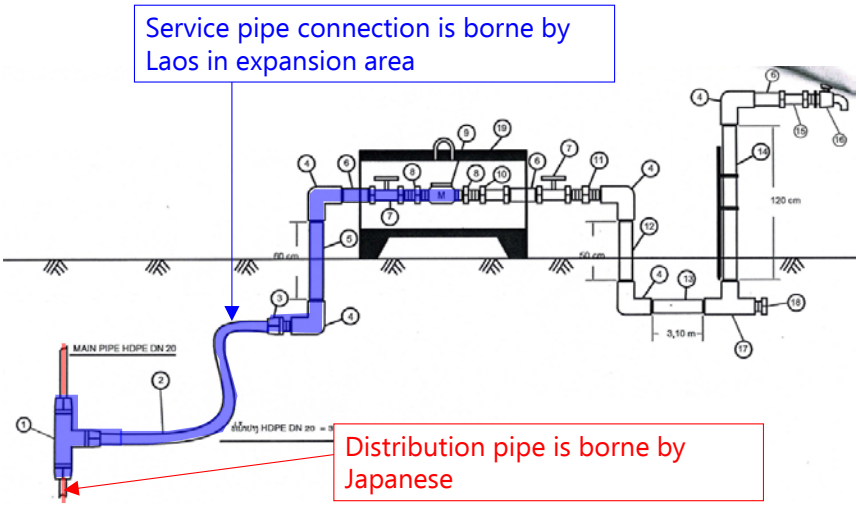
Item	Description
Who pays	− 100% paid by customer.
Connection charge	− Connection charge per customer is approx. 1 million Kip or approx. 120 USD (1 USD = 8, 300 Kip) − If installation of a distribution branch is required, the customer shall bear 30% of the installation cost (see Figure 2.3.2). − The charge is higher if the distribution pipe is far from the house.
Subsidy for house connection	− None
Ownership/Responsibility	− Up to the water meter: managed by WSSE-LPB − From the water meter to the house: managed by customer
Material of water supply pipe	− Polyethylene pipe
Installation	− By private company contracted by WSSE-LPB − About 1,000 connections that can be made per year
Meter country of origin	− Recently, Thai or Chinese products have been used



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.3.2 Cost allocation of water distribution branch pipe (tertiary pipe)

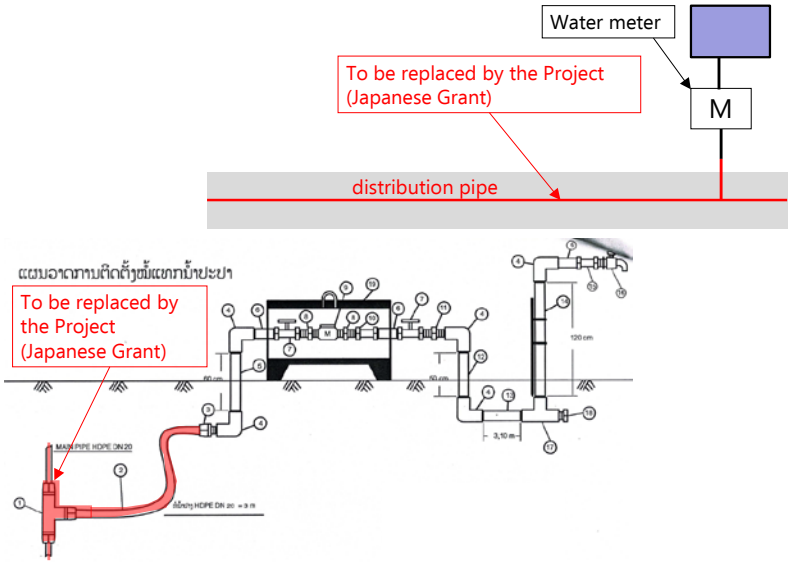
Even if the materials for house connection are procured under the project, the connection fee to be borne by the customer will not be reduced. Therefore, the project will not procure the materials for house connection. This resource will be put to installation of distribution branch pipe (tertiary pipe) instead since this will promote the interest in making the connection to the water supply. The house connections will be managed by the Lao side, with the residents responsible for requesting and paying for the connections.



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.3.3 Connection material for house connection to be borne by Lao side (in expansion area)

The connection between the existing house connection pipe and the new distribution pipe will be borne by the project (Japanese responsibilities) as shown in Figure 2.3.4**.** The pipe shown in red will be renewed by the project. If the pipe branching from the water distribution pipe is not changed by the project, disconnecting and reconnecting when the service pipe is installed will create a weak point that may result in water leakage. Therefore, the project will implement the re-connection works.



Source: Prepared by JPST based on the information from WSSE-LPB

Figure 2.3.4 Connection to house connections when replacing existing water distribution pipe

2.3.7 Power Supply

The Lao side will make the arrangement to bring power supply to the new reservoir site.

2.3.8 UXO

It is agreed that

- UXO survey will be carried out by the Lao side when the need arises[*1].
- If UXO is discovered during construction, the Lao side will be responsible for its removal.

* 1: No new UXO has been discovered since one was found at a construction site near the airport in Luang Prabang city. The possibility of coming across UXOs is expected to be small for pipeline installation and UXO survey will not be conducted for these sites. For the reservoir construction site, a UXO survey was conducted at the site before the soil and topo survey was carried out. Further UXO survey will be conducted by the Lao side when the need arises.

2.4 Project Operation Plan

Table 2.4.1 shows the draft staffing plan and job related impacts after project implementation.

Table 2.4.1 Draft staffing plan and job descriptions

Water Supply System Component	Impacts on Plant Operation	Actions Required
Expansion of Water Supply Area	Workload for meter reading staff will increase. By 2025, 600 more customers will be added to the supply system.	Add one more meter reader
Improvement of treatment process	The operation of Namkhan WTP will be partially changed and sludge treatment	Add two more contract employees for this facility

Water Supply System Component	Impacts on Plant Operation	Actions Required
	is added to the plant operation.	
O&M of WTP	Increase in power and chemical consumption at Namkhan WTP	No action is required because the revenue also increases. Revenue should be enough to cover cost.
Construction of new reservoir	Security must be provided for the new reservoir.	Redeploy security guards at Phousi reservoir to the new reservoir.
Monitoring System	Workload is reduced since flow data are collected automatically.	No staff adjustment is required.

1) Video monitoring at WSSE-LPB head office or monitoring by regular patrol is desired in the future for efficient management.

Table 2.4.2 shows the staff complement as well as the new hires considering the above job descriptions.

Table 2.4.2 Staff complement (as of March 2018)

Department	Number of Staff			Remarks	Change
	Regular Employee	Contract Employee	Total		
President, Vice President	3	-	3		
Audit Committee	4	-	4		
Organization・ Administration・ Planning	13	1	14		
Financial・ Accounting	7	1	8		
Design	26	3	29		
Namkhan WTP	8	-	8		2 additional persons (sludge treatment)
Phouphueng WTP	4	-	4		
Souphanouvong WTP	2	-	2		
Technical	24	3	27	support at site	
Customer service	9	1	10	meter reading, bill collection etc.	1 extra person
Nam Bark County	10	1	11		
Xieng Ngern County	10	1	11		

Department	Number of Staff			Remarks	Change
	Regular Employee	Contract Employee	Total		
Nan County	13	-	13		
Ngoi County	7	1	8		
Phon Xay County	4	1	5		
Security, cleaning, students, etc.	-	50	50		Security at Phousi reservoir redeployed to new reservoir
Total	144	63	207		

Source: Prepared by JPST based on the data provided by WSSE-LPB

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

2.5.1.1 Project Cost borne by Lao Side

The project cost borne by the Lao side is approximately 3,045 million LAK (40.1 million yen) (total expenses for the target year 2025), and its breakdown is shown in Table 2.5.1.

Table 2.5.1 Project cost borne by Lao side

No	Expenditure Item	Contents	Million LAK	Million JPY (equivalent)
1	Bank arrangement	• To open bank account • Commission for A/P[1)]	150	2.0
2	Land acquisition	• Land acquisition for new reservoir	750.0	9.9
3	Land clearing	• Clearing of the reservoir site	349.9	4.6
4	Access road construction	• Construction of access road to reservoir site	897.0	11.8
5	Namkhan WTP	• Repair civil structures • Removal of − hut in the area for the sedimentation basin − shrine and hut in the area for the lagoon − tree (or just trim) in the area for the new facilities	305.7	4.0
6	Namkhan WTP	• Operation and Adjustment of WTP during Namkhan WTP Construction	15	0.2
7	Electric supply to reservoir site	• Arrange for power supply	212.4	2.8
8	UXO, Stock yard	• Before construction • Removal cost when discovered	334	4.4

No	Expenditure Item	Contents	Million LAK	Million JPY (equivalent)
		• Stockyard • Arrangement with relevant agencies		
9	Soft component	• Prepare and install baffle plates	17	0.2
10	Environmental and social considerations	• Monitoring	14	0.2
	Total		3,045	40.1

1) A/P: Authorization to pay

2.5.1.2 Conditions for Cost Estimate

Cost estimates are based on the conditions shown in Table 2.5.2.

Table 2.5.2 Conditions for cost estimates

Item	Contents
Base Date of Estimates	June 2018
Exchange Rate	1 USD = 108.75 JPY 1 LAK = 0.0132 JPY
Construction Period	Total: 38 months Detailed design: 7 months (including bid document preparation) Bidding contract period: 5 months Construction procurement period: 26.0 months
Others	The project will be implemented in accordance with the procedures of Japan's Grant Aid Scheme.

2.5.2 Operation and Maintenance Cost

2.5.2.1 Increase in Personnel Expenses

The following staff must be added for the facilities to be constructed by the project.

Table 2.5.3 Additional staff and salary

Staff Position	No.	Schedule	Average salary	Exchange rate
Meter reader	1	From 2023	3,880,000 LAK/month (app. 51,000 JPY)	1LAK=0.0133JPY
Sludge transport workers (Namkhan WTP)	2	From 2023	943,600 LAK/month (app. 12,600JPY)	

Table 2.5.4 shows the increase of personnel expenses calculated from the above salary.

Table 2.5.4 Increase in personnel expenses for the facilities after project implementation

Year	Increase of staff		Personnel expense			Increase after the Project	
	Meter reader	worker (sludge)	Meter reader LAK/month	worker (sludge) LAK/month	Sub-total LAK/month	LAK/year	JPY/year
2016	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0
2023	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2024	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2025	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2026	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2027	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2028	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2029	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2030	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2031	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2032	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2033	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2034	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445
2035	1	2	3,880,000	1,887,200	5,767,200	69,206,400	920,445

2.5.2.2 Increase in Operation and Maintenance Cost

After project implementation, the daily average production will increase as well as operation cost for chemicals and electricity at the Namkhan WTP. Table 2.5.5 shows the current chemicals and electricity costs.

Table 2.5.5 2016 Chemicals and electricity costs (Namkhan WTP)

Ave. production m^3/day	Chemicals		Electricity	
	LAK/year	LAK/day	LAK/year	LAK/day
9,026	512,329,488 (6.8M JPY)	1,399,807 (18,600JPY)	974,902,071 (13M JPY)	2,663,667 (35,400 JPY)

Source: WSSE-LPB

Chemicals and electricity costs per 1 m^3 water production are as follows:

- chemicals: 155 LAK/m^3
- electricity: 295 LAK/m^3

Cost for sludge treatment is as follows:

- Unit price of sludge disposal: 287,000 LAK/m^3 (at Lakpaeth disposal site)
- Amount of sludge: approx. 540 m^3/year with average production of 10,800 m^3/day

Table 2.5.6 shows the increase in operating cost based on the above unit costs. Production amount shown in Table 2.5.6 is coming from the same conditions which are used for the financial simulation described in 2.5.2.4(6) Overall Financial Simulation**.**

Table 2.5.6 Increase in operation cost at Namkhan WTP after the Project

Year	Day ave. productior	Chemical	Electricity	Sludge disposal	Increase after the Project	
	m3/day	M LAK/year	M LAK/year	M LAK/year	M LAK/year	M JPY/year
2016	9,026	511	972	0	0	0
2017	9,000	509	969	0	0	0
2018	9,000	509	969	0	0	0
2019	9,000	509	969	0	0	0
2020	9,000	509	969	0	0	0
2021	9,000	509	969	0	0	0
2022	9,000	509	969	0	0	0
2023	9,000	509	969	129	129	1.7
2024	9,000	509	969	129	129	1.7
2025	9,500	538	1,023	136	214	2.8
2026	9,900	560	1,066	142	285	3.8
2027	10,400	588	1,120	149	374	5.0
2028	10,800	611	1,163	155	446	5.9
2029	10,800	611	1,163	155	446	5.9
2030	10,800	611	1,163	155	446	5.9
2031	10,800	611	1,163	155	446	5.9
2032	10,800	611	1,163	155	446	5.9
2033	10,800	611	1,163	155	446	5.9
2034	10,800	611	1,163	155	446	5.9
2035	10,800	611	1,163	155	446	5.9

2.5.2.3 Impact of Project Implementation on Finance

Table 2.5.7 shows the project specific financial performance, such as increases in personnel expenses and operation and maintenance expenses as calculated above. The overall operating costs will increase by about 200 million LAK (2.6 million yen) annually from 2023 after completion of the facilities and will gradually reach about 515 million LAK (6.8 million) yen after 2028. At the same time, the tariff revenue is estimated to be 600 million LAK (7.8 million yen) in 2025 and 2.4 billion LAK (reaching 32 million yen) after 2028, i.e. 4.6 times the operating cost.

Table 2.5.7 Project impact on operating and maintenance costs

Year	Water bill		Operation cost					Profit	
	Increment		Chemical	Sludge	Personal expense	Sub-total			
	M LAK/year	000 JPY/year	M LAK/year	M LAK/year	M LAK/year	M LAK/year	000 JPY/year	M LAK/year	000 JPY/year
2016	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0
2023	0	0	0	129	69	198	2,639	-198	-2,639
2024	0	0	0	129	69	198	2,639	-198	-2,639
2025	586	7,799	77	136	69	283	3,760	304	4,039
2026	1,129	15,018	143	142	69	354	4,711	775	10,306
2027	1,806	24,017	225	149	69	443	5,898	1,362	18,119
2028	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2029	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2030	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2031	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2032	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2033	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2034	2,425	32,258	291	155	69	515	6,849	1,910	25,409
2035	2,425	32,258	291	155	69	515	6,849	1,910	25,409

2.5.2.4 Overview of WSSE-LPB Business Operations

(1) Business Overview

The review of financial performance of WSSE-LPB for the past three years indicates that the corporation recorded a deficit in 2017. As shown in “2.5.2.4(4) WSSE-LPB Tariff Structure”, for the past three years the tariff has not been revised and is affecting profitability. Table 2.5.8 shows that cost management such as number of staff and wages has been inadequate in accordance with growth in operating revenue. This could have contributed to the deficit. As indicated in "2.5.2.4(5)Financial Status of WSSE-LPB", profits made in the urban areas compensate for deficits incurred in the rural areas. When the water supply service is expanded to the rural areas, improvement of management efficiency is critical for maintaining organizational financial health.

Table 2.5.8 WSSE-LPB performance indicators

	2015	2017	Changes 2015-17
Number of staff (people)	137	152	11%
Number of staff per 1,000 connections (people)	6.9	6.8	-2%
Total operating revenue per employee (1,000 kip)	191, 664	201, 609	5%
Charged water volume per employee (m3 / year)	54,079	55, 928	3%
Personnel expenses per employee (1,000 kip)	32, 405	44,028	36%

Source: Calculated by the JICA study team from the WSSE-LPB Annual Report and financial statements

WSSE-LPB’s operating and cash equivalent ratios are excellent compared to other WSSEs in Laos. Probably, it has the top performance among all the WSSEs. However, Table 2.5.9 shows that the financial indicators in 2017 deteriorated in all aspects except for the capital adequacy ratio. Operating profit and net income became negative in 2017 and this is the biggest issues. Cash equivalents /

monthly personnel cost for 2017 is in the lowest level in the past 5 years as shown in Table 2.5.9**.**

Table 2.5.9 Financial indicators of WSSE-LPB

	2013	2014	2015	2016	2017
Operating Ratio*	162%	184%	163%	193%	167%
Operating Profit to Revenue	8%	9%	7%	4.4%	-1.4%
Net income to Revenue	4%	5%	2%	0.8%	-4.5%
Capital Adequacy Ratio	76%	80%	77%	80%	98%
Cash Equivalents / Total Monthly Operating Expenses	7.3	10.6	10.1	12.8	9.5
Cash Equivalents / Monthly Personnel Cost	20.0	26.8	28.0	26.6	16.5

Note: * Excluding depreciation

Source: WSSE-LPB, calculated by JICA Study Team

(2) Accounts Receivable

The following Table 2.5.10 shows the *accounts receivable days* for each customer type, (outstanding receivables divided by daily average sales). The fewer days indicate better water bill recovery. Overall, there is a downward trend for the number of accounts receivable days, indicating improvements in bill recovery, except for government agencies which got worse in 2017.

Table 2.5.10 Customer type accounts receivable collection days *

Unit: day

	2012	2013	2014	2015	2016	2017
Household	37	52.7	32.4	16.2	26.0	19.9
Government Agency	259.9	278.7	217.7	204.7	188.7	225.8
Private Enterprises	45.5	58	38.8	33.6	20.5	16.3
Total	71	58.5	61.9	48.2	47.1	47.7

Note *: Value obtained by dividing accounts receivable by daily average revenue

Source: Calculated by JPST from WSSE-LPB financial statements

(3) WSSE-LPB Organization

Figure 2.5.1 shows the organizational chart of WSSE-LPB.

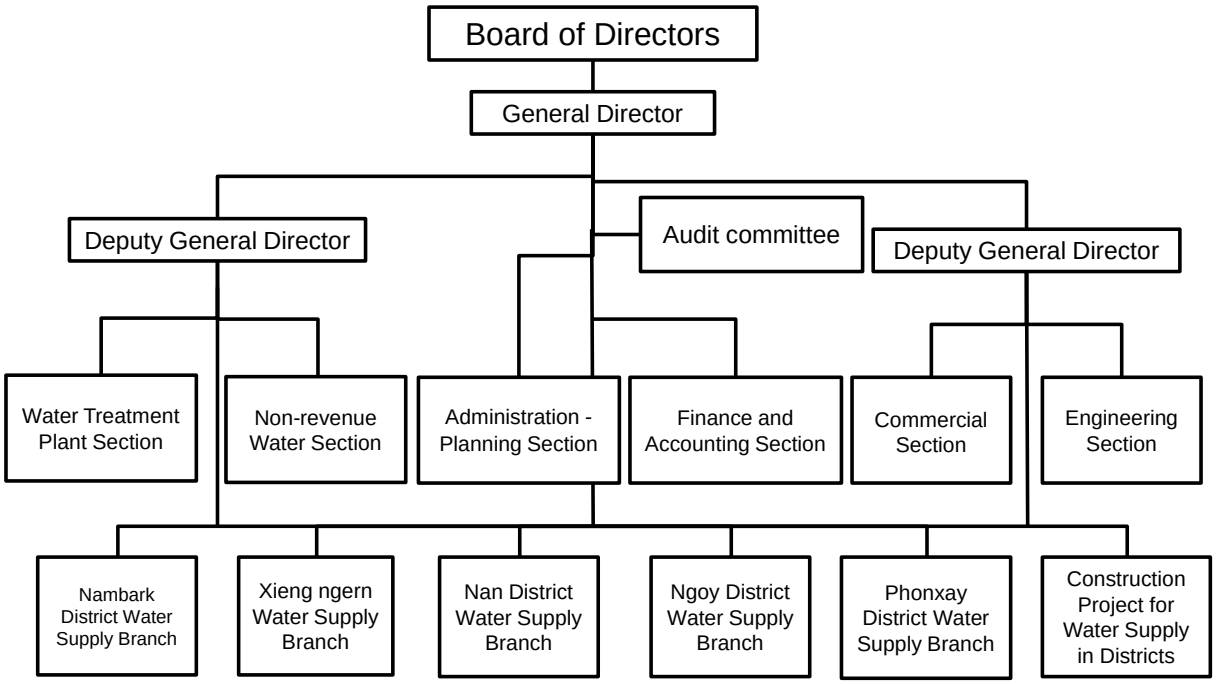


Figure 2.5.1 Organizational chart of WSSE-LPB

Source: WSSE-LPB Annual Report 2017

Table 2.5.11 shows WSSE-LPB employees by years of service and Table 2.5.12 shows the number of staff by age group. Most of the staff have less than 10 years of service. Since the organization is young, technical development of this cohort is a challenge.

Table 2.5.11 WSSE-LPB employees by years of service (2017)

Years of Service (Year)	No. of Office Worker	No. of Technical Staff	Total
1 - 5	34	20	54
6 - 10	11	17	28
11 - 15	14	12	26
16 - 20	4	7	11
21 - 25	4	3	7
26 - 30	2	2	4
31 - 35	4	1	5
36 - 40	1	1	2
>40	0	0	0
Total	74	63	137

Source: WSSE-LPB Annual Report 2017

Table 2.5.12 WSSE-LPB employees by age group (2017)

Age Group	No. of Office Worker	No. of Technical Staff	Total
<20	0	0	0
21 - 30	30	21	51
31 - 40	30	28	58
41 - 50	6	10	16
51 - 60	8	4	12
Total	74	63	137

Source: WSSE-LPB Annual Report 2017

(4) WSSE-LPB Tariff Structure

Table 2.5.13 shows the water tariff system of WSSE-LPB. From 2010 to 2012, there was no tariff revision. An annual increment of 3% was implemented from 2013 to 2015. From 2016 to 2017, the tariff remained unchanged. Intermittent tariff revision is one of the factors that creates financial instability in WSSE-LPB.

Table 2.5.13 WSSE-LPB water tariff

	Year	2013	2014	2015
Category 1: Households				
1 - 7 m^3	Kip / m^3	1,680	1,764	1,852
8 - 15 m^3		2,340	2,504	2,754
> 16 m^3		3,058	3, 156	3,251
Category 2: Government Agencies	Kip / m^3	2,990	3,289	3,618
Category 3: Companies, International Organizations	Kip / m^3	3,250	3,575	3,933

Source: WSSE-LPB

The water tariff revision process is shown in Figure 2.5.2. Following the decision by the Board of Directors, an application for revision is prepared by WSSE-LPB. The application is examined by the MPWT/DWS. The provinces are notified. The governor promulgates the new tariff, after deliberation and confirmation in the assembly. The most time-consuming step is the preparation of documents in WSSE-LPB. There are no templates, manuals or guidelines for tariff revision application, which means that each water supply company develops the documents in its own way.

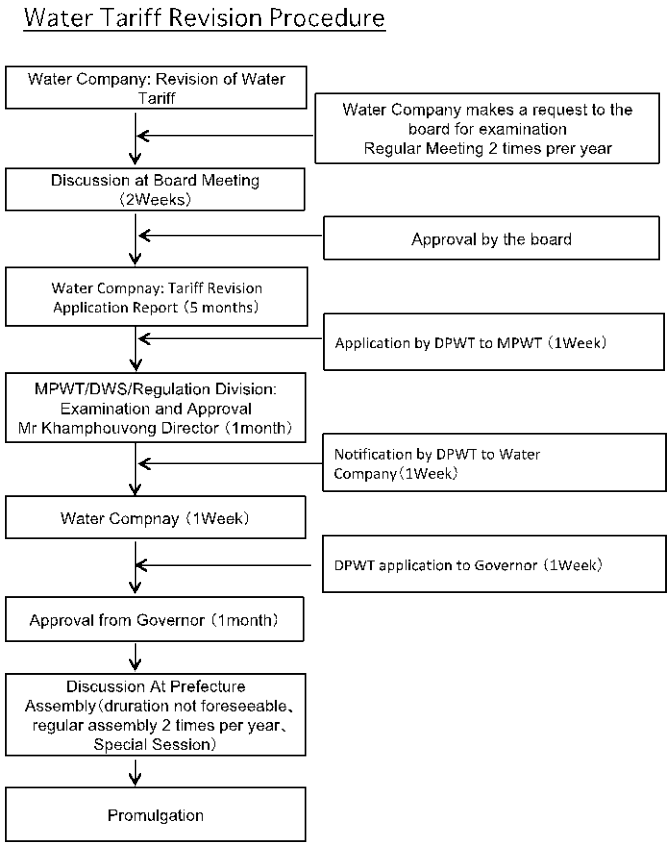


Figure 2.5.2 Water tariff revision process

(5) Financial Status of WSSE-LPB

1) Financial Structure of WSSE-LPB

Table 2.5.14 shows the income statement of WSSE-LPB for 2017 with breakdowns, including profits for each branch. The entire WSSE-LPB reported a surplus from 2013 to 2016 but a loss in 2017. Only Luang Prabang and Xieng Ngern reported a surplus in 2017, with no change in revenue structure among branches in the past 5 years. Luang Prabang and Xieng Ngern are subsiding the losses of other branches.

The unit cost for production for the branches reporting losses are two to three times higher than those of Luang Prabang and Xieng Ngern.

ADB is assisting with the expansions of the water supply in Nam Bark, Nan and Ngoi, which calls for a cautious cost management plan.

Table 2.5.14 WSSE-LPB income statement and breakdowns by branch for 2017

Unit LAK million

	Whole Province		Luang Prabang		Nam Bark		Xieng Ngern		Nan		Ngoi		Phon Xay	
Operation Indicators														
Production volume ('000 m^3)	11, 276		9,513		417		514		531		259		42	
Purchase volume ('000 m^3)	3,929		3,929											
Sales volume ('000 m^3)	8,501		7,012		353		437		443		218		38	
NRW (%)	25 %		26%		15%		15%		17%		16%		10%	
No. of customers	1,349		841		62		333		81		26		6	
Income Statement														
Revenue	30, 117	96%	25, 2006	110%	1,145	64%	1,673	110%	1,449	58%	721	29%	123	40%
Expenditure	31, 461	100%	22,834	100%	1,778	100%	1,525	100%	2,500	100%	2,515	100%	311	100%
Direct expenses	26,566	84%	19, 401	85%	1,505	85%	1,081	71%	2,004	80%	2, 327	93%	248	80%
Variable expenses	2, 324	7%	1,884	8%	57	3%	19	1%	62	2%	209	8%	92	30%
Overhead expenses	17, 406	55%	10,681	47%	1,447	81%	1,062	70%	1,941	78%	2,118	84%	156	50%
Water purchasing cost	6,836	22%	6,836	30%		0%		0%		0%		0%		0%
Distribution cost	1,071	3%	753	3%	44	2%	191	13%	64	3%	16	1%	4	1%
Water distribution maintenance	130	0.4%	83	0.4%	14	1%	8	1%	18	1%	5	0%	1	0%
Management cost	3,615	11%	2,524	11%	215	12%	238	16%	414	17%	167	7%	58	19%
Project related expenses	80	0%	74	0%	0	0%	6	0%	0	0%	0	0%	0	0%
Profit	-1,344	-4%	2,173	10%	-633	-36%	149	Ten%	-1,051	-42%	-1,794	-71%	-188	-60%
Unit Cost Indicators														
Unit Production	*2,356*		*2,040*		*3,610*		*2,103*		*3,772*		*8,97:*		*5,851*	

	Whole Province	Luang Prabang	Nam Bark	Xieng Ngern	Nan	Ngoi	Phon Xay
Cost (LAK / m^3)							
Production and Distribution Unit Cost (LAK / m^3)	*3,701*	*3,256*	*5,044*	*3,492*	*5,637*	*11,51*	*8, 137*
Average Sales price (LAK / m^3)	*3,543*	*3,566*	*3,248*	*3,832*	*3,268*	*3,30*	*3,226*

Note: The percent contribution of each branch to the financial items is calculated assuming the total expenditure as 100 %.

Source: WSSE-LPB

2) Income Statement

In the income statements of WSSE-LPB, the share of variable costs such as chemicals and electricity and depreciation expenses, shows gradual decrease while bulk water purchase cost shows the biggest increase. This trend is expected because the PPP project started its operation in 2014. Meanwhile, personnel expenses have shown a gradual increase which is unexpected because the transfer of operations to PPP should have contributed to a reduction in personnel expenses. This upward trend in personnel expenses may indicate some laxity in cost management.

In the income statement presented by WSSE-LPB, there is no record of corporate tax payments.

Table 2.5.15 Income statement for the entire WSSE-LPB water supply corporation 2017

Unit: LAK million

	2013		2014		2015		2016		2017	
Total operating revenue	16,807		23,152		26,519		28,048		30,020	
Water revenue income	15,115		21,374		23,603		25,318		27,302	
Other income	1,692		1,778		650		37		101	
Total operating cost	15,420	100%	21,007	100%	24,576	100%	26,824	100%	30,442	100%
Drug expenses	3,148	20%	2,146	10%	783	3%	720	3%	715	2%
Power cost	1,485	10%	1,479	7%	1,220	5%	1,287	5%	1,241	4%
fuel expenses	-		-		278	1%	188	1%	210	1%
Meter purchase cost	-		-		43	0%	394	1%	621	2%
Personnel expenses	3,813	25%	4,946	24%	5,898	24%	7,012	26%	8,364	27%
Depreciation cost	5,045	33%	8,445	40%	8,295	34%	8,341	31%	8,959	29%
Water purchase cost	0	0%	2,309	11%	3,906	16%	4,945	18%	6,836	22%
Other operating expenses	1,928	13%	1,682	8%	4,153	17%	3,938	15%	3,496	11%
Operating income (loss)	1,387	9%	2,145	10%	1,943	8%	1,224	5%	-422	-1%
Financial revenue	0	0%	0	0%	0	0%	0	0%	0	0%
Financial expenses	676	4%	990	5%	1,276	5%	1,028	4%	1,023	3%

Unit : LAK million

	2013		2014		2015		2016		2017	
Net financial income (loss)	-676	-4%	-990	-5%	-1,276	-5%	-1,028	-4%	-1,023	-3%
Profit before tax from continuing operations	712	5%	1,155	5%	667	3%	195	1%	-1,445	-5%
Extra profit	0	0%	0	0%	0	0%	37	0%	101	0%
Special loss	0	0%	-2	0%	-16	0%	0	0%	0	0%
Total operating revenue	0	0%	-2	0%	-16	0%	37	0%	101	0%
Water revenue income	0	0%	0	0%	0	0%	0	0%	0	0%
Other income	712	5%	1,153	5%	650	3%	232	1%	-1,344	-4%

Source: WSSE-LPB Profit and Loss Statement

3) Balance Sheet

WSSE-LPB maintains its balance sheet according to the standard accounting format with debits in balance with credits. Inconsistency between related items and unexplainable fluctuation of expenses are frequently observed in consecutive periods. Some amendments of inconsistencies were attempted during the preparatory survey but unresolved issues remain. WSSE-LPB recognizes that capacity building for accounting staff is urgently required so they have a deeper understanding of the principles of balance sheet and account classification to avoid reporting inaccuracies.

The rules for depreciation do not reflect the reality of water supply operations. For example, the depreciation of assets which should reflect expected service life is set at 20 years for buildings, 20 years for pipes, 20 years for motors and 5 years for pumps. The depreciation periods for ductile iron pipes and u-PVC pipes are both set at 20 years. It is highly probable that the service life is set excessively short. However, changing this may be difficult, since they are prescribed by a local tax law.

Table 2.5.16 WSSE-LPB balance sheet 2017

Unit (LAK million)

	2013	2014	2015	2016	2017
Current assets	17, 205	18,760	29, 952	33, 229	36, 192
Cash and cash equivalents	6,340	11,053	13,744	15,538	11,533
Accounts receivable	3,873	4,033	3,468	5,642	5,716
Inventory	2,372	3,294	2,886	2,685	3,546
Other current assets	4,620	380	9,854	9, 364	15,398
Fixed asset	85, 531	82,028	80,049	103, 220	100,060

	2013	2014	2015	2016	2017
Tangible fixed assets (acquisition price)	100, 227	103,975	100, 126	125, 869	127, 376
Accumulated depreciation expenses	-14, 695	-22,273	-20, 269	-32,559	-34, 545
Fixed assets (post depreciation value)	85, 531	81,702	79,856	93, 310	92,831
Construction in progress		61		0	
Other fixed assets	0	265	193	9, 910	7,229
Total assets	102, 736, 828	100,787	110, 001	136, 449	136, 253
Current Liabilities	468	528	2,666	495	1,007
Accrued interest	468	1,195	1,891		
Accounts payable	0	28	1,119	491	970
Other current liabilities	0	-970	-344	Four	37
Fixed liabilities	24, 405	22,447	22,838	26, 270	2,056
Long-term debt	24, 405	22,447	22,838	23,417	19,796
Other liabilities				2,853	-17, 740
Shareholders' equity	78,487	80, 205	84, 498	109, 683	125, 904
Paid-up capital	76, 218	77, 902	85, 945	108, 122	125, 902
Capital reserve	949	828	1,107	877	779
Capital investment fund subsidy / provision	382	292	676	586	567
Net income	1,018		98	98	-1,344
an earned surplus	-80	1,183	-3, 328	0	56
Liabilities and shareholders' equity	103, 360	100,787	110, 001	136, 449	128, 967

Source: WSSE-LPB Balance Sheet

4) Debt

Table 2.5.17 is a summary of WSSE-LPB's long-term loans and loan terms. The loans, repayments and outstanding debt also lack consistency with the balance sheet. These loans are provided to WSSE-LPB from the Ministry of Finance under an on-lending scheme denominated in the local currency. The associated currency risk is surcharged to the concessional loan as a currency risk premium to the lending interest, resulting to the interest level of above 6% per year. The loans except for the ADB

loans are repaid in accordance with the repayment schedule. The ADB loans, i.e. ones for Nan, Ngoi and Nam Bak, are exempted from principle repayment by the Ministry of Finance, with only the interest payment required.

Table 2.5.17 Long-term loans and conditions

		ADB			KfW[1)]		LDB[2)]
Project		Nam Bark	Ngoi	Nan	Luangprabang (Phase 1)	Luangprabang (Phase 2)	Namkhan New WTP
Project Cost	USD	-	1,785,096	1,379,367			
loan	USD	186, 764	535, 529	413, 810	640, 008	1,575,758	
	DM				1,056,013.55	2,600,000	
	LAK		4,227,969,600	3,241, 858, 510	460, 805, 913	1,528,484,848	8,043,000,000
Date of concluding the loan		1 - Jul - 1 0	1-Jul-08	1-Jan-08	15/7/1993	4/9/1996	09/03/2011
Repayment period (years)		25	25	25	22	20	8
interest rate		6.40%	6.40%	6.40%	6.00%	6.60%	7.00%
Grace period (year)		6	6	6	3	5	-
Balance (LAK)		93, 262 (USD)	3, 937, 870, 737	2,474,049,916	192, 003.39 (DM)	520,000 (DM)	1,043 million
As of Date		July 1 of 2018	July 1 of 2018	July 1 of 2018	July 1 of 2018	July 1 of 2018	July 1 of 2018

Source: WSSE-LPB

1) KfW: Kreditanstalt für Wiederaufbau (German)

2) LDB: Lao Development Bank

(6) Overall Financial Simulation

The following assumptions are used to evaluate the financial impacts of the project on the management of WSSE-LPB.

The water demand will follow the projections established in Table 2.5.18. Estimated production volumes of each water treatment plant and purchase volumes from the private water treatment plants are as shown in the Table 2.5.18. Unit consumption for chemicals and electricity per m^3 of water and prices are taken from 2017 records, and labor costs and other management costs are assumed to be same as in 2017.

Table 2.5.18 Daily average production by water purification plant

m^3／日

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Namkhan WTP	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,500	9,900	10,400	10,800	10,800	10,800
Phouphueng WTP	7,000	7,000	7,000	7,400	7,750	8,100	8,100	8,100	8,100	8,100	8,100	8,100	8,100
Asia WTP (Purchase)	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,800	7,600
)emco WTP （Purchase)	5,500	6,200	7,000	7,400	7,800	8,200	8,900	9,000	9,000	9,000	9,000	9,000	9,000
Total	27,500	28,200	29,000	29,800	30,550	31,300	32,000	32,600	33,000	33,500	33,900	34,700	35,500

Based on the above assumptions, the financial projections for Luang Prabang Branch and WSSE-LPB are shown in Figure 2.5.3.

The profit/loss accounts will show a continued deterioration as the water supply service will be obliged to purchase more water from private plants under the current tariff. The branch accounts will improve after the commissioning of the project, but the improvements cannot fully cover the loss of all the WSSE accounts.

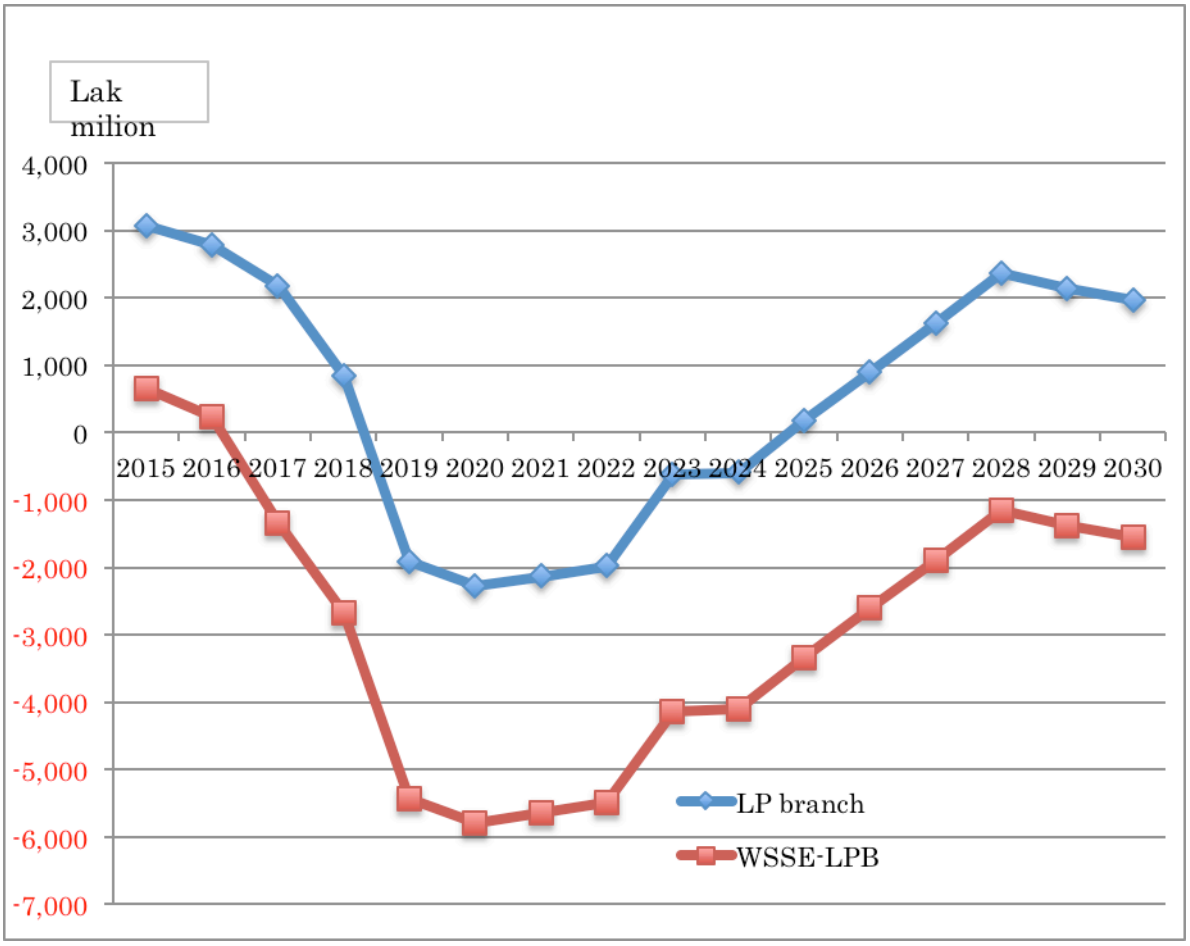


Figure 2.5.3 Profit/Loss movements in financial simulation of Luang Prabang branch and WSSE-LPB with project

Table 2.5.19 Financial simulation of Luang Prabang branch and WSSE-LPB with project

Unit: LAK million

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
P/L Luang Prabang Branch													
Revenue	25,203	25,902	26,602	27,308	28,014	29,943	30,912	31,888	32,674	33,462	34,255	35,049	35,904
Water Production Exp.	5,059	7,586	7,595	7,620	7,643	7,682	7,694	7,765	7,822	7,890	7,947	7,957	7,968
Water Purchase Exp.	7,449	7,914	8,445	8,710	8,975	9,241	9,705	9,772	9,772	9,772	9,772	10,278	10,785
Operation/Maintenance	163	164	163	164	156	156	163	164	164	164	164	165	165
Management Costs	2,361	2,360	2,360	2,359	2,367	2,367	2,360	2,360	2,360	2,360	2,359	2,359	2,359
Others	9,328	9,792	10,323	10,589	10,854	11,120	11,584	11,650	11,650	11,650	11,650	12,157	12,664
Net Profit of Branch	844	-1,913	-2,284	-2,135	-1,982	-623	-595	177	906	1,625	2,361	2,133	1,963
Entire NPLP Net Profit	-2,673	-5,430	-5,801	-5,651	-5,499	-4,139	-4,111	-3,340	-2,610	-1,891	-1,155	-1,384	-1,553

(7) Recommendations for Financial Improvements

As shown in (6) above, WSSE-LPB will continue to report deficits under the current management conditions. Therefore, it is important to implement management improvements proactively as follows:

- Human resource capacity development and effective human resource allocations,
- Reduction of NRW including leakage,[19]
- Enhanced customer base expansion, and
- Overall improvements in management efficiency.

In addition to the above management improvement efforts, there should be a gradual increase in tariff on an annual basis, without excessive burden to the customers. Any tariff revision must have public acceptance (through public outreach). Provincial and central governments will need to lend their support in improving management efficiency and customer base expansion, through their long-term planning exercises.

Table 2.5.20 shows the financial projection when the tariff is increased by 2%[20] per year from 2019 onwards. Luang Prabang Branch will show profits from 2024, and WSSE-LPB as a whole, from 2028.

[19] The projection incorporates a higher target for leakage reduction of 20% by 2028.
[20] An annual inflation rate has to be added to the actual increase.

Table 2.5.20 Financial projections for Luang Prabang branch and WSSE-LPB with project and 2% annual tariff increase

Unit: LAK million

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
P/L Luang Prabang Branch													
Revenue	25,203	26,420	27,134	27,854	28,574	30,542	31,531	32,525	33,327	34,131	34,940	35,750	36,622
Water Production Exp.	5,059	7,586	7,595	7,620	7,643	7,682	7,694	7,765	7,822	7,890	7,947	7,957	7,968
Water Purchase Exp.	7,449	7,914	8,445	8,710	8,975	9,241	9,705	9,772	9,772	9,772	9,772	10,278	10,785
Operation/Maintenance	163	164	163	164	156	156	163	164	164	164	164	165	165
Management Costs	2,361	2,360	2,360	2,359	2,367	2,367	2,360	2,360	2,360	2,360	2,359	2,359	2,359
Others	9,328	9,792	10,323	10,589	10,854	11,120	11,584	11,650	11,650	11,650	11,650	12,157	12,664
Net Profit of Branch	844	-1,395	-1,752	-1,588	-1,422	-24	24	814	1,559	2,295	3,046	2,834	2,682
Entire NPLP Net Profit	-2,673	-4,809	-5,062	-4,792	-4,517	-3,008	-2,848	-1,942	-1,079	-224	650	562	537

3. Project Evaluation

3.1 Preconditions

Preconditions and responsibilities by Lao side for the project implementation are described in "2.3 Obligations of Recipient Country". The key conditions are as follows:

(1) Land Acquisition for the New Reservoir

It is necessary to obtain the land for the construction of the new reservoir. As of 25 December, 2018, the land acquisition has been completed and the right to use the land has been handed over to WSSE-LPB.

(2) Construction of Access Road to the New Reservoir

It is necessary to construct the access road to the new reservoir. The access road must be constructed by Lao side before the start of the reservoir construction.

(3) Power Supply to the New Reservoir

Electrical distribution lines and incoming service to the new reservoir are provided by the Lao side. Power supply to the new reservoir must be in place before the completion of the reservoir construction.

(4) Heritage Impact Assessment (HIA)

HIA and approval is normally required for implementing a project in the WHS. The Lao side decided that HIA is not necessary since there will be no significant negative impact to the area by the project. The letter confirming this from the Luang Prabang World Heritage Office is attached in **Appendix 6-2**.

(5) Approval of IEE Report and ECC

ECC is required for project implementation in Lao PDR. ECC is issued when DONRE approves the IEE report.

The IEE report was approved on 22 November, 2018, and the ECC has already been issued.

3.2 Necessary Inputs by Recipient Country

(1) Installation of House Connections

The project will install new distribution pipelines including tertiary pipes in the expansion area. The house connections are installed based on the request of the residents and the cost is borne by the residents. Public outreach will be carried out to promote house connections by the Lao side as stated in the M/D dated 27th November 2018.

(2) Increase of WSSE-LPB Staff

3 more staff are required after the completion of the project: 2 for sludge treatment and 1 for meter reading in the expansion area.

3.3 Important Assumptions

Important assumptions consequential to project success and sustainability are as follows:

- Serious natural disaster will not occur.
- Serious deterioration of economy will not occur.
- Demographics in the project area will not change unexpectedly.
- The existing treatment capacity including those of the private WTPs will be maintained.
- The operation of the dam upstream of Namkhan WTP will be conducted with due consideration to prevent flooding and excess turbidity.

3.4 Project Evaluation

3.4.1 Relevance

3.4.1.1 Project Beneficiaries

The project will expand the water supply area and residents in the expansion area will be able to connect to the water supply system. About 600 new households are expected to connect to the water supply system in the expanded service area by 2025.

The coverage will increase from 90.2 % in 2017 to 96.2 % in 2025. The served population will increase by 12,000, from 59,000 in 2017 to 71,000 in 2025. The project will carry out improvements to Namkhan WTP, renewal of aged pipelines and construction of a new reservoir. These efforts will contribute to stabilization of supply volume, better water quality and water pressure. The overall improvement to the water supply system will benefit an estimated 71,000 people in 2025.

Luang Prabang city received approximately 650,000 tourists in 2017, since Luang Prabang city has a World Heritage Site. The improved water supply service will also benefit these tourists.

Fire hydrants will be installed to enhance the firefighting capability for better protection of Luang Prabang city including the World Heritage Site.

3.4.1.2 Urgency of Project Implementation

Although the coverage in the existing service area is high, there are problems with treated water quality caused by insufficient capacity of the sedimentation basin, leakage and lack of water pressure because of aged reservoir and pipelines. The renewal of 50-year old pipelines will reduce leakage and increase water supply pressure. Improvements are urgently needed to upgrade the service to supply safe water with adequate pressure.

The two critical issues to be resolved: turbidity of treated water and aged pipelines, are further explained below.

Although the rapid sand filter in Namkhan WTP has a capacity of 12,000 m^3/day, the capacity of the flocculation and sedimentation basin is only 6,000 m^3/day. The gap in capacity results in inadequate sedimentation and the floc flows to the filter. Sometimes turbidity exceeds the Lao water quality

standard of 5NTU, making it difficult to deliver safe water supply. Stable supply is also compromised when raw water turbidity is high especially in the rainy season and intake flows must be reduced to achieve the required treated water quality. A flocculation and sedimentation basin with adequate capacity is urgently needed.

Old pipelines are the main reason for high leakage rates. In recent years, NRW has increased, by 10% over just a 5-year period. Large amounts of leakage contribute to the problem of poor water supply pressure. Renewal of old pipelines will reduce leakage significantly and improve supply pressure. The NRW and leakage ratio are expected to be increased considering the recent trend ant the increases of NRW and leakage ratio have the adverse impacts including decrease of water supply pressure. Therefore, the renewal of the aged pipelines is also the urgent task.

3.4.1.3 Relevance to Lao National Plans

The 8th National Socio-Economic Development Five-Year Plan (2016) aims to increase the water supply coverage to 90% by 2020 for the central part of each city in Lao PDR. The coverage in the existing supply area in Luang Prabang city is 95.3%, i.e. the national target has already been achieved.

The current water supply service has to be improved to meet the goal in the Water Supply Planning Technical Guidelines developed with the support of MaWaSU project (see below). However, there are still problems with high turbidity of treated water caused by insufficient capacity of the sedimentation basin, leakage and lack of supply pressure because of aged reservoir and pipelines, and installation of the distribution pipelines in expansion area.

Water Supply Planning Technical Guidelines under the support of MaWaSU Project

Overall Goal	The water supply service should provide customers with safe, stable and sustainable water supply, and thereby improve public health and living environment.

The improvement of the WTP and the renewal of aged pipelines and installation of distribution pipelines in the expansion area by the project are consistent with the national plans.

3.4.1.4 Compliance with Japan’s Assistance Policy for Lao PDR

“Development of Economic and Social Infrastructure” is a high priority in Japan’s assistance policy for Lao PDR (2012). This includes the development of infrastructure including water supply in urban areas. JICA country analysis for Lao PDR (2015) shows that expansion of existing WTPs, construction of new WTPs and transmission/distribution pipelines, and renewal of aged pipelines have a high priority. Therefore, the project is consistent with Japan’s assistance policies.

3.4.2 Effectiveness

3.4.2.1 Quantitative Effects

The project is expected to provide the following beneficial outcomes:

Table 3.4.1 Quantitative Effects

No.	Index	Baseline (2017)	Target (Year 2025)
1	Served population	58,760	70,812
2	Number of new house connections in the expanded service area	-	600 Connections
3	Maximum turbidity of treated water in Namkhan WTP	12 NTU (Maximum in last 5 years from 2013 to 2017)	< 5 NTU
4	Water pressure	0-10 m	> 10 m

3.4.2.2 Qualitative Effects

The qualitative effects are as follows:

- The renewal of aged pipelines and installation of new distribution pipelines will improve water supply pressure and reduce leakage in the supply area.
- Improvement to Namkhan WTP will strengthen the stability of water supply and improve water quality.
- Installation of fire hydrants will improve protection and firefighting capacity in the WHS.