CHAPTER 3. PILOT PROJECT

3.1 Community and School Based Sanitation

3.1.1 Background

The Bremen Overseas Research and Development Association (BORDA) is an international NGO whose head office is located in Bremen, Germany. It has been working for improving living conditions of socially disadvantaged groups in an environmentally sustainable manner since 1977. One of its typical activities is to implement community based sanitation (CBS) projects with application of the Decentralized Wastewater Treatment System (DEWATS). More than 290 CBS projects have been installed so far in Southeast Asia by BORDA.

The Lao Institute for Renewable Energy (LIRE), which was founded in 2006 by a number of Lao companies, organizations and agencies to establish a platform for renewable energy research in Lao PDR, is a non-profit institution operating in Lao PDR. Since BORDA was in partnership with LIRE in the field of energy supply sector, the two organizations established the BORDA-LIRE DEWATS Programme Cooperation in 2009, aiming at promoting decentralized sanitation through CBS and small and medium enterprises.

The JICA Study Team and BORDA-LIRE discussed the general water management issues in Vientiane. In several meetings afterwards, both parties had shared relevant ideas and the possibility of implementation of the CBS program in Vientiane, as follows:

- Based on survey results conducted by BORDA-LIRE in eight Villages in Vientiane, sanitation problems mostly appeared. There is still lack of a proper septic tank even though most of the houses in the city have individual pour-flush toilets; and
- In the Study, the JICA Study Team identified that pollutant concentration in city canals is quite high and some of the contributions come from settlements along the canals. Water purification is one of the plans within the study and integration of community based sanitation program is considered to minimize the water pollution as well as encourage healthy and hygienic practices in urban communities.

The JICA Study Team and BORDA-LIRE confirmed their intention to jointly implement new CBS programs in Thongkhankham Village and Khoualuang Primary School in Chantabury District of Vientiane. These package treatment plants aim at treating domestic wastewater as well as human waste. They will be adapted to local realities of the institution, environment-friendly, easy to run and maintain and seen as a model replicable to other comparable institutions in Lao PDR. Further, it was expected that the pilot project of environmental education would be conducted more effectively with the implementation of construction which would actually treat water environment problems by the participation of targeted people.

A selection process of pilot project sites is described in the following subsections, and technical matters and management structure on the CBS and SBS (School Based Sanitation or CBS installed in a school) are mainly described afterwards.

3.1.2 Project Site Selection

(1) Integrated Selection of Joint Project Sites by Both Parties

After starting the joint pilot project by PTI-JICA and LIRE-BORDA from October 2009, both parties shortlisted the candidate sites to implement "CBS and SBS construction" and "water

environmental with sanitary education" jointly as shown in Table 3.1 by integrating two screening results above-mentioned.

(2) Final Sites Selected

Both parties finally selected the following two sites located in Chanthabouly District after conducting intensive field reconnaissance and discussion based on above **Table 3.1**. General location of both sites is as shown in **Fig. 3.1**.

- Unit 11-13, Thongkhankham Village (as CBS site in Hong Thong drainage area)
- Khoualuang primary school, Khoualuang Village (as SBS site in Hong Pasak drainage area)

Table 3.1 Integrated Selection of Candidate Sites for Joint Pilot Project

Village Name/ (District)	Drainage Area	Score in Each Preliminary Screening		Total Score	Remarks
		PTI-JICA (Environmental Education)	LIRE-BORDA (CBS/SBS Construction)		
Khoualuang (Chanthabouly)	Hong Pasak	6	6	12	Suitable for both SBS and CBS
Hongka (Chanthabouly)	Hong Pasak	3	6	9	Suitable for CBS
Thongkhankham (Chanthabouly)	Hong Thong	4	5	9	Suitable for CBS
Thongtoum (Chanthabouly)	Hong Pasak	2	6	8	Suitable for CBS
Nong Douang Thong (Sikhottabong)	Hong Wattay	-	5	-	Outside of objective Hong Pasak/Hong Thong drainage areas
Nong Douang Neua (Sikhottabong)	Hong Wattay	-	6	-	

(3) Approval of Pilot Project by Competent Authorities

In parallel with the site selection and the preparatory activities there, both parties discussed with the following competent authorities and gained the approval and cooperation on the pilot project implementation at two selected sites from those authorities.

- PTI, MPWT (main C/P agency)
- DPWT (DPWT implemented extensive sewerage project in wide areas including Thongkhankham Village with the cooperation of DANIDA around 2004)
- Chanthabouly District Office (to manage the district where two sites are located) <Note: A JOCV (Japan Overseas Cooperation Volunteers) dispatched from February 2010 to the environmental division of the office to conduct "Environmental Education" for two years.>
- Department of Education, Vientiane (to manage nine District Educational Offices)
- Chantabury District Educational Office (to manage primary and lower secondary schools in the District)
- Thongkhankham Village Office (to manage the village including the objective site)
- Khoualuang Village (to manage the village including Khoualuang primary school)

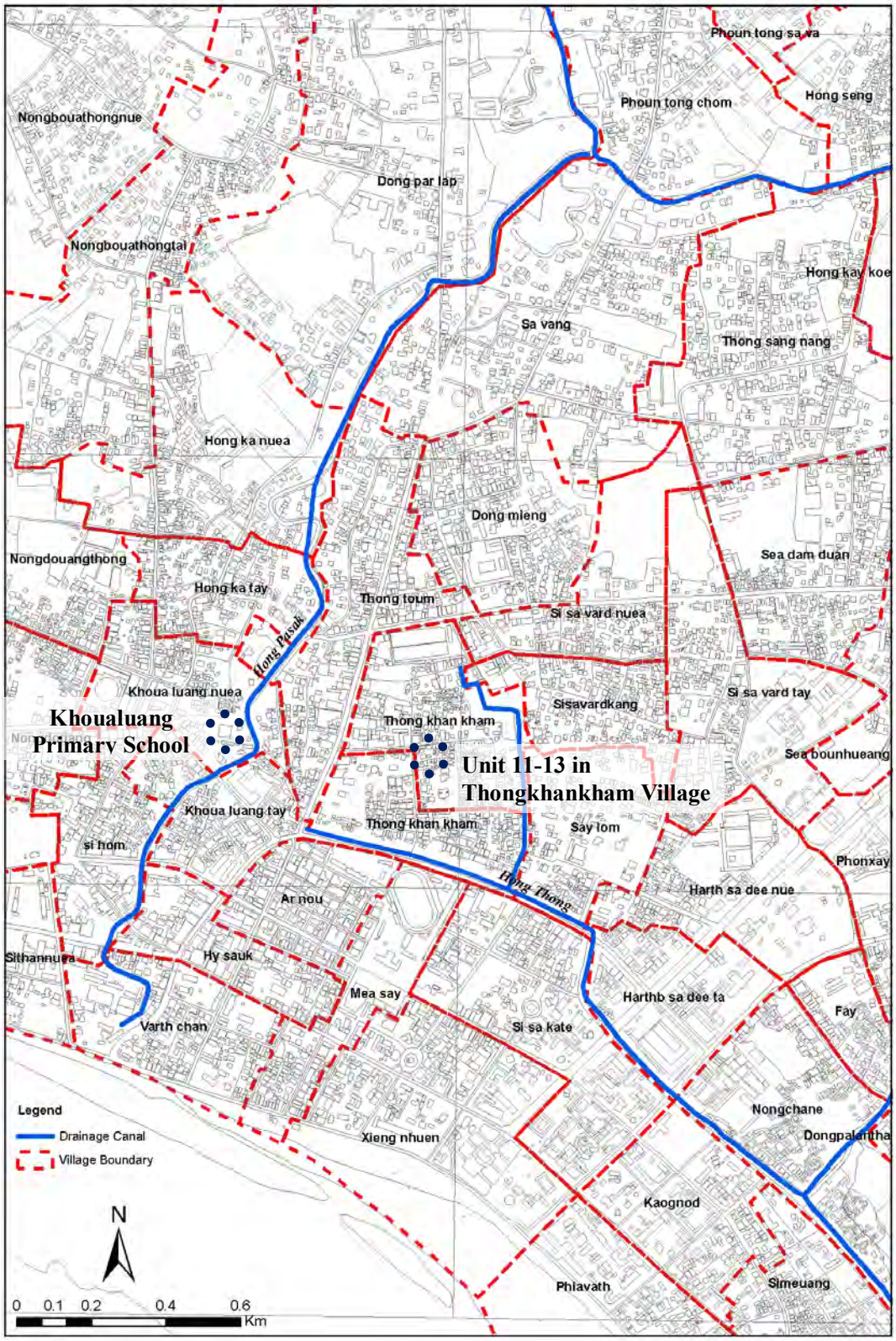


Fig. 3.1 Location of Two Selected Pilot Project Sites

3.1.3 Objectives and Beneficiaries

The CBS and SBS were implemented with similar objectives. They are:

- To improve the sanitary conditions and water environment at densely urban settlements or schools in Vientiane,
- To provide an alternative solution for wastewater treatment system to communities or schools,
- To implement a pilot project of the Decentralized Wastewater Treatment System (DEWATS) in Lao PDR, and
- To provide health and hygiene education program as well as water environment training for community residents or students and teachers.

The beneficiaries in the pilot project are as summarized below.

Table 3.2 Beneficiaries of CBS and SBS

	Thongkankam Village	Khoualuang Primary School
Location	Thongkankam Village, Chanthabouly District	Khoualuang Village, Chanthabouly District
Drainage Basin	Hong Thong	Hong Pasak
Number of User	146 people of 22 households	116 people in total: 87 pupils 4 teachers 25 monks

3.1.4 Designing of CBS and SBS

(1) Participatory Approaches for CBS and SBS

After selection of suitable sites for CBS and SBS construction, the both parties of JICA Study Team and LIRE started to obtain the approval of competent governmental agencies, such as MPWT, DPWT, Department of Education, District office and Village offices, for CBS and SBS. Finally the both construction works were approved by the governmental agencies in July 2010.

Apart from detailed designing of both CBS and SBS, the following activities were taken mainly at the project sites.

Table 3.3 Participatory Approaches for CBS and SBS

	CBS: Thongkankam Village	SBS: Khoualuang Primary School
Rapid Participatory Assessment	Nov. 2009	Nov. 2009
Discussion on Community/ School Action Plan	Nov. 2009	Jun. to Jul. 2010
Health Impact Assessment	Aug. 2010	Jan. 2010
DEWATS Information and Technology Presentation	Jul. to Aug. 2010	Jul. 2010
Establishment of CBS/SBS Committee	Aug. 2010	Aug. 2010
Determination of Contribution and O&M Fees	Aug. 2010	Aug. 2010

(2) Engineering Designs of CBS and SBS

In parallel with the above approaches, engineering designing proceeded after completion of feasibility study done in Dec. 2009 at both sites. The basic conditions for engineering design of DEWATS are summarized in **Table 3.4.**

Table 3.4 Design Conditions for CBS and SBS

	Unit	CBS: Thongkankam Village	SBS: Khoualuang Primary School
Number of Users	people	146	116
Hydraulic Retention Time	days	2	2
Daily Wastewater to be treated	m^3	11.2	7
Inflow COD	mg/l	970	970
Inflow BOD	mg/l	540	540
Outflow COD	mg/l	80	65
Outflow BOD	mg/l	28	23
Land Requirement	m^2	30	21
Volume of Wastewater Treatment Plant	m^3	23.76	20.77

Figs. 3.2 to 3.3 present locations of CBS and SBS, and **Fig. 3.4** presents SBS facilities' design as typical drawing.

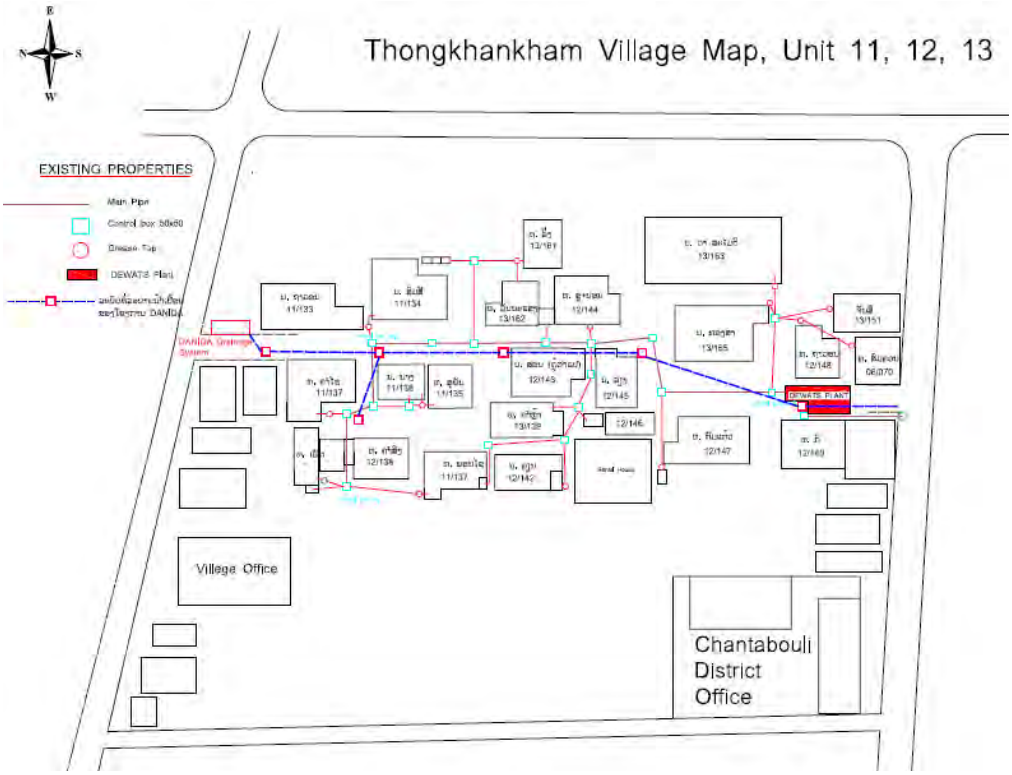


Fig. 3.2 Layout of CBS Sewer Network Plan

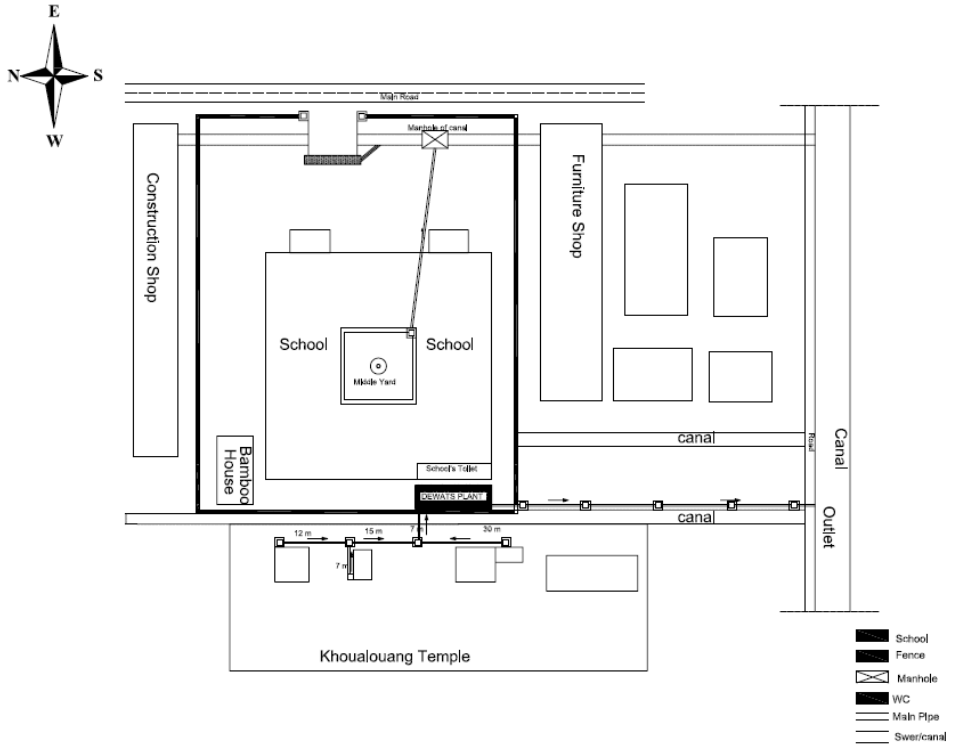


Fig. 3.3 Layout of SBS Sewer Network Plan

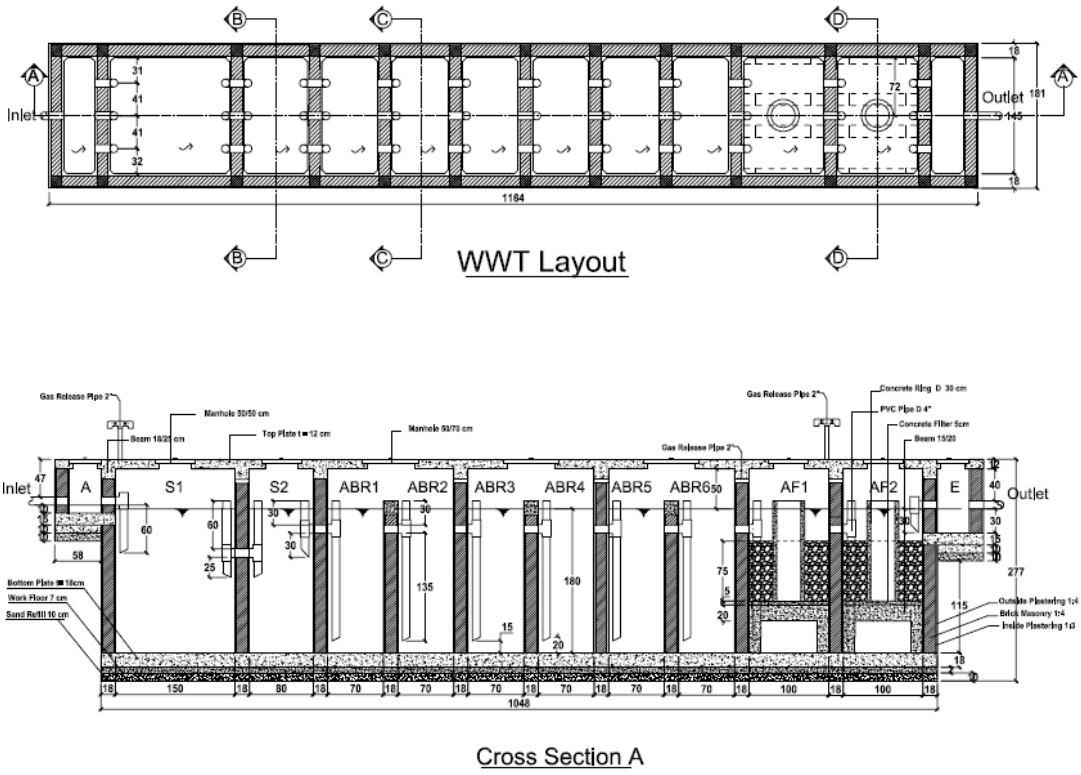


Fig. 3.4 Structural Design of SBS for Khoualuang Primary School

The estimated cost is 38,127 USD for CBS and 41,593 USD for SBS including design, supervision, system guarantee, and 3-months operation and maintenance cost which is equivalent to 15 % of the net construction cost.

3.1.5 Management Structure for CBS and SBS

Committees for CBS and SBS were already established for their smooth operation and maintenance. Those management structures are as described below.

(1) CBS Committee

CBS committee was established mainly among the users of Thongkhankham Village in August 2010. A Chairperson heads the CBS Committee and two Deputy Chairpersons are under him. Under the Deputy Chairperson, three units are set up; namely, (a) financial and contribution unit; (b) operation and maintenance unit; and (c) mass organization. For three units, two or three residents are assigned as persons responsible for the unit.

(2) SBS Committee

SBS committee was established among the teachers, monks and janitors living in the school in August 2010. A Chairperson heads the CBS Committee and a Deputy Chairperson was selected. Under Deputy Chairperson, one unit for operation and maintenance was set up.

3.1.6 Operation and Maintenance

After construction of both CBS and SBS, proper operation and maintenance works guarantee full functioning of the system. The operation and maintenance includes budgetary and maintenance schedule. The O&M budget is 110,000 kip/month paid by 22 households for CBS, while it is 50,000 kip/month for SBS.

3.1.7 Evaluation of Functions of CBS and SBS

Water quality monitoring for the CBS and SBS was made on 25 May 2011 to verify the treatment effects of both facilities. Both of these facilities were completed at the end of December 2010, and they have been operated for almost 5 months. Thus the sludge in the treatment tank might be already stabilized so that their treatment effects could appear properly. Wastewater sampled and testing results are as presented in **Photo 3.1** and **Table 3.5**.

From the results, while outflow of BOD_5 slightly exceeds the standard value of wastewater discharge of 30 mg/l, outflow of TSS meets the one of 40 mg/l. Although the sludge inside is stabilizing even for 5 months after completion, further testing in succeeding sampling shall be necessary since the treatment efficiency had been increasing for 2 years after completion referring to an example in the Philippines.

Regarding removal ratios, they are 56% in BOD_5, 92% in TSS, and 56% in Fecal Coliform monitored in CBS, while they are 68% in BOD_5, 96% in TSS, and 57% in Fecal Coliform monitored in SBS. As recognized in the photos, removal effects of suspended solids are significant. On the other hand, the effects of BOD_5 and Fecal Coliform would increase as the sludge stabilizes in future.

CBS: From the right, inflow tank, intermediate tank and outflow tank

SBS: From the left, inflow tank, intermediate tank and outflow tank

Photo 3.1 Wastewater Sampled from CBS/SBS on 25 May 2011

Table 3.5 Results of Water Quality Test

Parameter	Unit	Inflow Tank	Intermediate Tank	Outflow Tank
CBS				
pH		6.7	6.7	6.9
Water Temperature	°C	28.4	28.7	28.8
NH_4^+-N	mg/l	42.6	34.5	37.6
BOD_5	mg/l	82	41	36
TSS	mg/l	168	40	13
Fecal Coliform	Colonies/100ml	5,370,000	2,685,000	2,369,000
SBS				
pH		6.7	7.0	7.2
Water Temperature	°C	27.7	28.1	27.7
NH_4^+-N	mg/l	83.7	36.7	55.8
BOD_5	mg/l	99	38	32
TSS	mg/l	294	29	11
Fecal Coliform	Colonies/100ml	2,580,000	1,765,000	1,115,000

3.2 Water Environment and Hygiene Education

3.2.1 General

Both parties of PTI-JICA and LIRE-BORDA agreed to implement the pilot project jointly at the same project sites integrating the following activities:

- PTI-JICA: water environmental education (soft component)
- LIRE-BORDA: CBS and SBS construction (hardware) (+ hygiene education (soft component)

Based on the agreement, both parties jointly implemented the preparatory activities of the pilot project Phase I (project location preparation), including the selection of two appropriate project sites (1 CBS and 1 SBS) from October 2009 to February 2010.

Both parties implemented Phase II (CBS project implementation) of the pilot project successively at two selected sites from June 2010 to March 2011. The Phase II activities consist of DEWATS plant construction and water environmental and hygiene education as shown below. The major joint events and meetings in Phase II are summarized as shown in **Table 3.6**.

- DEWATS plant construction for CBS and SBS (structural measures): detailed engineering design and construction works
- Water environmental and hygiene education for primary school (teachers and higher-grades pupils) and community residents (non-structural measures)
  - Development, publication and dissemination of educational side reader
  - TOT (training of trainers) workshops at project sites

Table 3.6 Joint Activities and Meetings with LIRE-BORDA in Phase II

DATE	VENUE	CONTENTS
June 22, 2010	PTI	Discussion on joint activity schedule and the contract on DEWATS construction to LIRE
June 23	LIRE office	Contract on DEWATS construction to LIRE
June 29	Thongkhankham Village office	Briefing and consensus formation to the Village head and deputy Village head towards the CBS committee establishment for the commencement of DEWATS construction
June 30	Khoualuang Primary School	Briefing and consensus formation to the teachers towards the SBS committee establishment for the commencement of DEWATS construction
July 6	Thongkhankham Village	Project briefing to objective Unit 11-13 residents
July 7	Khoualuang School	Discussion on the SBS committee establishment with village head, teachers and a monk representative of the adjacent temple
July 16	Khoualuang School	Briefing on technical issue (DEWATS service area and its designing) and consensus formation of the SBS committee establishment with village head, teachers and a monk representative
July 19	Thongkhankham Village	Re-request to the Village head on the CBS committee establishment
July 20	LIRE office	Discussion on TOT workshops on water environment, hygiene and sanitation at 2 sites and the drafting of the side reader
July 21	Khoualuang School	SBS stakeholder meeting: Discussion on the SBS committee establishment and the agreement on DEWATS service area with teachers and monk
August 2	Thongkhankham Village	CBS stakeholder meeting on the briefing of CBS
August 9	Khoualuang School	SBS stakeholder meeting on the final selection of the SBS committee members and the confirmation of each member's role
August 10	Thongkhankham Village	CBS stakeholder meeting on the briefing of the CBS construction works and the necessity of the CBS committee establishment
August 24	Thongkhankham Village	CBS stakeholder meeting on the selection of the CBS committee members and the operation and maintenance
August 31	Thongkhankham Village	CBS stakeholder meeting on the final confirmation of the CBS committee members and the consensus formation on the reserve fund for the operation and maintenance
September 28	LIRE office	Discussion on the progress of the DEWATS construction and the treatment of buried facilities by former DANIDA-DPWT project
October 5	LIRE office	Discussion on the preparatory works for the TOT workshops at 2 pilot project sites on water environmental and hygiene education and the preparation of the side reader
October 8	Khoualuang School	Discussion on the preparation of the TOT workshops
October 8	Thongkhankham Village	Discussion on the preparation of the TOT workshops
October 8	LIRE office	Weekly meeting on the DEWATS construction progress
October 12	Thongkhankham Village	The 1st community TOT workshop on water environmental and hygiene education at Unit 11-13
October 15	PTI	Weekly meeting on the DEWATS construction progress
October 15	Khoualuang School	The 1st school TOT workshop on water environmental and hygiene education
October 19	Thongkhankham site	The 2nd community TOT workshop
October 22	LIRE office	Weekly meeting on the DEWATS construction progress
October 26	Khoualuang School	The 2nd school TOT workshop
October 29	PTI	Weekly meeting on the DEWATS construction progress
October 29	Thongkhankham site	The 3rd community TOT workshop
November 2	Khoualuang School	The 3rd school TOT workshop
November 4	LIRE office	Discussion on the final editing of the side reader for printing works
November 5	LIRE office	Weekly meeting on the DEWATS construction progress
November 23	PTI	Discussion on the final editing of the side reader before printing work

3.2.2 Development and Dissemination of Side Reader

(1) Development of Side Reader

As a part of the Phase II pilot project, PTI-JICA and LIRE-BORDA jointly developed and published an educational side reader entitled "Let's Learn Water Environment, Hygiene and Sanitation" (23 pages, both Laotian and English versions). The basic development policy is as shown below:

- Target:
  - 4-5 grades primary school pupils (considering minimum learning competency)
  - community residents
- Integration of water environmental module (PTI-JICA) and health & hygiene module (LIRE-BORDA)
- Optimization and localization of the contents through the discussion with the participants of TOT workshops
- No technical term as it is and easy wording for the target people to understand
- Consideration of TCP (Teacher - Children - Parent) approach
- Combination of (1) classroom lecture + (2) participatory indoor & outdoor activities (Most important factor to be considered is to "Learn with Pleasure".)
- Lecture at school to be principally conducted using extracurricular activities other than seven regular subject

The table of contents is shown in **Table 3.7**.

Table 3.7 Table of Contents of Developed Side Reader

Title: **Let's Learn Water Environment, Hygiene and Sanitation**
(for Primary School and Community)

Introduction
Table of Contents

1 Let's Learn about Water Pollution
1) If water is polluted, what will happen?
2) What is the cause of water pollution?
3) Does only human being use water?
4) Where does tap water come from and wastewater go?

2 Let's Learn How to Make Household Wastewater Clean

3 Let's Check around Your School/ Community
1) Let's check where polluted water is around you
2) Let's clean around your school or community together
3) Let's reconfirm proper quantity of detergent in laundry
4) Let's go to see new facilities to clean wastewater

4 Let's Wash Hands with Soap

5 Let's Learn Good and Bad Hygiene Behaviors

6 Let's Keep Clean Environment through Housekeeping
1) Keep your bathroom and toilet clean!
2) Keep your environment and surrounding clean!

Afterward

Note: Chapter 1-3 were developed by PTI-JICA and Chapter 4-6 were developed by LIRE-BORDA

(2) Publication and Dissemination of Side Reader

It is necessary to promote and disseminate the water environment and hygiene education from the two pilot project sites to the whole area of Vientiane. For this purpose, PTI-JICA and LIRE-BORDA printed and distributed 7,200 copies of the Laotian side reader to all the 353 public primary schools (complete school with 4-5 grades only) in Vientiane and related agencies from January to March 2011 in cooperation with the Department of Education and nine district educational offices in Vientiane, as shown in **Table 3.8**.

Table 3.8 Dissemination of Side Reader to Relating Agencies

Name of Organization		Name of District	Number of Schools/ Offices	Number of Copies Disseminated	Total
Department of Education		-	1	80	80
District Educational Office		-	9	40	360
Public primary schools in urban districts	1	Chanthabouly	22	40	880
	2	Sisattanak	22	40	880
	3	Xaysetha	39	40	1,560
	4	Sikhottabong	37	40	1,480
Public primary schools in suburban districts	5	Xaythany	83	5	415
	6	Hatxaifong	43	5	215
	7	Naxaithong	40	5	200
	8	Parkngum	38	5	190
	9	Sungthong	29	5	145
				Total	6,405
District offices in urban central area			5	160	800
				Total	7,205

3.2.3 TOT Workshop at Project Site

(1) General

As a part of the pilot project Phase II activities (CBS project implementation), PTI-JICA and LIRE-BORDA jointly conducted the TOT (training of trainers) educational workshops on water environmental and hygiene for pupils, teachers and residents at two pilot project sites in October and November 2010 using the developed side reader. A series of workshops were conducted as Phase 1 of the "Activity Promotion Roadmap," the priority activity of the Master Plan, as follows:

- Three (3) school TOT workshops (Khoualuang Primary School) (Oct. 15, 26 and Nov. 2, 2010)
- Three (3) community TOT workshops (Unit 11-13, Thongkhankham Village) (Oct. 12, 19 & 29, 2010)

Several appropriate trainees as candidate trainers were selected out of the representatives of the CBS/SBC committees in Unit 11-13. Four teachers at SBS site and five community representatives at CBS site were finally selected as trainees. PTI-JICA and LIRE-BORDA trained the trainees through the workshops so that they could make lectures for their pupils or residents by themselves (refer to **Tables 3.9** and **3.10**).

All the TOT workshops were successfully completed with positive participation of the teachers, pupils and community residents and also with practical side reader development through eager discussion among the participants.

(2) School TOT Workshop (Khoualuang Primary School)

A series of school TOT educational workshops on water environment and hygiene were conducted three times at Khoualuang Primary School in October and November 2010. The contents, program and photo images of the workshops are as shown in **Table 3.9** and **Photo 3.2**, respectively.

Table 3.9 Program of School TOT Workshop

No.	Date	Programs	Trainers	Trainees
1	Oct 15, 2010 (1:30-4:30pm)	Model lecture using side reader	PTI-JICA & LIRE-BORDA staff	4 school teachers
		Discussion on side reader revision	All trainers and trainees	
2	Oct 26, 2010 (1:30-4:30pm)	Model lecture using side reader (hygiene and sanitation)	4 "Trained" teachers	23 4th-5th grade pupils
		Participatory activities (School mapping)	PTI-JICA staff	4 school teachers
		Participatory activities (Hand washing practice)	LIRE-BORDA staff	
3	Nov 2, 2010 (1:30-4:30pm)	Model lecture using side reader (water environment)	"Trained" 4 teachers	23 4th-5th grade pupils
		School mapping		
		Hand washing practice		

(3) Community TOT Workshop (Unit 11-13, Thongkhankham Village)

Three community TOT educational workshops on water environment and hygiene were conducted at Unit 11-13, Thongkhankham Village in October 2010. The contents, program and scenery of the workshops are as shown in **Table 3.10** and **Photo 3.3** respectively.

Table 3.10 Program of Community TOT Workshop

No.	Date	Programs	Trainers	Trainees
1	Oct 12, 2010 (2-5pm)	Model lecture using side reader	PTI-JICA & LIRE-BORDA staff	5 representatives of Unit 11-13
2	Oct 19, 2010 (3-6pm)	Model lecture by side reader	"Trained" unit representatives	Unit 11-13 residents (22 households)
		Participatory activities (Proper usage of detergent)	PTI-JICA staff	3 representatives of Unit 11-13
		Participatory activities (Hand washing practice)	LIRE-BORDA staff	
3	Oct 29, 2010 (3-5pm)	Proper usage of detergent	"Trained" unit representatives	Unit 11-13 residents (22 households)
		Hand washing practice		

1st Workshop: Discussions, review and revision of side reader to make the contents easier to understand by reflecting the opinions of teachers.

2nd Workshop: Model lecture by ~~t~~rained" teachers for 4th-5th grade pupils using the side reader.

3rd Workshop: School mapping by 4th-5th grade pupils guided by ~~t~~rained" teachers (field walking around the school to investigate the location of dirty places).

3rd Workshop: School mapping by 4th-5th grade pupils (mapping of field walk results by pupil groups guided by ~~t~~rained" teachers).

3rd Workshop: School mapping by 4th-5th grade pupils (presentation of each completed map by pupil group representative).

3rd Workshop: Practical training on hand washing with soap guided by ~~t~~rained" teachers.

Photo 3.2 Scenes of School TOT Workshop (Khoualuang Primary School)

1st Workshop: Training for unit representatives as potential trainers on the lecture method using the side reader.

2nd Workshop: Model lecture by ~~t~~rained" unit representatives for unit residents using the side reader.

3rd Workshop: Lecture to unit residents on the measurement of proper quantity of detergent by ~~t~~rained" unit representatives.

3rd Workshop: Demonstration on the measurement of detergent by unit residents as trainees guided by ~~t~~rained" representatives.

3rd Workshop: Lecture to unit residents on hand washing with soap by ~~t~~rained" unit representatives.

3rd Workshop: Practice of hand washing by unit residents as trainees guided by ~~t~~rained" representatives.

Photo 3.3 Scenes of Community TOT Workshop (Unit 11-13, Thongkhankham Village)

3.3 Lessons Learnt through the Pilot Project

As the pilot project, sanitary improvement facilities were constructed in one community of Thongkhankham Village and in Khoualuang Primary School, and environmental education in cooperation with LIRE, a Lao NGO, was conducted as well. Lessons learnt through the activities regarding the construction CBS/SBS in a community and a primary school are as discussed below.

(1) Treatment Effects of CBS/SBS and Necessity of Continuous Monitoring Activities

According to the water quality sampling and testing made in the end of May 2011, the outflow of BOD5 slightly exceeded the 30 mg/l standard value of wastewater discharge while the outflow of TSS met the 40 mg/l standard. Even if the sludge inside had stabilized for 5 months after completion, further testing in succeeding periodical sampling shall be necessary, since treatment efficiency increases for 2 years after completion as shown by an example in the Philippines.

On the other hand, proper understanding by communities and schools on the CBS/SBS and necessary operation and maintenance activities shall be indispensable for their proper operation and maintenance. Thus continuous educational activities shall be necessary to deepen the understanding on the facilities and on monitoring of their organizational and social activities in addition to water quality monitoring.

(2) Future Extensibility of CBS/SBS and their Issues

Wastewater treatment effects of CBS/SBS have been verified already in the preceding part as a pilot project. On the other hand, the installation ratio of sanitary facilities at individual houses/buildings in the urban areas of Vientiane is quite high as clarified through the Pre-F/S, so that needs of improving sanitary facilities in the communities might not be high as a whole. Even though the number of suitable sites for CBS in the impoverished communities is small in the urban areas of Vientiane, CBS could be effective in such areas as well as in new developments in the suburban areas and new developments at relocation sites by some projects. The communities, where the decentralized and small-scale sanitation improvement facilities will be installed, shall solve the following issues through participatory agreement.

- The CBS Steering Committee shall be established for operation and maintenance by community members themselves, utilizing the existing organization of resident self-governance.
- For proper maintenance of CBS, necessary budget collection and allocation system shall be established and properly operated through participatory agreement. The budget shall be used for periodical extraction works of grease, desludging of septage once in a few years, and repair works to the damaged parts.

Regarding the SBS constructed in Khoualuang Primary School, there was enough space to construct it so that pupils and teachers now enjoy the new facilities including renovated toilets. Furthermore, the SBS receives black and gray water from the neighboring monks' dormitory in the Khoualuang Temple. The SBS to be constructed in a large dormitory, for instance, Pakpasak Technical College as proposed in the Pre-F/S, would be effective for the improvement of water environment. Some extended SBSs, which treat not only their own wastewater but also wastewater from neighboring communities, would be more effective.

(3) Sustainable Extensibility of Environmental Education

Environmental education has been made in a community of Thongkhankham Village and Khoualuang Primary School in relation to the construction of CBS and SBS. Considering deterioration of surface water at present mainly due to domestic wastewater inflow without any treatment, water environment is closely influenced by the daily life of residents. Thus enhancement of people's awareness on the conservation of their environment could strongly boost improvement of the environment. In this context, proper combination of continuation of the above enhancement and implementation of structural improvement works are crucial.

The remaining issue was how to keep the sustainability and extensibility of the educational works in the communities after completion of pilot project of environmental education. It may be physically difficult to continuously hold workshops in each community, so that its sustainability also will not be assured in future. Meanwhile, some sustainable extensibility can be expected in environmental education in the primary schools due to strength of governmental organization, as follows:

- The Department of Education (DOE) in Vientiane as the leading organization shall organize the education office in each district which will manage the primary school in the district.
- In principle one primary school is placed in one village, so that the results of environmental education could possibly be conveyed from pupils to parents.
- After technology transfer on the side reader of environmental education and methodologies of the education to the district education offices, workshops shall be held in the district offices for the teachers concerned. This process could contribute to enhance people's awareness in environment through their children.

In parallel with this kind of steady efforts, more sustainable extensibility of people's environmental awareness could be practically attained through site visit to improved water and canals by the improvement projects.

CHAPTER 4. DRAFT MASTER PLAN OF WATER ENVIRONMENTAL MANAGEMENT

Basic Approach and Composition of the Master Plan

The master plan has been formulated, taking into consideration the interactions among the plan components; namely, (1) Structural water environment improvement plan; (2) Institutional and legal improvement plan; and (3) Environmental education/hygiene education promotion plan.

In the structural water environment improvement plan, the future development scenario describes how the water environment changes in the target year 2020 based on the projected rapid urban development. To cope with water quality deterioration, alternatives include cases of (1) environmental deterioration without any action; (2) conventional sewage treatment approach; and (3) realistic wastewater treatment measures, for the selection of optimum strategy. Alternative (3) has been selected as the optimum strategy through such comparative study as minimum cost, easier maintenance and operation, future sustainability and expandability of technology to other urban areas, considering compliance with the future socioeconomic development in Vientiane.

Structural Water Improvement Plan

There are two distinct seasons, the dry season and the wet season. The most urgent issue in the water environment is water quality deterioration in the dry season, since domestic wastewater is directly discharged without any treatment through the open sewer system in Vientiane. Water pollution in the dry season could be regarded as one of the serious urban environment improvement issues of Vientiane.

The master plan proposes comprehensive countermeasures in accordance with the causes of pollution and applicability of countermeasures. These are mainly (1) administrative instructions to control highly polluted effluents from the slaughterhouses in Hong Wattay in particular; (2) installation of simple small-scale wastewater treatment plants with local interceptors along the drainage canals of Hong Pasak, Hong Khoua Khao and others; (3) installation of in-stream treatment plant along the bank of Nong Chanh against highly polluted water of Hong Thong; and (4) sanitary improvement in individual house or community level through installation of CBS or septic tank at the time of rebuilding or building the houses. These countermeasures for sanitation and water environment improvement shall be carried out simultaneously in an integrated manner toward the target year 2020.

Institutional and Legal Improvement Plan

Various international donors, such as ADB and SIDA, have proposed or finalized several kinds of policy measures for water environmental conservation including environmental education, environmental information, national land use plan, and public expenditure policy in addition to direct regulation. There are still needs to develop regulations and guidelines for effective and smooth implementation of various laws and bylaws established.

In the master plan, draft guidelines and regulations are proposed focusing on drainage management and sanitary improvement. The "Draft Guidelines on Wastewater Management of Vientiane City" includes promotion of septic tank installation, proper septage management accumulated in septic tanks, effluent control of industrial wastewater, and proper management of open sewer canals. On the other hand, the "Draft Regulations on Desludging/Hauling Business Control" describes the management of business for desludging/hauling of septage.

Environmental Education/Hygiene Education Promotion Plan

Actions only by administrative bodies are not enough for preventing deterioration of water environment due to wastewater discharged from Vientiane urban areas, which will cause irreversible destruction of the environment. Thus, it is aimed to make citizens (community people and children in particular) able to take part in water environment conservation by cooperating with administrative bodies through raising awareness on environment conservation by environmental education.

Targeting pupils in a primary school and general residents in the communities, environmental education activities have been made in parallel with the pilot project of construction of community/school based sanitation (CBS and SBS). Based on the experiences conducting the above pilot projects, the master plan proposes the following virtuous cycle: (1) distribution of side-readers prepared the study to the related urban districts; (2) conducting TOT (training of trainers) for primary school teachers and afterwards carrying out curriculum-based environmental education to their pupils; and (3) enhancement of people's awareness on environment through parent-child dialogue.

4.1 Planning Considerations

4.1.1 Framework Setting in the Target Year 2020

(1) Population Increase and Expansion of Urban Area

The population in Vientiane shall be projected up to 2020, keeping consistency with that of "Preparatory Survey on Industrial Zone Development in the Lao People's Democratic Republic, Progress Report, 2009, JICA" (hereinafter referred to as "Preparatory Survey on Industrial Zone"), which increases at slightly less than 3% steadily.

Table 4.1 Population Projection in Vientiane

Year	2005*	2006	2007	2008	2009	2010	2011	2012
Population (000 Person)	692	713	734	755	778	801	825	849
Year	2013	2014	2015	2016	2017	2018	2019	2020
Population (000 Person)	874	900	927	955	983	1,013	1,043	1,074

* Population in 2005 is a data from Statistics Survey.
Source: Preparatory Survey on Industrial Zone Development in the Lao People's Democratic Republic, Progress Report, 2009, JICA

(2) Economic Development of Vientiane

Gross Regional Domestic Product (GRDP) shows the scale of economic activities of an area. It is estimated that GRDP in Vientiane increases not only in terms of amount but also in terms of the share in the country, according to the "Preparatory Survey on Industrial Zone." Situations of Vientiane as the Capital are expected to be more important and significant in the future.

Table 4.2 Estimated GRDP in Vientiane

(Unit: constant in 2008 price, billion KIP)

Year	2008	2009	2010	2011	2012	2013	2014
GDP	46,215	49,449	52,908	56,610	60,571	64,809	69,344
GRDP in Vientiane	10,574	11,391	12,272	13,220	14,242	15,343	16,529
Share	22.9%	23.0%	23.2%	23.4%	23.5%	23.7%	23.8%
Year	2015	2016	2017	2018	2019	2020	
GDP	74,196	79,575	85,344	91,531	98,167	105,284	
GRDP in Vientiane	17,807	19,176	20,650	22,238	23,948	25,789	
Share	24.0%	24.1%	24.2%	24.3%	24.4%	24.5%	

Source: Preparatory Survey on Industrial Zone Development in the Lao People's Democratic Republic, Progress Report, 2009, JICA

GDP/GRDP shows the scale of the economy or its impact while per capita GDP/GRDP shows the economic development or pecuniary richness. Estimation of per capita GRDP of Vientiane can be made with the data given above. It increases at 4.5% to 4.7% annually. It is generally thought that consumption of each person increases as the economic develops. It means that the consumption of the Vientiane people is expected to increase and environmental load per person is also expected to increase.

Table 4.3 Estimated Per Capita GRDP in Vientiane

(Unit: constant in 2008 price, thousand KIP)

Year	2008	2009	2010	2011	2012	2013	2014
GRDP per capita	14,005	14,641	15,321	16,024	16,775	17,555	18,366
Growth Rate	-	4.5%	4.6%	4.6%	4.7%	4.6%	4.6%
Year	2015	2016	2017	2018	2019	2020	
GRDP per capita	19,209	20,080	21,007	21,953	22,961	24,012	
Growth Rate	4.6%	4.5%	4.6%	4.5%	4.6%	4.6%	

Source: Preparatory Survey on Industrial Zone Development in the Lao People's Democratic Republic, Progress Report, 2009, JICA

4.1.2 Projection of Water Quality at the Target Year (2020)

The water quality at Mak Hiao river basin in 2020 has been computed using the water quality model.

(1) Pollution Load Generation in 2020

Table 4.4 shows pollution load generation in 2020 by category, with the values of 2009 as a reference. As shown in the table**,** total pollution load generation in 2020 reaches 45,081 kg/day (1.43 times of the 31,485 kg/day in 2009).

Table 4.4 Pollution Load Generation by Category (2009 and 2020)

		Pollution Load Generation (kg/day)		(2)/(1)
		2009 (1)	2020 (2)	
1	Domestic	16,326	22,451	1.38[1)]
2	Commercial	2,441	3,735	1.53[1)]
3	Industrial	300	1,340	4.47
4	Livestock	12,107	17,245	1.42
5	Non-point	309	310	1.00
Total		31,485	45,081	1.43

Note: [1)]
The value of (2)/(1) for commercial is bigger than that of domestic, because the number of people to which the drinking water is serviced by pipe-pile increase year by year (in this Study, the commercial wastewater is supposed to originate from the area where the drinking water is supplied by pipe-line.).

Pollution load generation by basin is shown in **Table 4.5.** Total pollution load in Hong Ke and Hong Xeng basins accounts for 12,700 kg/day or 28.2 % of the total, indicating that the basins remain a major pollution source in Mak Hiao river basin. By category, Hong Ke and Hong Xeng are dominated by domestic and commercial load (Hong Xeng: 86.1%; Hong Ke: 91.9% of the total).

Pollution load from other areas are also big in amount (32,381 kg/day). However, considering the pollution load by category, a large portion (49.3%) of the load is generated from livestock (see **Table 4.6**).

Table 4.5 Pollution Load Generation by Basin (2020)

Basin	Area (km^2)	Pop. (person)	Pop. Density (per./km^2)	BOD Load (kg/d)		Percentage (%)	(2)/(1)
	2020	2020	2020	2009 (1)	2020 (2)		
Hong Xeng	**56.6**	**163,852**	**2,896**	**7,574**	**10,106**	**22.4**	**1.33**
- Nam Pasak	30.4	47,077	1,548	2,378	3,070	6.8	1.29
- Wattay	9.3	33,698	3,630	1,877	2,281	5.1	1.22
- Pasak	2.2	10,931	4,891	759	616	1.4	0.81
- Others	14.6	72,146	4,929	2,561	4,139	9.2	1.62
Hong Ke	**9.5**	**44,173**	**4,631**	**2,900**	**2,594**	**5.8**	**0.89**
Other areas	346.8	290,897	839	21,011	32,381	71.8	1.54
Total	412.9	498,922	1,208	31,485	**45,081**	100.0	1.43

Table 4.6 Pollution Load Generation by Basin and Category (2020)

Upper: Pollution Load (kg/day); Lower: Percentage (%)

Basin	Point loads					Non-point load
	Total	Domestic	Commer-cial	Industrial	Livestock	
Hong Xeng	10,106	7,373	1,324	300	1,066	42
	(100.0)	*(73.0)*	*(13.1)*	*(3.0)*	*(10.5)*	*(0.4)*
- Nam Pasak	3,070	2,118	273	0	655	23
	(100.0)	*(69.0)*	*(8.9)*	*(0.0)*	*(21.3)*	*(0.8)*
- Wattay	2,281	1,516	303	300	154	7
	(100.0)	*(66.5)*	*(13.3)*	*(13.2)*	*(6.8)*	*(0.2)*
- Pasak	616	492	98	0	24	2
	(100.0)	*(79.9)*	*(16.0)*	*(0.0)*	*(3.9)*	*(0.2)*
- Others	4,139	3,247	649	0	232	11
	(100.0)	*(78.4)*	*(15.7)*	*(0.0)*	*(5.6)*	*(0.3)*
Hong Ke	2,594	1,988	398	0	202	7
	(100.0)	*(76.6)*	*(15.3)*	*(0.0)*	*(7.8)*	*(0.3)*
Others	32,381	13,090	2,013	1,040	15,977	260
	(100.0)	*(40.4)*	*(6.2)*	*(3.2)*	*(49.3)*	*(0.9)*
Total	45,081	22,451	3,735	1,340	17,245	310
	(100.0)	*(49.8)*	*(8.3)*	*(3.0)*	*(38.3)*	*(0.6)*

(2) Water Quality Projection in 2020

Projection of water quality change is shown in **Fig. 4.1** with BOD values of 2009 and 2020. Water quality in 2020 is projected under the condition of "No action" (in "No action", only natural increase in septic tank installation rate is assumed).

Compared to the water quality in 2009, the one in 2020 worsens in the entire basin. In particular, BOD exceeds 30 mg/l in almost the entire Hong Ke and Hong Xeng basins, mainly due to increase of runoff coefficient as a result of expected secondary drainage improvement works. At the middle stream of Mak Hiao River (MP4 and MP5), BOD ranges from 8.5 to 8.6 mg/l, almost double of 2009's. The water quality deterioration at the stretch is brought about by the deterioration in Hong Ke and Hong Xeng basins, as well as treated water discharged from large-scale development areas such as Vientiane Industrial Zone. On the other hand, at the downstream end of Mak Hiao River (MP6), BOD remains at about 3 mg/l mainly due to the purification function in the downstream stretch of Mak Hiao River.

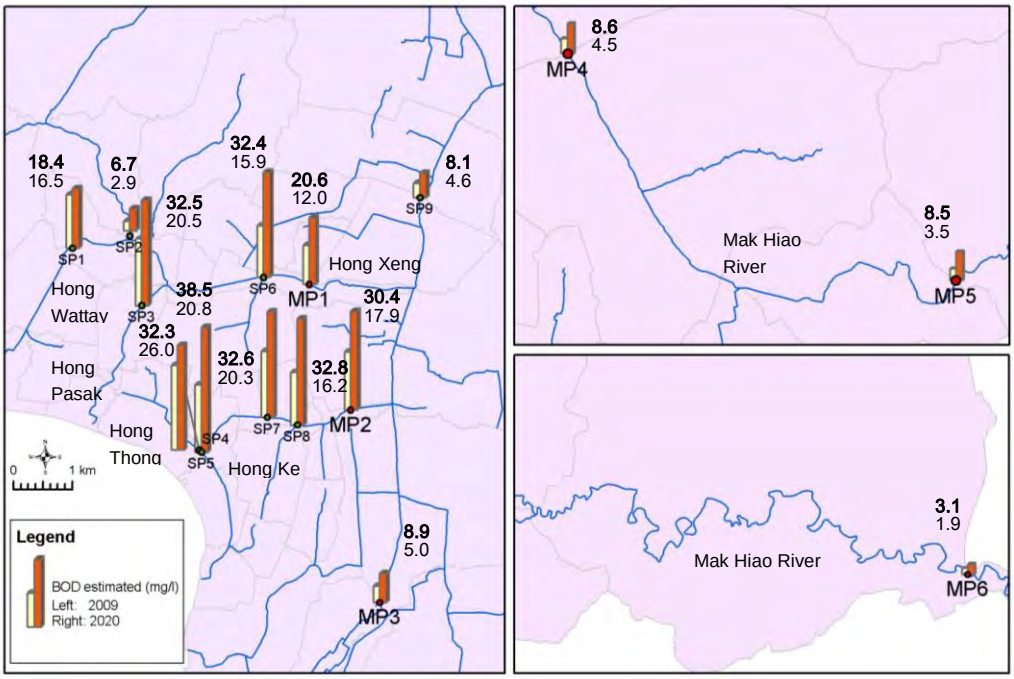


Fig. 4.1 Projection of Water Quality Change from 2009 toward 2020

4.1.3 Present and Future Issues for Improvement

Various issues related to water environment were encountered in the course of the study. It is crucial to clarify them for smooth preparation of the improvement strategy and master plan in water environment.

(1) Water Environment in the Study Area

(a) Present and Future Water Environmental Conditions in Urban Drainage System

The surface water along the urban drainage canals has been deteriorating mainly due to domestic organic pollutants. Water quality in Hong Thong and Hong Pasak, which receive wastewater discharge from the urban center of Vientiane, is seriously deteriorated. The BOD values are 20 to 30 mg/l at present. In future, more worsened BOD concentrations exceeding 30 mg/l could be projected in the entire stretches of urban drainage system covering Hong Ke and Hong Xeng.

(b) Aquatic Lives in Urban Drainage Canals

The urban drainage canals are combined open sewers conveying both rainwater and wastewater generated in the urban areas of Vientiane. Various fishes go upstream through those canals in the rainy season, and people enjoy fishing and catching fishes using a net, being not so much popular as in previous time. It could be an urgent issue to conserve the still existing rich water environment for the future generations and to improve the water environment since fishes could make their habitat even in the dry season.

(c) Prevention of Concrete Covering on the Drainage System

Hong Thong receives wastewater and rainwater from the most congested areas of Vientiane similar to Hong Pasak where canals are covered with concrete slab in almost all the stretch. Although this kind of measures is one of the alternatives to make people look away from offensive odor and deteriorated scenery of worsened water quality, the difficulty of improving the water environment will come out due to invisibility of existing conditions of water quality and inability of conducting improvement works and monitoring their effects. Conducting the possible improvement measures on the water environment in a step-by-step manner would rather be recommended than removing the deteriorated environment from the urban residents.

(d) Sanitary Conditions in Community and Household Level

In order to clarify the actual sanitary conditions in individual houses of Vientiane, the pre-feasibility study under this master plan study was conducted in 2010. In parallel, rapid assessment was also conducted under WSP (Water and Sanitation Program) of the WB (World Bank) for similar purposes. The survey results revealed that more than 95% of households and buildings in the survey areas had installed t sanitary facilities of septic tank or soak pit. They also, however, made it appear that maintenance work on desludging of septage was not properly and periodically done. In addition, these facilities receive only night soil so that domestic wastewater is discharged without any treatment, resulting in the major source of water contamination in the canals.

One CBS (Community Based Sanitation) was constructed in the urban village as a pilot project under the master plan study. As a result of the pilot project as well as the pre-feasibility study, the possibility of further expansion of coverage by such CBS facilities could not be found in the urban area of Vientiane due to the high installation ratio of individual sanitary facilities and the difficulty of securing land for the installation of CBS.

(e) Conservation of Marshes/Wetlands

Wastewater discharged from the urban areas flows down through the drainage system, and empties into the That Luang Marsh. The Mak Hiao River receives the surface water from the marsh, runs through the Na Khay Marsh and various pondage stretches, and finally joins the Mekong mainstream. Due to the natural purification function of wetlands and ponds along the river course and the dilution of natural runoff and irrigation tail water, BOD of 3 mg/l is computed at the river mouth of Mak Hiao even in 2020, which could still be regarded as good water quality.

Rapid urbanization, however, has been progressing in/around the That Luang Marsh so that the marsh areas and their functions shall be conserved or spared from the land use planning of Vientiane. Furthermore, the remaining marshes in the urban areas, such as Nong Chanh, Nong Bo, and Nong Tha, shall be conserved as well. Unless such conservation measures take place, a similar process in which various wide mashes that existed in the past have been reclaimed into urban areas would occur in the above-mentioned remaining marshes.

(2) Issues on Institution/Regulation and Implementation System for Water Environment Management

(a) Weakness of Institutional Management for Environment

The capability of institutions is not sufficient for the proper management of not only the water environment but also the entire environment. This might be due to shortage of practically experienced staff in the central government as well as local governments, and the budgetary constraints on government services for water quality monitoring and drainage maintenance. In particular, the capacity of WERI-WREA, which is expected as the national environmental research laboratory, shall be strengthened with regard to the testing of environmental parameters such as water, air and so on.

(b) Development Needs for Regulations and Guidelines

International donors such as SIDA and ADB assisted in the improvement and establishment of the environmental legal system; basic laws and important bylaws. However, the preparation of additional administrative instructions and guidelines are indispensable to smooth implementation and effective regulation based on these laws.

(c) Necessity of Practical Water Quality Standard

The presently existing surface water quality standards stipulate that BOD concentration shall be less than 1.5 mg/l in any surface water. However, this level of BOD concentration would be over-strict for any kind of public water body. Requirements of water quality in other countries are normally designated in accordance with water usage. If such standards would be established, various realistic and practical approaches could be applied for the improvements.

(d) Strengthening/Establishing Implementing/Coordinating Agencies for Integrating Related Government Agencies and Donors/NGOs

There are various donors and NGOs as well as government agencies involved in water environmental improvement activities. However, there is no integrative agency/organization to coordinate and make them focus their activities on clear and concrete directions. This kind of organization or network is indispensable for comprehensive approach, since wastewater management is reflected from socioeconomic conditions and is complicated.

(e) Disclosure and Dissemination for Awareness Development of the People

To solve problems caused by the general public, such as water quality deterioration by domestic wastewater, awareness of the people is very important. Disclosure of environmental information is the key to dissemination and public awareness on environment. Presently, there is no organization or institution that can disclose enough information which people can easily access. The establishment of such an organization to provide appropriate information and conduct activities that will enhance people's awareness could result in supporting the appropriate and timely action of the related governments.

4.2 Strategy on Water Environment Improvement

Based on the discussion on planning conditions and encountered issues in the preceding section, the water environment improvement strategy is discussed in this section for the formulation of the water environment master plan.

4.2.1 Goal and Objectives

(1) Goal

The National Urban Development Strategy and Investment Plan (NUDSIP) have the same target year 2020 as the water environment master plan. The NUDSIP vision is "*Lao PDR shall develop modern urban centers that are clean and beautiful, and that provide safe and secure living conditions, protect cultural heritage and architecture, and protect the environment and human health.*" To support this vision, the Draft Urban Wastewater Strategy and Investment Plan (UWSIP) proposed the vision by 2020; namely, "*Lao PDR shall manage the wastewater sector appropriately and provide good wastewater services to the urban population to protect human health and the environment and to facilitate social and economic development in urban centers.*"

The water environment master plan should also support the above national visions so that the goal shall be "***to support increased access to sustainable wastewater facilities and services in the urban areas of the capital city of Vientiane***" in line with the UWSIP Goal.

(2) Objectives

The target area of the water environment master plan is the Mak Hiao river basin which originates in the most congested area of the urban center of Vientiane. The concrete objectives of the master plan are as enumerated below.

- To conserve the existing water environment in the entire Mak Hiao river basin, particularly, the natural function of water purification in the That Luang Marsh, the Nakhai Marsh and the lower reaches of Mak Hiao River;
- To restore the lost water environment in the urban drainage canal system; namely, the Hong Ke and Hong Xeng systems, for conserving and increasing the inhabitable environment of aquatic life along the canal system; and
- To treat the wastewater discharged from urban households in Vientiane City as the dominant source of surface water deterioration, and to improve the water environment in the drainage canal system.

4.2.2 Overall Targets on Water Quality

(1) Water Quality Standards/Guidelines

In general, water quality criteria could be closely related to water usage (beneficial use), so that many countries established relationship between water usages and water quality classification in their water quality standards/guidelines.

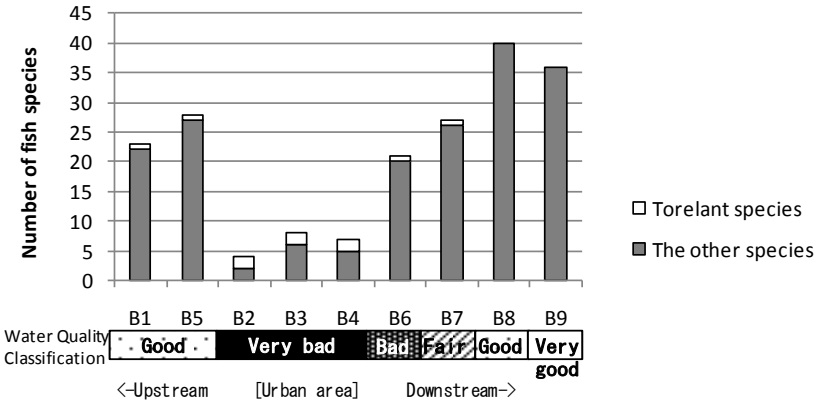
In due consideration of the situation of the Study Area for setting of the target water quality, fishery water could be most suitable for conservation of aquatic life as well as beneficial use to the Study Area; namely, the Mak Hiao river basin. The following standards are typical water quality criteria for fishery in the Asian countries.

Table 4.7 Surface Water Quality Standards for Fishery in the Asian Countries

Country / Parameters	Japan	Philippines	Malaysia
Standards/Guidelines: Name and Classification	Environmental standards for conservation of living environment (water quality in river): Class C	Revised water usage and classification/water quality criteria: Class C	National water quality standards: Class III
Beneficial Use	Fishery for carp and crucian	Fishery water for the propagation and growth of fish and other aquatic resources	Fishery water to protect common and moderately tolerant aquatic species of economic value
BOD	≤ 5 mg/l	≤ 7 mg/l	≤ 6 mg/l
DO	≥ 5 mg/l	≥ 5 mg/l	≥ 3 mg/l
pH	6.5-8.5	6.5-8.5	5-9
SS	≤ 50 mg/l	-	≤ 150 mg/l

(2) Aquatic Biology Survey Results

As tabulated above, the criteria in Asian countries show suitable BOD for fishery water ranging from 5 mg/l to 7 mg/l. On the other hand, the present condition for existing fish species clarified through the aquatic biological survey as shown in **Fig. 4.2** and the location of survey sites shown in **Fig. 4.3** indicate that numerous fish species make their habitat in the uppermost part and the lower part of the river system in which the monitored water quality is observed also in fair to very good conditions.



Surey frequency: Eight times excepting B9. B9 is seven times since it was not explored in July 2009 due to high water level.

Fig. 4.2 Total Number of Fish Species Observed in the Eight Surveys from 2009 to 2010

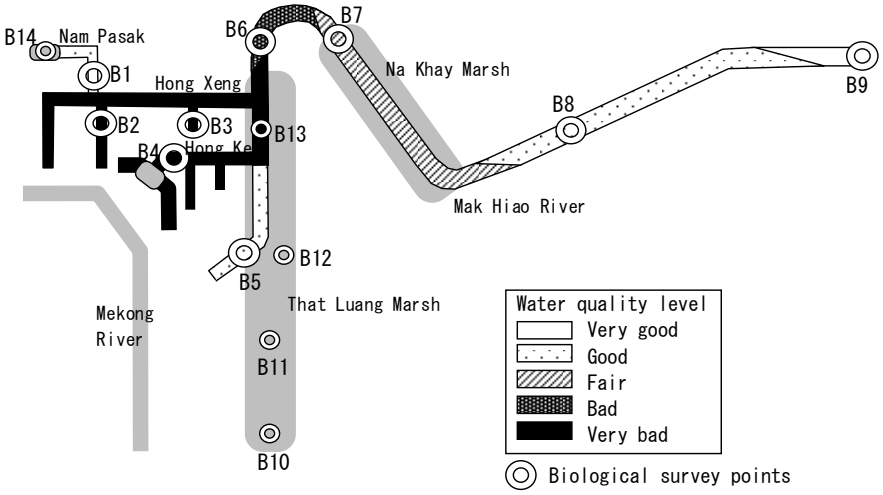


Fig. 4.3 Schematic Diagram of Water Quality Classification along the Mak Hiao River System

In addition, the following figure illustrates the relationship between water quality classification from aquatic biology and actual water quality monitoring results. The figure indicates that the water quality classification could be categorized easily by using the BOD parameter.

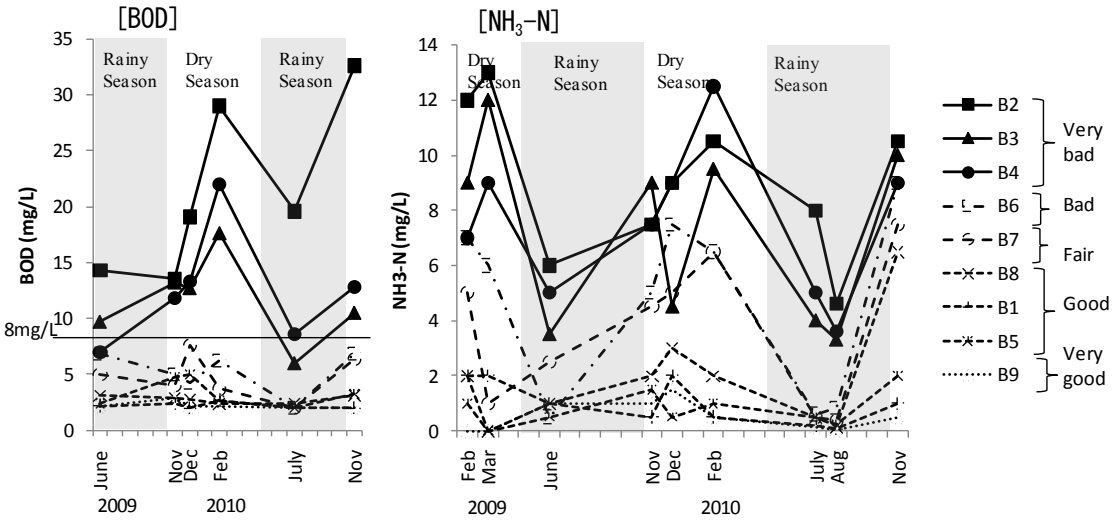


Fig. 4.4 Relationship between Water Quality Classification from Aquatic Biology Survey and Monitored Water Quality

(3) Water Quality Target

Organic pollutants are considered as dominant in the water deterioration in Vientiane urban areas. Thus, BOD was selected as the suitable indicator of water quality in the Master Plan. Regarding the planning targets of BOD, the following criteria on water quality shall be set-up based on the water quality criteria in other countries as tabulated in **Table 4.7** and the aquatic biology survey results as presented in **Figs. 4.2** to **4.4**.

Table 4.8 Planning Water Quality Targets

River/Canal Stretch	Water Quality Requirements in BOD	Remarks
Down-most Stretch of Mak Hiao River (Near river mouth)	≤ 5 mg/l	Best requirement for fishery water
Middle Stretch of Mak Hiao including That Luang Marsh	≤ 8 mg/l	Allowable lowest requirement for sustaining fishery water
Urban Drainage Systems: Hong Xeng and Hong Ke	8 – 12 mg/l	Expected requirement for restoration of inhabitable environment for fish

Although the urban drainage systems, Hong Xeng and Hong Ke, are the combined open sewer type to convey storm water and wastewater, water quality requirement should be set-up to improve the water environment through the enhancement of water quality and to provide minimum habitats for returning fish species as well as the existing ones. If these efforts could be successfully attained, the preferred urban water environment of the drainage network would be restored as it had previously existed.

4.2.3 Needs of Comprehensive Approach

There are several means of water environment management, which include structural measures, bio-engineering measures and management practices in legal system and institutional mechanism. Structural measures are hardware involving the application of technologies and implementing infrastructures. Bio-engineering measures are the application of biological process and engineering in environmental enhancement. Management practices encompass nonstructural approaches such as regulations, laws and institutional strengthening.

From the viewpoint of physical process of wastewater generation through discharging it into public water body up to downstream end of river system, there are several institutions as well as several wastewater treatment facility mechanisms involved. The people involved are building/house owners and sanitation, drainage and river administrators in institutions, while the wastewater treatment mechanisms are the on-site, communal and centralized wastewater treatment facilities, and the natural purification by wetland and dilution by river stream flows.

Numerous stakeholders are involved in the water environment management process from its generation to the treatment end. Efforts must be applied not only by the governments but also by the private sectors and the communities as a whole, to restore the urban drainage system at least to the level of what it has been previously considered for its beneficial use. Thus comprehensive approach involving various measures and wider stakeholders should be taken in wastewater management for water environment improvement.

In addition to the management of water quality mentioned above, improvement works had been implemented for storm water drainage by many donors including ADB from 1991 to 2008 following the JICA study in 1990. As a result, situations have improved to the extent that damage due to drainage overflow has not occurred in the rainy season.

It can be said that the prevention of such inundation damage is attributable to the storage function and flood retarding function of existing marshes. Therefore, it is required that existing marshes be conserved continuously from the viewpoints of water quality improvement and storm water drainage. It is further preferred that the future expansion of urban area outside of the Hong Ke and Hong Xeng drainage areas shall be accompanied with storm water drainage system construction consistent with the city plan.

4.3 Alternative Study on Structural Measures for Water Improvement

4.3.1 Alternative Structural Measures

There are various levels of wastewater treatment and structural measures are infrastructures meant to improve water quality. Discussed below are the possible options for wastewater management based on the results of the pilot project and the pre-feasibility study.

(1) Onsite Wastewater Treatment

(a) Septic Tank and Soak Pit

Most of the residents and businesses in Vientiane manage their excreta (black water) by means of the septic tank or soak pit as the onsite sewage facility.

(b) Combined Individual Sewer System

The combined individual sewer system (―*Johkaso*" in Japanese) is commonly applied in Japan as a typical household excreta and domestic wastewater combined treating system. It is adopted in individual houses, housing estates and public facilities where public sewer system is not available. An anaerobic and aerobic combined biological process with high efficiency has been commonly employed as the onsite wastewater treatment system for over 30 years in Japan. Since initial costs are considerably high for installation and operation/maintenance which consist of electricity for aeration, chlorine dosing for disinfection and high frequency of desludging of septage, this system might not be an appropriate technology for low-income households, but might be feasible as a communal facility.

(2) Water Environment Improvement in Community Level

(a) CBS (Community Based Sanitation)

One of the options to deal with domestic wastewater is to treat it in community level in-between onsite and centralized systems. Called as the Decentralized Wastewater Treatment System (DEWATS), it requires no energy input which has been the bane of conventional wastewater treatment systems. This system has the advantage of treating wastewater as close as possible to where it is generated and to where its potential beneficial reuse is located.

A typical system for domestic households basically consists of a primary treatment system of a settling and sedimentation tank and a secondary treatment system of an up-flow type baffled reactor which digests wastewater anaerobically. If extra space is available and high level treatment is required, it additionally has a tertiary treatment in subsurface horizontal flow through sand filters with reed beds, and finally a polishing pond for oxygenation and UV disinfection from the sun's rays. DEWATS can attain 80 to 85% reduction in BOD and COD, 80% reduction in Phosphates and 60% reduction in ammonia.

As described in **Subsection 4.1.3**, the installation ratio of sanitary facilities is quite high, up to more than 95% in individual houses and buildings, so that the applicability of CBS might be low from the original purpose of improvement of sanitary conditions in the community level. CBS, however, can be still applicable enough to the communities in newly developed suburban areas where enough space is available, as well as in public

buildings including schools and dormitory houses, for the purpose of sanitation improvement.

(b) Local Wastewater Treatment System

Even though the installation ratio of sanitary facilities is high and its effect is limited to storing and treatment of night soils, domestic wastewater is discharged into the public water bodies, in particular drainage canals, without any treatment. This process is a major cause of water quality deterioration. Although the secondary drain system such as roadside drain is already installed and conveys wastewater to the trunk drainage canals, the maintenance of secondary drains is poor so that stagnant water could often be seen at various places inside of the city.

Based on the above situation, decentralized wastewater treatment approach in the local level could be proposed through intercepting the wastewater at the outlets of secondary drains. Their feasibility was examined in the pre-feasibility study as an alternative measure of CBS. As the results of the study, possibility of wastewater treatment from the secondary drains was clarified through installation of small-scale interceptors and construction of simple treatment plants like CBS mainly utilizing the public lands along the canals.

(3) Centralized Wastewater Treatment System

(a) Combined Sewer System and Wastewater Treatment Plant

Wastewater in many places flows through storm drains. In the combined sewer system, two types of wastewater treatment approaches could be proposed.

In the first type, wastewater conveyed through canals is pumped up to the treatment plant and treated water is discharged back to the canals. The treatment plant is normally constructed at the downstream end, and water volume is determined from the dry-season flow. Thus surface water quality in the canals will not be improved until the wastewater is treated by the treatment plant.

With regard to the second type, wastewater is intercepted just before it discharges into trunk canals, and the intercepted wastewater is conveyed to a treatment plant. In the dry season, however, most of the flow is wastewater, so that a new issue on the dry-up of canals will come out in the dry season.

(b) Conventional Sewerage System

The conventional sewerage system includes household connections, conveyance pipeline, lift stations, if necessary, and sewage treatment plant. This practice significantly increases the cost. In addition, wastewater must be often pumped from various drainage basins to the central treatment plant through long and large trunk sewers. In this approach, a new issue on the dry-up of canals will also come up in the dry season.

4.3.2 Combination of Structural Alternatives

Based on the above considerations, the combination of possible structural measures shall be considered as alternatives in suitable space and time. In the first step, the study area shall be categorized into spatial differences, such as built-up area, new large-scale development area, rural-type aggregated community, and rural villages, as follows:

(i) Hong Ke and Hong Xeng drainage area: urban areas as built-up areas and surrounding rural-type aggregated community;
(ii) Large-scale development areas: Vientiane Industrial Zone and New City Development; and
(iii) Others: newly expanded built-up areas and rural villages.

The suitable structural measure for wastewater treatment shall be selected in accordance with the above town/village classification. For the next step, the planning timeframe shall be considered stepwise; namely, (1) until the year 2020 as the master plan target; and (2) 10 to 20 years after the master plan target as the long-term target. There are two types of step-wise measure, as follows:

(i) To continue the selected measures beyond the target year 2020; and
(ii) To upgrade the selected measures in parallel with economic growth; for instance, septic tank to individual sewer system, and wastewater treatment plant in combined sewer system to conventional centralized sewerage system.

Based on the above spatial and temporary divisions, **Table 4.9** tabulates applicable structural measures. This is based on the idea that the environmental foundation of a city shall be changed according to the characteristics of the land at the time of new construction and renewal of houses in a long run. It can be paraphrased as follows:

(1) Built-up area: CBS construction shall be promoted in an area where sanitary facilities such as toilet are not enough and extra space is available. For areas where extra space is not available, septic tank shall be promoted at the time of new construction and renewal of houses in a short-term, and *jokaso* shall be promoted in a long-term on the assumption that society would be affluent.
(2) Rural-type aggregated community: For rural agricultural communities where houses are scattered, on-site treatment facilities shall be basically promoted. Septic tank shall be promoted at the time of new construction and renewal of houses in a short-term, and *jokaso* shall be promoted in a long-term.
(3) Newly expanded built-up area and rural villages: Same manner as item (2) above.

In terms of drainage canal, two alternatives; namely, centralized type and decentralized type, are proposed and compared.

4.3.3 Comparative Study on Alternatives through Water Quality Simulation

Based on the possible structural alternatives as tabulated in **Table 3.9**, they shall be examined focusing on urban drainage system of Hong Ke and Hong Xeng. The comparative study shall be made in the following manner:

- Structural alternatives shall be set in the urban drainage systemd, Hong Ke and Hong Xeng.
- Evaluation of effects on water quality shall be made for the entire basin encompassing the urban drainage basin to the Mak Hiao river mouth.
- The natural water purification function of remaining marshes; namely, Nong Bo (in the Nong Ping development area) and Nong Tha in the upper reaches of Hong Xeng, shall be preserved in the development projects.

The comparative study process is summarized below. The comparative study results are tabulated in **Table 4.10**, and illustrated in **Fig. 4.5**.

Table 4.9 Possible Alternative Structural Measures

Mak Hiao River Basin		Alternatives in Time Frame	
Divided Area	Sub-Areas	M/P (until the year 2020)	10 to 20 years after M/P
Hong Ke and Hong Xeng drainage areas	Storm water drainage		
	Remaining marshes & drainage canal system	Conservation and improvement of remaining marshes for flood retarding.	Canal improvement for increasing draining capacity, if necessary.
	Wastewater management		
	Built-up area	(1) Installation of wastewater treatment plant in combined sewer system.	(1) Construction of conventional centralized sewerage system, if necessary.
		(2-1) Villages with available spaces and without proper sanitation facilities: Installation of CBS.	(2-1) Villages with available spaces and without proper sanitation facilities: Installation of CBS.
		(2-2) Villages without available spaces: Installation of septic tank at the time for rebuilding or newly building.	(2-2) Villages without available spaces: installation of combined individual sewer system at the time for rebuilding or newly building.
	Rural-type aggregated community	Installation of septic tank at the time for rebuilding or newly building.	Installation of combined individual sewer system at the time for rebuilding or newly building.
	Drainage canal	(1) Introduction of centralized treatment facility: Construction of treatment plants with combined sewer system	Construction of conventional type of treatment plants (if necessary).
		(2) Introduction of decentralized treatment plants: - Installation of decentralized simple treatment plants with interceptors. - Installation of in-stream contact aeration treatment facilities. - Application of vegetation measures for strengthening natural purification functions.	
	Conservation of existing marshes	Conservation of remaining marshes in drainage areas including Nong Bo, Nong Tha, Nong Chanh (conservation of natural purification function as well as flood retarding mentioned above).	
New large-scale development	Industrial estate and new city development	Storm water drainage	
		Construction of storm water drainage system.	
		Wastewater management	
		Construction of wastewater treatment facilities at downstream ends of developing areas or inside individual factories.	
Other areas	Newly expanded built-up area	Storm water drainage	
		Construction of storm water drainage system, if necessary.	
		Wastewater management	
		Installation of CBS or septic tank at the time for rebuilding or newly building.	Installation of combined individual sewer system at the time for rebuilding or newly building.
	Rural villages	Wastewater management	
		Installation of septic tank at the time for rebuilding or newly building.	Installation of combined individual sewer system.

(1) No Action

No action taken by all sectors concerning wastewater to improve the water environment indicates that water quality represented by BOD will continue deteriorating even at the target year 2020. Compared to the present water quality, the "no action" option would make the water quality worse in the entire stretch, far above the target BOD.

(2) Alternative 1

This alternative is the conventional way to install a wastewater treatment plant and to introduce wastewater into the plant utilizing the existing combined sewer system. This improvement might be the fastest way among the plant installation measures. The lower reaches of Hong Pasak, Hong Kai Keo, and Hong Ke are possible points for the construction of a treatment plant considering the deteriorated quality of water to be treated and the possibility of land acquisition. Since the BOD of target wastewater is more or less 30 mg/l, contact aeration type treatment facilities, which are assumed to reduce 70% of pollution load, would be appropriate. Furthermore, administrative guidance shall be made by the Ministry of Industry and Commerce or the Department of Industry and Commerce of Vientiane by applying the Regulation on Industrial Wastewater and the Water Quality Standards to install wastewater treatment facilities against highly polluted wastewater discharged from slaughterhouses in Hong Wattay. Although the results of simulation meet the target BOD in the lower stretch of the plants, water quality in the upper reaches will exceed the target BOD due to the nature of sewerage treatment and utilization of the existing combined sewer system.

(3) Alternative 2

This alternative is to cope with water environmental deterioration in accordance with the characteristics of wastewater sources and the particular features of the canals. This alternative is composed of the following measures:

- Hong Wattay: As in Alternative 1, Alternative 2 consists of the installation of wastewater treatment facilities against highly polluted wastewater discharged from slaughterhouses with administrative guidance by the Department of Industry and Commerce of Vientiane.
- Hong Pasak: Alternative 2 consists of the installation of local interceptors and simple wastewater treatment plant along the canal to treat the domestic wastewater inflow.
- Hong Khoua Khao, Hong Kai Keo, Hong Ouay Louay and Hong Phone Thanh: Similar to Hong Pasak, the alternative will utilize the available spaces along the canal.
- Hong Thong: The alternative consists of the construction of in-stream wastewater treatment plant utilizing the open space at the south bank of the Nong Chanh Marsh, and pumping up wastewater from the canal.

The in-stream treatment facilities shall be constructed in open spaces along the bank of Nong Chanh Marsh, to treat wastewater discharged from the outfall of Hong Thong, of which almost the entire stretch is covered with concrete. The removable rate of pollution load is set at 70% with reference to the experiences in Japan.

The results of simulation as shown below could meet the target BOD over the stretch of urban drainage system. Regarding the suitable type of contact media for the proposed contact aeration type facilities, the string type of contact media was selected due to advantages against clogging of generated sludge, based on the experiences through various substantive tests in Japan.

Table 4.10 Comparative Study Results

Alternatives	Outfall of Urban Drainage System				Mak Hiao River			
	Hong Wattay	Hong Pasak	Hong Xeng	Hong Ke	That Luang Marsh Downstream End	Na Khay Marsh Upstream End	Na Khay Marsh Downstream End	River Mouth
Target BOD	8-12				8			5
Present	16.0	19.7	11.7	17.2	4.6	4.5	3.5	1.9
No Action	18.6	31.6	20.1	29.1	8.1	8.6	8.5	3.1
Alternative 1	11.0	9.0	10.0	8.3	5.3	6.6	7.5	2.9
Alternative 2	11.0	11.4	10.2	11.2	5.5	6.7	7.5	2.9

Unit: mg/l
Present: Simulation results under the conditions in 2009
Alternative 1: Construction of contact aeration plant in downstream ends of Hong Pasak, Hong Kai Keo and Hong Ke
Alternative 2: lant in the

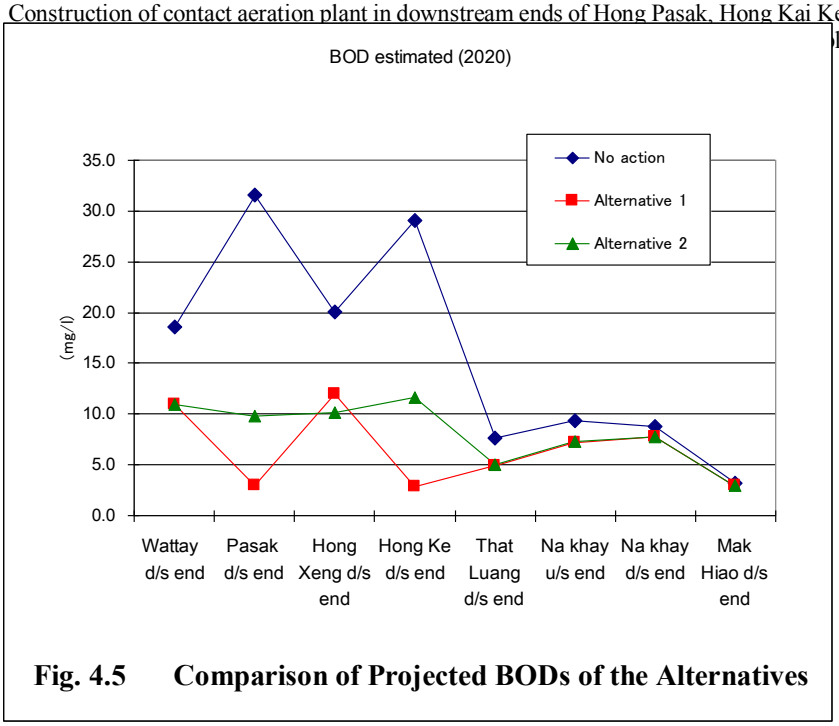


Fig. 4.5 Comparison of Projected BODs of the Alternatives

4.3.4 Comparative Study Results

Cost estimates and yearly O&M costs of the two alternatives are shown in **Table 4.11**. As shown in the table, Alternative 2 has a higher construction cost while Alternative 1 has a higher O&M cost.

Construction cost for Alternative 1 includes that of sewerage treatment plants (contact aeration method) including discharge pumping stations. For Alternative 2, construction cost includes decentralized treatment systems along the canals and in-stream contact aeration plants at the end of downstream of Hong Thong.

As for O&M cost, Alternative 1 includes electricity cost for the operation of contact aeration plants, as well as sludge disposal cost. Alternative 2 includes sludge disposal cost accruing from decentralized treatment plants and in-stream contact aeration plants as well as electricity cost for the operation of contact aeration plant.

Table 4.11 Cost Estimation for Alternative Treatment Systems

	Construction Cost (Mil. USD)			O&M Cost (Mil. USD) per year		
	Decentralized System	Contact Aeration	Total	Decentralized System	Contact Aeration	Total
Alternative 1	-	21.86	21.86	-	0.17	0.17
Alternative 2	14.65	3.07	17.72	0.01	0.03	0.04

Comparative study results are as summarized in the following table, which shows that Alternative 2 is considered the most recommendable option for appropriate water environment improvement in Vientiane. The decentralized simple wastewater treatment plants could improve surface water in the stretches required to improve their water quality in the drainage system, and their operation and maintenance could be much easier than the others. Furthermore, in-stream treatment facilities with contact aeration could improve the local water quality in a certain stretch if site space is available.

Table 4.12 Comparative Evaluation of Alternative Treatment Systems

Evaluation Items	Alternative 1 (Sewage Treatment Plants)	Alternative 2 (Decentralized Simple Treatment Plants & In-stream Treatment Plant)
(1) Initial Cost	High	CA: Low
(2) Construction Site	Private land in downstream ends of Hong Pasak and Hong Kai Keo and public land in the downstream end of Hong Ke as EU Pond	CA: Public land in both contact aeration type and simple treatment types along the canal system, and educational land in planned SBS.
(3) O&M Cost	High	CA: Low
(4) Easiness of O&M	Experience is required for O&M.	Contact aeration type is the same as in Alternative 1. O&M is easy for simple treatment facility, but it would become complicated when the number of installation is increased.
(5) Effects on Water Environment	It improves water quality at downstream of plants but does not improve water quality at upstream.	CA: Improvement of water quality over the entire drainage stretch
(6) Sustainability	It requires a mass of land. Land acquisition should be made in advance.	CA: O&M is easy and its space is spared along the canals (canal area). High sustainability is expected in the future; it can be constructed where it is required.
(7) Necessity of technology transfer to other areas/canals and its expandability	Technology transfer of small type of contact aeration treatment facility is necessary; contact medium which can be acquired locally should be developed.	CA: Contact aeration type is the same as in Alternative 1. Technology transfer of a simple treatment facility including CBS/SBS is necessary and its expandability is high.
(8) Others	It is a time consuming and costly process to install lateral piping systems over the drainage basin, if upgrading of the separated sewerage system is required.	CA: Relatively short time is necessary for completion of system installation.
Overall Judgment	Low advantage at present	**High advantage**

CA: Comparative Advantage

Fig. 4.6 illustrates water quality predictions among the status at present, with noaction and with the optimum plan in future.

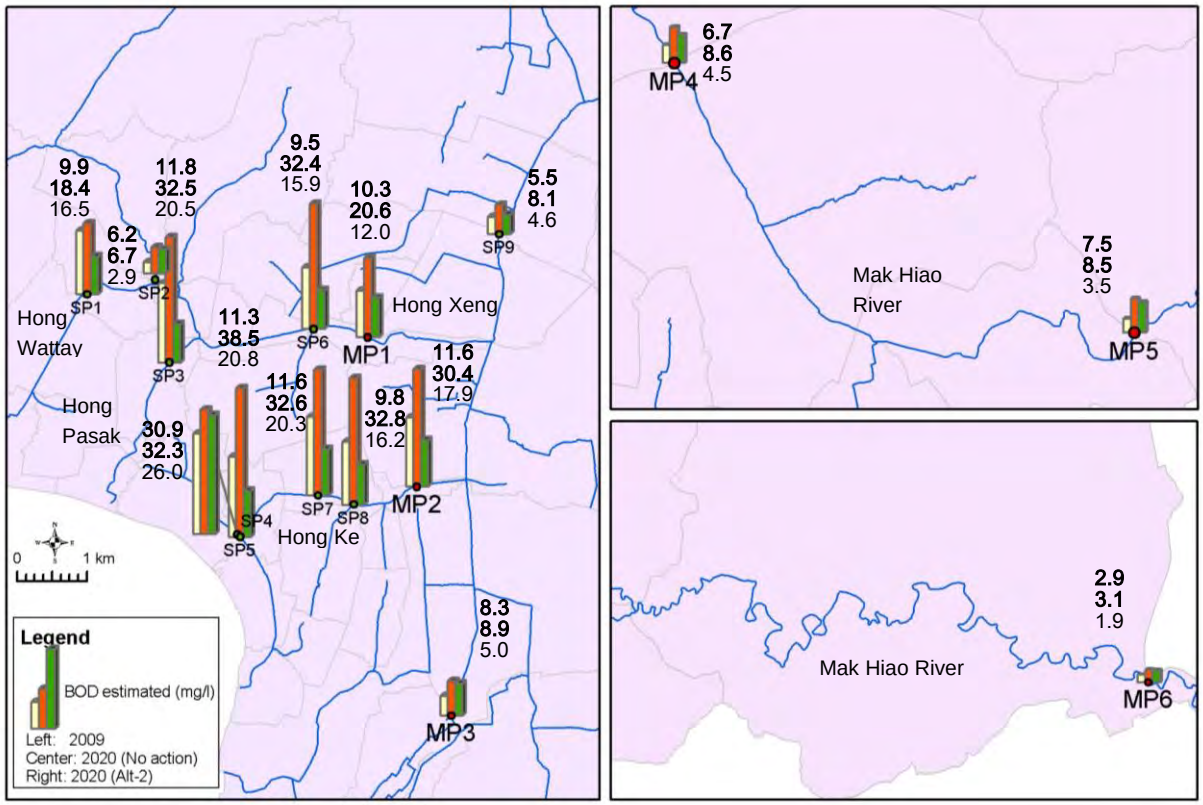


Fig. 4.6 Projected BOD at Present, with No-Action in Future and with Optimum Plan in Future

4.4 Master Plan for Water Environment Management

4.4.1 Master Plan Structure

As described in **Section 4.2** of strategy on water environment management, comprehensive approach is necessary in order to attain the sound water environment. Comprehensive approach includes the following concepts:

- To integrate the engineering and biological technologies and management practices,
- To involve the entire stakeholders related to wastewater generation and management, including private and business sectors as well as government agencies, and
- To cover from sanitary improvement in individual houses and communities to water quality improvement in the public water body.

Thus master plan components were divided into three areas; namely, (1) structural water improvement; (2) institutional and legal improvement; and (3) environmental education. The following figure depicts the relationship among these components.

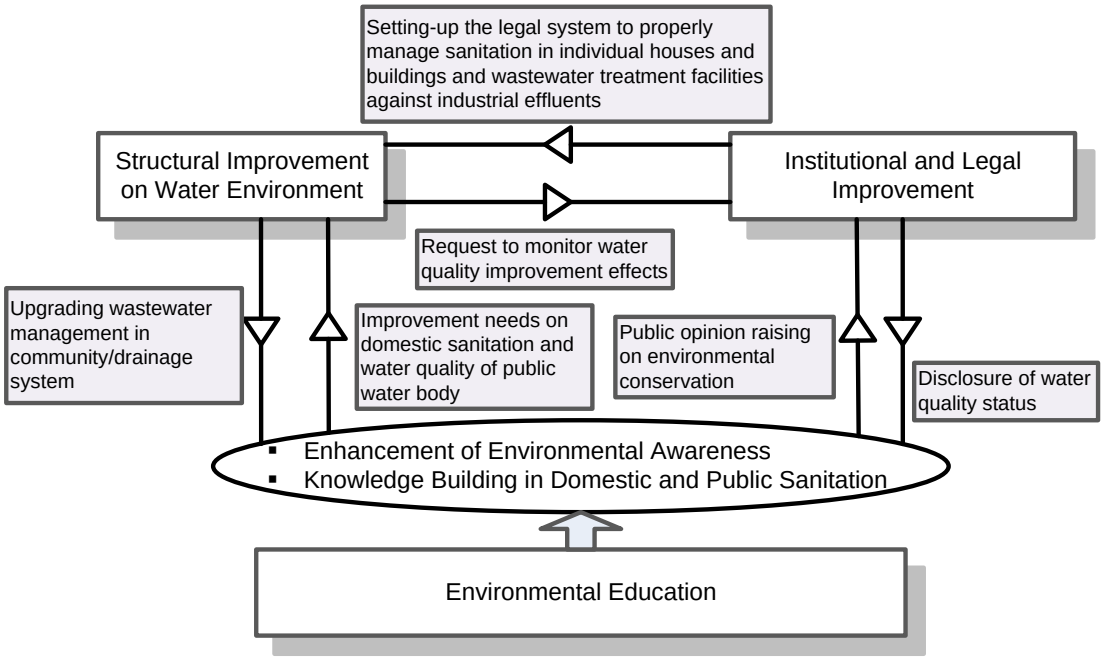


Fig. 4.7 Interaction among Three Master Plan Components

4.4.2 Structural Water Environment Improvement Plan

(1) Improvement Concept

As described in **Subsection 4.3.2, Combination of Structural Alternatives**, the water environment improvement plan shall be formulate taking spatial and time features into consideration. Based on the comparative study results, the structural water improvement components are as summarized in the following table.

Table 4.13 Structural Water Quality Improvement Components

Mak Hiao River Basin		Alternatives in Time Frame	
Divided Area	Sub-Areas	M/P (until the year 2020)	10 to 20 years after M/P
Hong Ke and Hong Xeng drainage areas	Storm Water Drainage		
	Remaining marshes & drainage canal system	Conservation and improvement of remaining marshes for flood retarding	Canal improvement to increase draining capacity, if necessary
	Wastewater Management		
	Built-up area	(1) Villages with available spaces and without proper sanitation facilities: Installation of CBS (2) Villages without available spaces: Installation of septic tank at the time for rebuilding or newly building	(1) Villages with available spaces and without proper sanitation facilities: Installation of CBS (2) Villages without available spaces: Installation of combined individual sewer system at the time for rebuilding or newly building
	Rural-type aggregated community	Installation of septic tank at the time for rebuilding or newly building	Installation of combined individual sewer system at the time for rebuilding or newly building
	Drainage canal	Construction of decentralized treatment facilities: (1) Construction of simple wastewater treatment plants collecting wastewater by local interceptors (2) Construction of in-stream contact aeration facilities (3) Application of vegetation measures for strengthening natural purification functions	
	Conservation of existing marshes	Conservation of marshes remaining in the drainage areas such as Nong Bo, Nong Tha, and Nong Chanh (natural purification function as well as flood retarding mentioned above)	
New large-scale development	Industrial estate and new city development	Storm Water Drainage	
		Construction of storm drainage system	
		Wastewater Management	
		Construction of wastewater treatment facilities at the downstream end of the developing areas or inside the individual factories	
Other areas	Newly expanded built-up area	Storm Water Drainage	
		Construction of storm drainage system, if necessary	
		Wastewater Management	
		Installation of CBS or septic tank at the time for rebuilding or newly building	Installation of combined individual sewer system at the time for rebuilding or newly building
	Rural villages	Wastewater Management	
		Installation of septic tank at the time for rebuilding or newly building	Installation of combined individual sewer system at the time for rebuilding or newly building

(a) Storm Water Drainage

Basically, for newly expanded urbanizing areas including large-scale developments, construction of new drainage canals or improvement of existing drainage canals shall be carried out in accordance with the urgent necessity to attenuate flooding issues.

Regarding the drainage areas of Hong Ke and Hong Xeng, remaining marshes shall be conserved and improved for their storm water retarding functions until the target year 2020. These are Nong Bo in Nam Pasak, Nong Douang in Hong Wattay, Nong Tha in Hong Xeng, and Nong Chanh in Hong Ke. A retarding capacity for storm water of the marshes in the basin of Hong Xeng area (equivalent to 0.5 m increase in water depth) was estimated to have an effect of reducing the peak hydrograph at 2-year return period from 90 m^3/s to 42 m^3/s at the downstream end.

(b) Wastewater Management in Built-up Areas

CBS receives both black water and gray water so that it has strong impacts on community sanitation improvement as well as surface water improvement in the drainage system. On the other hand, the septic tank receives only black water, and gray water is discharged to the surrounding environment without treatment. Selection of CBS or septic tank depends on the necessity of a CBS system, which is decided by the installation of existing sanitation facilities such as toilets, and the land availability for the installation. Considering the successful cases in Southeast Asia, it seems that CBS is accepted smoothly by such communities consisting of low income families which do not have toilets, where CBS applies to the needs of users. Furthermore, securing of land for installation of CBS might be a significant obstructive factor to expand their installation due to private lands. Based on the high installation ratio of sanitation facilities in the individual houses and buildings, the necessity of CBS installation might be extremely low in the urban areas of Vientiane.

In order to upgrade such functions of the septic tank, the combined individual sewer system was invented in Japan. It can receive both black and gray water, but it needs electricity for aeration. Thus the combined individual sewer system shall be introduced for sanitation in individual houses in future when people's income would grow remarkably.

In addition some wastewater treatment plants shall be constructed in the downstream ends of the large-scale development areas or inside of factories, since their impacts to the public water environment would be quite significant.

(c) Wastewater Management in Rural Villages

Installation of septic tank at present and individual sewer system in future is recommendable for domestic sanitation improvement in the rural villages in a similar manner mentioned above.

(d) Development Project in Remaining Marshes

Development plans/projects have been progressing, targeting Nong Bo in Nam Pasak and Nong Tha in Hong Xeng. In these areas, proper wastewater treatment measures shall be carried out on the effluent of developed areas. Furthermore, the natural purification function of marshes shall be preserved since wastewaters discharged from the drainage basin are being purified naturally, before the development.

(e) Water Improvement along Drainage Canals

To improve the water quality of drainage flow, the following measures shall be carried out in accordance with the status of water deterioration, its causes and feasibility of countermeasures. Furthermore, vegetation, which naturally and thickly grows in the canals, shall be preserved wherever possible to expect additional purification functions of vegetation against wastewater.

- Hong Wattay: Administrative instructions shall be made by the Department of Industry and Commerce of Vientiane for treatment facilities against highly polluted effluents from the slaughterhouses.
- Hong Pasak: Government sectors shall install local interceptors and simple wastewater treatment plants along the canals.
- Hong Koua Khao, Hong Ouay Louay, Hong Phone Thanh, Hong Kai Keo: Government sectors shall install the same facilities step by step as applied in Hong Pasak because of available spaces along the canals. In addition, as they have natural purification function according to the field survey, installation of appropriate works shall be examined based on enough monitoring activities.
- Hong Thong: Common countermeasures could not be applied to Hong Thong due to concrete cover in almost the entire stretch of the canal so that in-stream treatment facilities shall be constructed along the bank of Nong Chanh, introducing wastewater from Hong Thong by pumping up through DANIDA intake near the outfall of the canal.

(2) Issues on Implementation and Points to be Considered

In the structural water improvement plan, the major measures are local interceptors and simple wastewater treatment plants, septic tank and in-stream treatment facilities. **Table 4.14** shows the responsible body in their installation and operation and maintenance, and the major issues. Funding for simple wastewater treatment plants with local interceptors and in-stream treatment facilities is the most important issue, while establishment of legal system including guidance is urgently necessary in the installation of septic tanks.

Table 4.14 Responsible Body and Major Issues on Structural Measures

Structural Measures	Responsible Body in Installation	Responsible Body in Operation & Maintenance	Major Issues
Simple Wastewater Treatment Plants with Local Interceptors	Vientiane/VUDAA	Vientiane/VUDAA	Funding for installation
Septic Tank	House/Building Owner	House/Building Owner	Legal system for installation
In-stream contact aeration treatment	Vientiane/VUDAA	Vientiane/VUDAA	Funding for installation

In addition, the following points shall be considered for smooth implementation of the above structural measures:

- To extend installation of simple wastewater treatment plants, wide open spaces in public schools, temples and local government offices shall be utilized as installation sites for intercepting the wastewater through drainage pipes.
- To promote septic tank although soak pit is popularly installed due to land availability and its low cost; plastic-made septic tank is major in Thailand but Lao people still have

difficulty in accepting the use of plastic for human waste treatment. Furthermore, traditional septic tanks and plastic septic tanks have almost the same cost (300 USD for an average size), but the latter one needs a smaller area for installation. Thus plastic type may be gradually accepted in future.

- To conduct smooth construction and operation and maintenance of the facilities, construction of proper GIS is indispensable, integrating secondary and tertiary drainage networks, topographic information and facilities installed.
- To manage the water environment improvement activities conducted by various donors and NGOs in an integrated manner, an environment and sanitation center shall be established for formulating a robust network and communication system among the actors including governmental organizations.

(3) Stepwise Plan of Structural Water Improvement

(a) Mid- and Long-Term Stepwise Plan of Structural Water Improvement of Drainage Network

Scrutinizing the present water environmental conditions and the future ones predicted, an appropriate strategy to remedy the future worsening situations shall be established for midterm and long-term time frame. **Fig. 4.8** could depict such process.

The target year of the midterm timeframe shall be year 2020 in accordance with the water environment improvement master plan. In addition, long-term consideration shall be necessary for further improvement on water environment, since construction of sewerage system including collection pipe network needs much longer time and large investment. Thus, water environment improvement strategy could be divided into three steps:

Step I: Mid-Term Improvement (until year 2020)

Immediate and on-site applicable remedial measures for water environment shall be conducted in the most seriously deteriorated canals: Hong Xeng giving a first priority to Hong Pasak, and Hong Ke also giving it to Hong Thong. The effective measures are interceptors of wastewater inflow and small-scale treatment plants along the canals, and in-stream treatment system at the outfall of Hong Thong. The small-scale treatment plant is similar type and structural components to CBS/SBS. In addition to those measures, vegetation measures should be applied in the canals to expect their natural purification functions.

Step II: Long-Term Improvement (after year 2020)

After completion of midterm improvement works, water quality of surface water in the canal system, however, is expected to worsen due to denser congestion of existing urban areas and further extension of urbanizing areas. Sewage treatment plants shall be constructed at the downstream ends of Hong Xeng and Hong Ke. If the artificial wetlands proposed by WWF are realized, those wetlands could be expected to attain similar functions of the above treatment plants. Furthermore, these wetlands have advantages that operation and maintenance is easier and more significant effects are expected in treatment to the lower concentration of contaminated water through midterm improvement works. The conceptual design of artificial wetlands is presented in **Fig. 4.9**.

Step III: Long-Term Improvement (after Step II)

After completion of Step II project, pipe network installation shall be started to extend coverage of sewerage system and to improve sanitary conditions of unconnected

households to the public sewer. Underground trunk sewer pipe shall run along the trunk canal bank like interceptor collecting wastewater from lateral sewer network. In general some lift pump stations shall be constructed at the necessary intermediate points along the trunk sewer pipe.

This kind of works is the general procedure of installation of conventional sewerage system. If decentralized treatment approach in Step I could function well and artificial wetlands would be selected in Step II, decision making shall be made based on enough examination on the conditions of that time when huge amounts of investment are required for improvement of the malfunctioning secondary drain networks to connect to simple treatment facilities as well as wastewater treatment in newly expanded built-up areas.

Present Conditions

Present Sewer System

Wastewater conveyance means in Vientiane

↓

Natural or manmade canal network connecting to the That Luang Marsh

↓

Combined open sewer system

Seasonal Periodical Changes of Surface Water in the Canal

Rainy season	:	• Receiving rainwater as well as domestic wastewater, water quality betters due to dilution of increased stream flow. • Aquatic species, in particular fishes, come back to the canal.
Dry season	:	• Receiving only domestic wastewater, water quality worsens due to no natural inflow. • Aquatic species move downwards to Hong Xeng and That Luang Marsh.

↓

Alternative Remedial Measures

No action (Future trend)	:	In parallel with densely urbanizing, water quality in the canal network will worsen in the rainy season as well as the dry season.

Midterm Strategy: Step I (Target Year of 2020)

Simple treatment plants with local Interceptors	:	Advantage
	(1)	Improving surface water quality on site along the canal
In-stream contact aeration treatment plant	:	Advantage
	(2)	Improving surface water quality at a pinpointed site

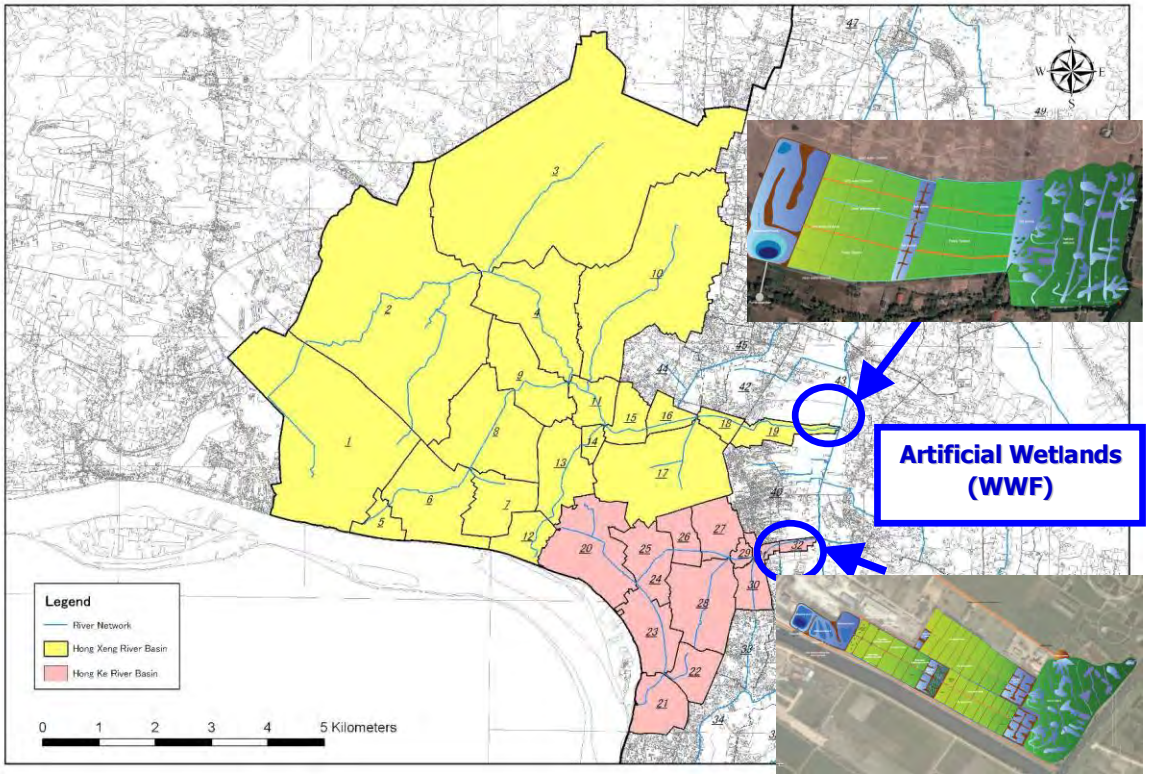
Long-term Strategy: Step II (After 2020)

Construction of sewage treatment plant with existing combined sewer system (At downstream end of Hong Ke and Hong Xeng)	:	Prerequisite
	(1)	Method, which further treats surface water whose quality is improved in Midterm Strategy, shall be employed.
	(2)	Main objectives are to conserve marshes at downstream (That Luang and Na Khay), and to protect biodiversity, etc.

Long-term Strategy: Step III (After 2020 and the assumption of drastic increase in national income)

Installation of sewage system including collection pipe/drain network	:	Prerequisite
	(1)	Whether its installation is actually necessary shall be examined based on the enough analysis of the conditions at that time.
Improvement of wastewater Treatment plant	(2)	Countermeasure against the drying-up of drainage flow in the dry season
	(3)	Acceptance of long-term construction period and huge amount of investment

Fig. 4.8 Mid- and Long-Term Interaction among Three Master Plan Components



Source: WWF

Fig. 4.9 Artificial Wetland Concepts proposed by the WWF

(b) Short- and Mid-Term Stepwise Plan on Structural Water Improvement of Drainage Network

In the preceding clause, improvement directions on water environment were proposed for midterm plan towards 2020 and long-term plan afterwards. Stepwise plan in short terms is proposed towards the target year 2020.

In a few years, a pilot project shall be implemented as early as possible to showcase the water environment improvement in the upper reaches of Hong Pasak based on the results of Pre-F/S in this Study. It is appropriate that the following facilities and actions for environment improvement be implemented in order from upstream to downstream. If they are implemented starting from the uppermost, effects on water quality improvement would be quite obvious:

- SBS (School Based Sanitation) shall be installed to collect gray and black water from the dormitories of Pak Pasak Technical College, which is located in the uppermost of Hong Pasak,
- Four (4) small-scale simple treatment plants with local interceptors of wastewater inflow shall be constructed along the canals of upper Hong Pasak.
- In parallel with water quality improvement, green corridor shall be installed along the improved stretch for restoration of riverside as relaxation places to the citizens.

Afterwards, expansion of the countermeasures to the lower reaches of the Pre-F/S target area in Hong Pasak and further in Hong Khoua Kao, and construction of in-stream treatment facilities in Hong Thong shall be conducted. Water quality in the worst polluted drainage canals will be improved with these countermeasures. Meanwhile, measurement of effects of these countermeasures and water quality monitoring in the whole area shall be implemented simultaneously, appropriate countermeasures shall be

considered based on the water quality of such drainages that have no countermeasures, and necessity of simple treatment facility and possibility of water purification by vegetation will be examined. The objective of these activities is to find countermeasures which can realize the largest effects through the monitoring activities, considering the present conditions in Lao PDR as well as reducing project costs. Required minimum assistance shall be extended with presenting these policies for the activities, which is expected to prepare a foundation for the counterpart to assume project implementation itself. For other drainage areas, however, only technical assistance shall be made with establishing a development policy in consultation with counterparts following a detailed survey in dry season. Details of such technical assistance include:

- Technical assistance to WREA on water quality monitoring of drainage canals, which will enable WREA to carry out by itself in the future;
- Implementation of experiment of water quality improvement by a low cost method other than simple treatment facilities such as vegetation in collaboration with WREA, PTI, DPWT of Vientiane, VUDAA and Lao National University in parallel with water quality monitoring; if such countermeasure is proved to be feasible and effective, alternatives of structural measures which can be carried out by the Lao side will be expanded and cost of structural measures will be reduced;
- Continuation of technical assistance on governmental guidance to the slaughterhouse at Hong Wattay, which is still pending; and
- Enough consultation with counterparts on whether the newly developed areas of Nong Ping and Nong Tha fulfill the water quality requirement that water quality shall not be worse than that before the development as well as on the guarantee of its enforcement.

Based on the activities mentioned above, short- and mid-term stepwise development plan is formulated as follows:

Table 4.15 Short- and Mid-term Stepwise Plan on Structural Water Improvement of Drainage Network

Year	Improvement Target	Rainy Season (Apr. to Sep.)	Dry Season (Oct. to Apr.)
2011/2012	Formulation of the total plan	Examination of the water quality improvement policy and consultation with counterpart agencies	
2012/2013	Examination of present conditions and appropriate improvement direction	Detailed examination of water quality: development policy for each target drainage canal	
2013/2014	Water quality improvement in the upper reaches of Hong Pasak	F/S and D/D based on field survey	Construction in order from upstream end to downstream end
2014/2015	Water quality improvement in the upper reaches of Hong Pasak	Water quality monitoring, continuous F/S and D/D	- Same with above - Detailed examination of suitability on countermeasures in other drainage canals
2015/2016	Construction of in-stream treatment plant in Hong Thong	D/D on in-stream treatment plant in Hong Thong	Construction of in-stream treatment plant in Hong Thong
2016/2017 to 2020/2021	Selection of drainage canals to be improved and their appropriate measures, and implementation of them through water quality monitoring	Selection of canals to be improved and examination of appropriate measures: lower reaches of Hong Pasak, Hong Kai Keo, Hong Ouay Louay, Hong Phone Thanh	Implementation of appropriate measures and examination of their effects through water quality monitoring

Since human resources and budget of DPWT in Vientiane as an administrator of the drainage network and related organizations are limited, the work items mentioned in the above table could be categorized into two groups; namely, self-made projects and donor supported projects. These are summarized below.

Table 4.16 Work and Budgetary Allocation on the Structural Water Improvement

Responsible Agency	Projects/Works
Self-made Projects/Works	
Vientiane and PTI	Site survey along the target drainage canals; Application of plants for natural water purification and its monitoring; Dredging of accumulated sediment if necessary
WREA	Periodical water quality monitoring in the drainage network
Donor Supported Projects/Works	
Vientiane and PTI	Establishment of detailed improvement directions for the target canals; Construction of simple wastewater treatment plants along the canals; Construction of in-stream wastewater treatment plant along Nong Chanh Marsh

4.4.3 Institutional and Legal Improvement Plan

(1) Consideration on Further Development of Regulations/Guidelines

Keeping in mind the present capacity of implementing water environment management, development of regulations/guidelines required to be considered in the specialized fields are summarized in **Table 4.17**. Items stipulating only general activities of authorities should be

developed in the form of regulations while those stipulating detailed activities of authorities as well as activities of the people or private companies should be developed in the form of guidelines in the first step.

The following figure illustrates the relation among the regulations/guidelines to be considered.

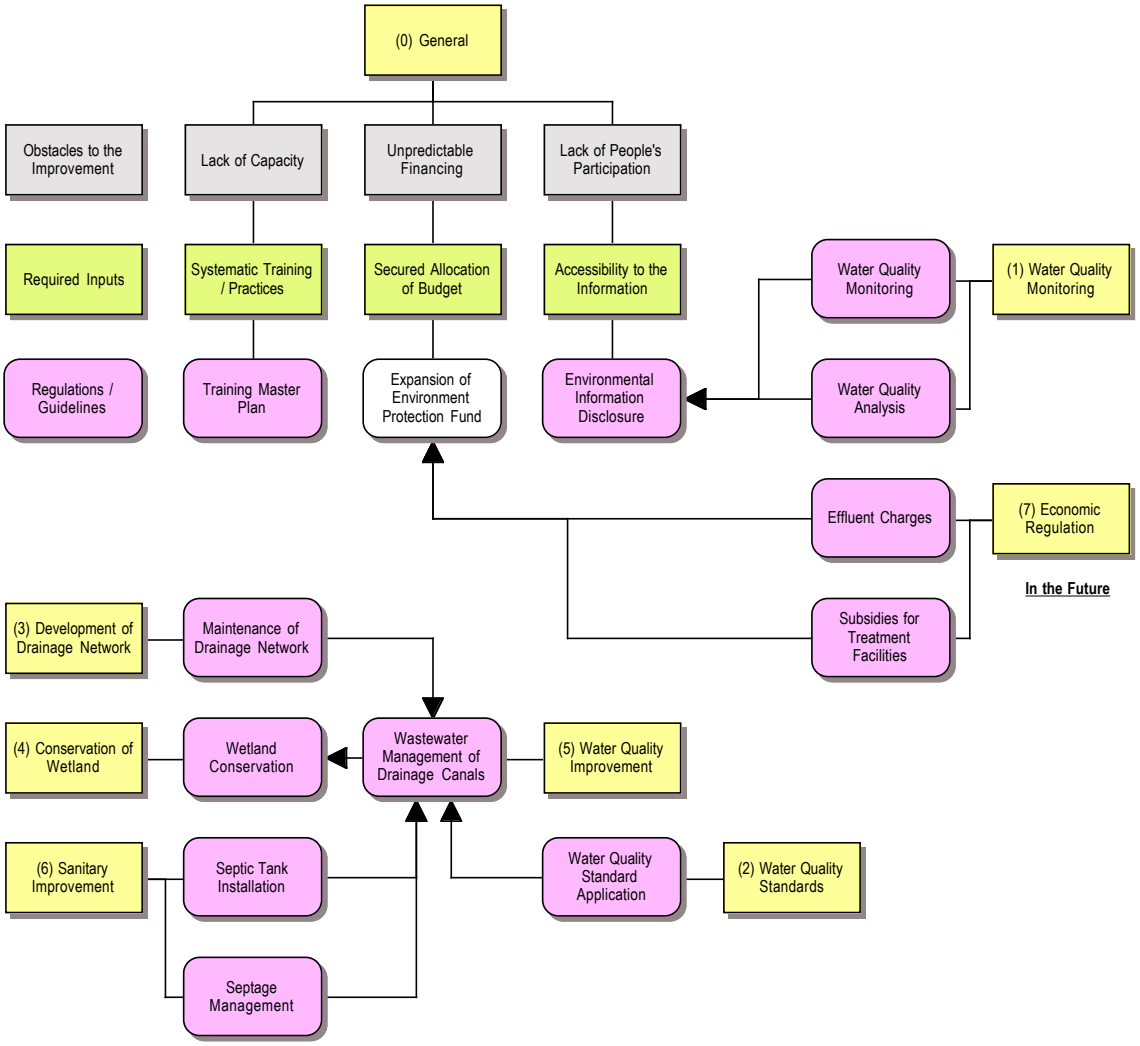


Fig. 4.10 Relation among the Regulations/Guidelines

Table 4.17 Menu of Development Regulations/Guidelines to be Considered

Specialized Field / Objective	Items to be Developed	Main Contents	Responsible
(1) General ♦ To support the implementation of water environment management	• Regulation on environmental information disclosure	➢ Easy access to water environmental information ➢ Annual report on water environment ➢ Water environment database	➢ WREA
	• (Expansion of Environment Protection Fund)	➢ (Expansion of the fund)	➢ EPF
	• Guideline on training master plan for technical staffs in government offices	➢ Clarify requirements to posts ➢ Career build-up model	➢ Prime Minister's Office
(2) Water Quality Monitoring ♦ Basic data of water quality in the target area should be collected and accumulated by Lao engineers themselves, which will be the basis for the management and planning. ♦ Water quality monitoring network system (WQMNS) should be established for data accumulation. ♦ Capacity of WREA Lab should be developed to carry out its responsibility in the WQMNS.	• Regulation on water quality monitoring	➢ Periodical monitoring ➢ Linkage between DOE-WREA and WREO ➢ Linkage between WREA and DI-MIC ➢ Clarify the responsibility of WREA Lab ➢ Water quality database ➢ Disclosure of the data	➢ WREA
	• Guideline on water quality monitoring	➢ Monitoring method ➢ Establishment of WQMNS ➢ Management of WQMNS ➢ Training on monitoring	➢ WREA
	• Guideline on water quality analysis	➢ Analyzing method ➢ Management of laboratory ➢ Analyzing service to customers ➢ Training on analysis	➢ WREA
(3) Water Quality Standards ♦ BOD value for surface water standard is set at very severe level for the actual conditions without setup of water quality classes.	• Guideline on water quality standard application in Vientiane	➢ Setup of more realistic targets of water quality ➢ Setup of water quality classes	➢ WREA
(4) Development of Drainage Network	• Guideline on the maintenance of drainage network	➢ Monitoring of drainage network ➢ Maintenance requirements	➢ MPWT
(5) Conservation of Wetland ♦ It is required not only to conserve the functions of wetland but also to disseminate information to the public.	• Regulation on wetland conservation	➢ Monitoring of wetland (water quality, biodiversity, etc.) ➢ Regulation on development at the periphery of wetland ➢ Annual report on wetland ➢ Establishment of a wetland conservation center	➢ WREA
(6) Water Quality Improvement (Drainage Canals) ♦ Presently, there is no regulation for domestic wastewater.	• Guideline on wastewater management of drainage canals (Details of the guideline is shown in a later subsection.)	➢ Dredging requirements ➢ Requirements of water quality monitoring ➢ Development of database ➢ Cooperation with DOE-WREA and MIC-DI	➢ MPWT
(7) Sanitary Improvement ♦ Septic tanks should be promoted in Vientiane. ♦ Appropriate management is indispensable for effective function of septic tanks.	• Guideline on septage management (Details of the guideline is shown in a later subsection.)	➢ Monitoring of installations in the buildings ➢ Performance requirements ➢ Requirements for administration and management ➢ Requirements for construction, installation and operation ➢ Education and dissemination	➢ MPWT
(8) Economic Regulation ♦ Study of its applicability to Lao PDR in the future	• (Model Guideline of economic regulations)	➢ Effluent charges to factories' wastewater ➢ Subsidies for the installation of treatment plants by factories	➢ WREA

(2) Management of Wastewater in the Drainage Canals

According to the Study results, the surface water along the urban drainage canals is deteriorating mainly due to domestic organic pollutants. This is due to the gray water or sometimes the black water which is flowing into the drainage canals without any treatment. The most realistic and quick solution for the problem is to expand the use of septic tanks as well as to promote proper management of domestic wastewater and septic tanks. Presently, the management framework of

domestic wastewater and/or septage (the combination of scum, sludge, and liquid that accumulates in septic tanks) is not developed yet. On the other hand, some industrial effluent at a certain point causes high value of COD/BOD of the drainage canal but this situation has been left for a long time even though the legal system is already developed to a certain extent. In this case, the most important issue is how to enforce the laws/regulations.

(a) Existing Laws/Regulations on Wastewater

Existing laws and regulations related to wastewater and effluent management are as shown below.

Table 4.18 Existing Laws/Regulations on Wastewater

Classification	Title	Description
Basic Law	Environmental Protection Law	–
EIA	Decree on Environmental Impact Assessment	–
Water Quality Standard	The Agreement on National Environmental Standards in Lao	It contains Surface Water Quality Standard and Wastewater Discharge Standard.
Industrial Effluent	Regulation on the Wastewater Discharge from Industrial Processing Factories	It prohibits discharging directly or indirectly into public water body wastewater that may have adverse impacts on ecology of water body, health of people or use of water.

In terms of solid waste management, which is closely related and similar to septage management, the following regulations and guidelines have been made.

1) Regulation on Business Registration of Solid Waste Transportation Service in Vientiane
2) Ministerial Regulation on Landfill Management for Public Health
3) Guideline on Household Solid Waste Management in Vientiane

If a transport company is reported to have done an illegal thing, it is asked to appear at VUDAA and warned. In the third time of warning the business license of the company is canceled. This penalty is conducted by the discretion of the Chief of the Solid Waste and Landfill Management Section, the responsible section of VUDAA.

(b) Problems on Wastewater

[Domestic Wastewater]

Presently, domestic wastewater is discharged from buildings to the canals virtually without any treatment although this is considered to be the main cause of the water quality deterioration of canals. Large buildings (hotels, restaurants, apartment houses, schools, government offices, etc.) can construct onsite treatment facilities for domestic wastewater. It is not realistic to require private houses to construct such facilities since they do not have enough land space, and to inspect each house for proper management. Thus, domestic wastewater from large buildings should be managed by the building owners themselves and that from private houses should be managed collectively by the government. In addition, the government should promote the education of the general public and dissemination of information on proper management of domestic wastewater at the source from the long-term viewpoint.

[Septage]

A standard design of septic tanks was approved in 1991 and included in DHUP's "Manual on Construction Regulations (1992)." This design is used as the standard design of septic tanks. It has three chambers and its size depends on the number of users. The same design standard is used for hotels, offices, dormitories, hospitals, etc., although the wastewater discharge standard is different. According to WSP, the manual is not necessarily effective for the installation of septic tanks due to the following reasons:

- The manual is not applied for the improvement of an existing building;
- The manual has the standard for construction design but not for operation and maintenance. Proper operation and maintenance are indispensable for the effective work of septic tanks; and
- There is no system for enforcing this decision to be complied by building owners such as inspection during or after the construction.

The problems on the operation and maintenance of septic tanks are:

(1) Some house owners do not properly desludge their septic tank. Sometimes they use the toilet without desludging for many years. Thus, black water flows into the drainage system without any treatment. WSP reported that a significant majority of the septic tanks surveyed had at most one 6–inch diameter desludging hole. It is assumed that this is done for ease of construction and subsequent reduction in construction cost. Thus, it is difficult for house owners to check the sludge accumulation in their septic tanks.

(2) Concerning the transport of septage, there is no regulation even though desludging companies are required to register their business at district offices. A company owner said that septage was illegally dumped in a public area because the dumping site had been moved to a very far place from the city center. WSP reported that there was evidence of indiscriminate and illegal dumping of septage in rural villages in the vicinity of Vientiane City.

An effective management framework is now required to be established, including the development of regulations/guidelines, as well as clarification of responsibility of parties involved.

[Industrial Effluent]

In terms of laws/regulations on industrial effluent, the Decree on EIA requires a certification which shows that the Environmental Management and Monitoring Plan (EMMP) has been approved. In addition, the Regulation on the Wastewater Discharge from Industrial Processing Factories stipulates water quality standards, inspection and penalty by the authorities concerned. It can be said that the legal system is already developed to a certain extent. The main issue here is how the laws/regulations can effectively be enforced.

(3) Proposed Domestic Wastewater Management Framework

Considering the problems mentioned above, the framework of domestic wastewater management is as summarized in the following table.

Table 4.19 Proposed Domestic Wastewater Management Framework

Responsible	Objectives	Activities
Private house owners	To reduce the discharge of wastewater	To minimize water use at each house
Large building (hotel, restaurant, apartment house, school, government office, etc.) owners	To treat domestic wastewater at source point	To construct onsite wastewater treatment systems (CBS/SBC, for example).
DPWT/VUDAA	To improve awareness of the general public on water quality	To promote environmental dissemination and education.
	To improve the water environment of canals	To dredge the canals periodically; To construct clustered treatment facilities for domestic wastewater from private houses.
	To enforce the regulation for onsite wastewater treatment systems	To require an onsite wastewater treatment system upon issuance of the building permit; To conduct inspection of the onsite wastewater treatment systems.
MPWT	To promote the construction of onsite wastewater treatment systems	To issue regulations for the onsite wastewater treatment systems.

(4) Proposed Septage Management

Septage management relates to many authorities as well as desludging/hauling companies and users. Activities and responsibilities of all the parties should be clarified at each step from desludging to final disposal for the effective management, as summarized below.

Dissemination of Septic Tanks: It is not realistic to force all houses, both newly built and existing ones, to install septic tanks in Vientiane, considering the present standard of living and the manpower of authorities. Even if the regulation is developed, it is unlikely that the regulation would be enforced effectively. Promotion of septic tanks should be started by improvement of awareness of the people or information dissemination. Their appropriate O&M should also be disseminated. Subsidy or soft loan to house owners should be taken into consideration for the installation of septic tanks in the future.

Guideline of Septic Tank Design: One of the major reasons why some house owners use toilets without desludging for many years is that it is very difficult to check the sludge accumulation in the prevailing design of septic tanks. An appropriate design which is easier to check should be devised.

Certification and Inspection of Desludging/Hauling Companies: Desludging/hauling companies should be registered and their work results also recorded in the database of the authorities. If it is reported that a company conduct an illegal thing, it should be inspected by DPWT. Building owners can select a good company through the database. It is expected that the bad providers will finally be excluded from the business.

Water Quality Monitoring: WREA Lab should monitor the quality of water in the drainage canals periodically to evaluate the effect of the management system. Support of foreign donors is required to conduct the periodical water quality monitoring, considering the present capacity of WREA Lab.

Compost Plant: It has been reported that desludging companies dump septage in public areas or sell it to farmers as fertilizer. Even if it is used as fertilizer, it should be processed and managed properly. Otherwise, it would cause a hygienic problem. Compost can be a solution for sanitary use of septage as fertilizer, as well as for preventing illegal dumping. Compost plants should be promoted and disseminated by DPWT with technical support by universities and NGOs.

(5) Enforcement of Industrial Effluent Laws/Regulations

Comparison of actual cases which recently caused a water pollution problem is useful for considering the effective way for enforcement of laws/regulations, and could lead lessons for future improvement.

- Cassava flour factory: After administrative instruction, the factory constructed enough facilities for treating its wastewater.
- Slaughterhouse: Highly polluted wastewater from the slaughterhouse is still discharged into public water body.

Some lessons from the two actual cases, a case where the countermeasure was quickly taken and another case where measures were not enough, could be learned. The most significant difference between the two is the presence of strong leadership inside the government. Therefore, the first key to the enforcement should be how to get the top of government to take a strong leadership. The second key is how to get government staff to start working casually even if the leadership of top government is not so strong. Possible measures can be summarized as follows:

- To improve awareness of the people on environmental issues by dissemination and education: If awareness of the people is improved it is easier for top government to take the leadership and also for the staff to start working. In addition, the mass media tend to carry the news as the news value increases.
- To develop detailed procedures, guidelines or manuals on the execution of laws and regulations: If such detailed manuals are developed, the government staff can start without asking their superiors for every step of work. Such manuals should be reviewed every time they are applied to improve the description and to avoid mismanagement.
- To evaluate staffs properly and to promote them based on the evaluation result: If the staff believe they will be promoted due to the work results, they are expected to have the motivation and the confidence on their work.
- To not only document the results of cases but also to share them to all government staff: The most significant problem here is that the lesson from the successful cassava case was neither analyzed enough nor communicated for coping with the other cases such as the slaughterhouse case.

(6) Proposed Regulations/Guidelines

Compared with the present legal development and the proposed domestic wastewater management framework, the proposed septage management flow, as well as the ideas on effective enforcement of industrial wastewater control, it has been clarified that drafting of the following guidelines and regulations should be prioritized to improve the water environment:

- Guideline on Wastewater Management by Vientiane
- Regulation on Desludging/Hauling Business Control by Vientiane

(a) Outline of Draft Guideline on Wastewater Management by Vientiane

Chapter 1 [Objectives of the Guideline]: Although water environment of drainage canals in the center of Vientiane has deteriorated with canal water turning dark or black and emitting bad odor, there is presently no regulation on wastewater management. This

guideline aims to contribute to the improvement of water environment of drainage canals before necessary laws or regulations are developed.

Chapter 2 [References]: There are several policies, laws and regulations concerning environment and water quality which have been enacted in Lao PDR. Since this guideline was compiled considering these existing laws and regulations, it is required to refer to them when how to apply and construe the guideline is not clear.

Chapter 3 [Domestic Wastewater]: Domestic wastewater is the main pollution source of the water quality in the canals. Therefore, the management of domestic wastewater is indispensable to the improvement of water environment in Vientiane. People living in private houses are recommended to reduce the water uses in various living scenes with various ways to reduce the wastewater. The owners of large buildings (offices, schools, shops, markets, hospitals, theaters, residences, hotels, or restaurants) are required to install a wastewater treatment system on the building site. On the other hand, the DPWT/VUDAA is required to make a plan of, and to manage the construction of a clustered wastewater treatment system to treat the domestic wastewater discharged from private houses.

Chapter 4 [Septic Tank and Septage]: Septic Tank is recommended as the black water treatment system, considering the present economic and social situations of Vientiane. In addition, poor management of septic tank and septage is also causing the deterioration of water quality in the drainage canals. Thus, promotion of appropriate management of septic tank and septage is also important for the improvement of the water environment in the drainage canals.

Chapter 5 [Industrial Wastewater]: The legal system is already developed to a certain extent. The main issue here is how the laws/regulations can effectively be enforced. Hence, the responsibilities and activities of relevant agencies are clarified and inspection, sanctions and public relations are stipulated.

Chapter 6 [Drainage Canals]: Accumulated sludge in drainage canals causes water quality deterioration and bad odor in addition to some inundations in the vicinity and thus, periodical dredging is one of the major points of management of drainage canals in the city center. Since the dredging exercise by the government authorities is not satisfied due to shortage of budget and manpower, participation of the people should be considered.

Chapter 7 [Wastewater Management Committee]: Since various stakeholders are related to the wastewater management, a committee shall be established to share the information and to conduct the management in an integrated manner among the stakeholders.

Chapter 8 [Glossary]: Important technical terms are explained here collectively for easier understanding of the text.

(b) Outline of Draft Regulation on Desludging/Hauling Business Control by Vientiane

Chapter 1 [General Principles]: This regulation aims to improve sanitation and water environment of urban areas with the proper control of desludging/hauling business as well as promote the sound development of desludging/hauling business to provide suitable services to users.

Chapter 2 [Business Certificate]: A desludging/hauling business entity is required to obtain a business certificate from the district office having jurisdiction over the area where the entity plans to do its main business.

Chapter 3 [Illegal Dumping]: Any person may report in writing to a government authority if he finds that illegal dumping has been made. The government authority may inspect the business entity concerned and ask it to present the hauling track records of all its vehicles for the purpose of clarifying the fact of the illegal dumping reported.

Chapter 4 [Punishment and Compensation]: If it is clarified through the hauling track record that a desludging/hauling business entity has committed illegal dumping, the business certificate of the desludging/hauling business entity shall be terminated and renewal of the business certificate shall not be permitted for one month. A desludging/hauling business entity which commits illegal dumping shall compensate the damage caused by the illegal dumping.

Chapter 5 [Database and Data Share]: The Department of Public Works and Transport shall maintain a database of the desludging/hauling business entities certified by the district offices in the city.

Chapter 6 [Disclosure]: The Department of Public Works shall disclose the database of desludging/hauling business entities to those intending to request desludging/hauling services. (Building owners can select a maintenance service provider through the database. It is expected that improper business entities will be finally excluded from the business.)

(7) Implementing Schedule

Items listed in the "Menu of Regulations/Guidelines to be Considered" should be implemented in stepwise basis. Implementation is recommended to follow the schedule shown below. Prioritized regulations/guidelines and those which support such measures including expansion of the Environment Protection Fund, training master plan and disclosure should be developed. In addition, those related to monitoring and WREA Lab also should be developed in the early stage of the master plan since they are the basis of all other water environment management activities.

Table 4.20 Implementing Schedule

Item	Time Frame		
	M/P (Until the year 2015)	M/P (Until the year 2020)	10 to 20 years after M/P
Budget	Expansion of the Environment Protection Fund	Expansion of the Environment Protection Fund	Expansion of the Environment Protection Fund
Human Resources Development	Development of guidelines on training master plan for related agencies; Preparation of the training master plan of WREA Lab	Preparation of training master plans of other related authorities; Execution of the training master plan of WREA Lab	Execution of the training master plan of other related authorities
Regulations/Guidelines	Development of prioritized regulation/guideline; Development of regulations and guidelines on water quality monitoring, and guidelines on water quality analysis	Development of other regulations/guidelines	Examination of economic or indirect approaches
People's Participation	Development of the regulation on environmental information disclosure	Execution of activities stipulated in the regulation such as establishment of database, issuance of annual report, etc.	Expansion of people's participation activities

4.4.4 Water Environment and Hygiene Education Promotion Plan

(1) Setup of Planning Objective

The planning objective of the water environment and hygiene education promotion plan (target year: 2020) as a component of the Master Plan has been setup, as follows:

Counterpart (C/P) agencies will implement water environment and hygiene education sustainably and broadly in Vientiane urban area with the cooperation of related organizations so that the awareness of citizens will be raised to behave in a good manner in their daily lives.

Coordination on the following subject matters has been considered in the setup:

- Strategy of the Master Plan of water environment improvement.
- "National Strategy on Environmental Education and Awareness to the year 2020 and Action Plan for the years 2006-2010" (issued by STEA, the predecessor of WREA, in 2004 with the support of SIDA).

(2) Formulation of Activity Promotion Roadmap

A practical activity promotion roadmap has been formulated as shown in **Tables 4.21** (Summary) and **4.22** (Detail) to accomplish the planning objective noted above taking the following subject matters into consideration. Responsible/implementing agencies in these activities are primarily the district education offices, and primary school teachers shall substantially perform those activities in cooperation with experienced PTI officials.

- Consistency with the phasing and alternatives of the structural measures in the Master Plan.
- Synergistic effect of the software and hardware by carrying out water environment and hygiene education (non-structural measures) for students and residents in line with the construction of wastewater treatment facilities (structural measures).
- Verification of its effectiveness, appropriateness, sustainability and potentiality by reflecting the experiences and lessons learned from the implementation of the pilot project.

Table 4.21 Activity Promotion Roadmap of Environmental Education (Summary)

Phasing	Activities	Target Area
Phase 1 (2010-2011)	TOT (training of trainers) based activities are conducted for the teachers, students and villagers in the 1st pilot school and community in line with SBS/CBS construction.	Hong Pasak and Hong Thong drainage areas
Phase 2 (2012-2015)	The 2nd pilot schools and communities will be selected. They will have TOT by trained trainers of the 1st pilot school and community to disseminate the activities in line with the construction of wastewater treatment facility.	Hong Ke and Hong Xeng drainage areas
	Related organizations will monitor and assist in the activities as well as carry out public relations services.	
Phase 3 (2016-2020)	Pilot schools and communities will gradually be increased, so that the activities will be implemented and expanded sustainably and broadly in line with the dissemination of wastewater treatment facilities.	Hong Ke and Hong Xeng drainage areas and other Vientiane urban areas
	Related organizations will monitor and assist in the activities as well as carry out public relations services.	

Table 4.22 Activity Promotion Roadmap of Environmental Education

Planning Objective to year 2020		Counterpart (C/P) agencies will implement water environmental and hygiene education sustainably and broadly in Vientiane urban area with the cooperation of related organizations so that the awareness of the citizens will be raised to behave in a good manner in their daily lives.		
Phasing			Activities	Target Area
Master Plan (until the year 2020)	Phase 1 (2010-2011)	1)	The cooperation with the C/P agencies and related organizations will be established through conducting the following activities in line with "National Strategy on Environment Education and Awareness to the year 2020 (2004)".	Hong Pasak and Hong Thong drainage areas (built-up Vientiane urban center with the most deteriorated water quality)
		2)	The 1st pilot school and community will be selected and awareness raising activities are conducted for the teachers, students and villagers there in line with SBS and CBS cnstruction.	
		3)	TOT (training of trainers) workshops with model classroom lectures and participatory activities will be conducted at the 1st pilot school and community to train potential trainers who are expected to promote the activities continuously.	
		4)	Through above TOT workshops, an educational side reader will be developed.	
		5)	PR activities by distributing the side reader will be conducted to disseminate the activity widely.	
		6)	The lessons learned from Phase 1 activity will be reviewed in order to implement next Phase 2 smoothly and sustainably.	
		7)	The capacity of the C/P to promote Phase 2 by themselves will be enhanced through above activities.	
		8)	The cooperation with the C/P agencies and related organizations will be strengthened through conducting above collaborative activities.	
	Phase 2 (2012-2015)	1)	The 1st pilot school and community established will continue the activity regularily with the assistance of related organizations.	Hong Ke and Hong Xeng drainage areas (built-up Vientiane urban areas)
		2)	The 2nd pilot schools and communities will be selected to disseminate the activities widely in line with the construction of wastewater treatment facility.	
		3)	The 2nd pilot schools and communities (primary school teachers and key villagers) will be trained by the trained teachers and villagers of the 1st pilot school and communitiy.	
		4)	Above newly trained trainers will promote activities in their 2nd pilot schools and communities.	
		5)	The relevant agencies will monitor and assist the above activities as well as conduct PR activity in collaboration with the relevant organizations.	
	Phase 3 (2016-2020)	1)	Pilot schools and communities will gradually be increased in a strategic manner with the same methodology in the Phase 2, so that the activities will be implemented and expanded sustainably and broadly in line with the construction of wastewater treatment facility.	1) Hong Ke and Hong Xeng drainage areas 2) Other surrounding urban areas to be developed
		2)	The relevant agencies will monitor and assist the above activities as well as conduct PR activity in collaboration with the relevant organizations.	
10 - 20 years after Master Plan		1)	The activity achievement and the lessons learned until 2020 will be reviewed in order to start next step activity smoothly and sustainably.	All the built-up Vientiane urban areas
		2)	Pilot schools and communities will continuously be increased so that the educational activities will be implemented and disseminated sustainably and broadly in the target area.	

4.4.5 Action Plan

A two-phased 5-year action plan shall be formulated for smooth implementation of the master plan components, and the rolling plan system shall be employed. After completion of the 1st phase action plan, its results shall be evaluated and some modification shall be made in the 2nd phase action plan based on the evaluation due to rapid changes of socioeconomic situations surrounding the projects. The following table summarizes a phased action plan.

Table 4.23 Water Environmental Management Action Plan

Components	1st Phase Action Plan	2nd Phase Action Plan
Structural Water Improvement	(1) Finding funding donors for installation of SWTP with local interceptors (2 Detailed design and installation of simple wastewater treatment plants (SWTP) with local interceptors in Hong Pasak (3) Finding funding donors for in-stream treatment facilities (4) Implementation of in-stream treatment plant construction in Nong Chanh (5) Detailed survey and study on appropriate countermeasures for water quality improvement in other drainage canals	(1) Review of appropriate countermeasures for remaining drainage canals based on monitoring results (2) Installation or application of appropriate measures for drainage canals, if necessary (3) Implementation of conservation of remaining marshes, if necessary
Evaluation of Progress	(1) Checking progress in SWTP installation (2) Periodical monitoring on drainage canals and remaining marsh situations	(1) Checking operational status of SWTP (2) Checking status of water quality improvement from monitoring results
Implementation Agencies	PTI, DPWT,WREA	
Institutional and Legal Improvement	(1) Expansion of regulation on environment protection fund (2) Development of guidelines on training master plan for related agencies (3) Formulation of training master plan of WREA Lab (4) Development of prioritized regulation/guidelines (5) Development of regulations/guidelines on water quality monitoring, and guidelines on water quality (6) Development of regulations on environmental information disclosure	(1) Expansion of environment protection fund (2) Formulation of training master plans of related agencies (3) Training activities for WREA Lab (4) Development of regulations/guidelines on other measures (5) Execution of activities stipulated in the regulations such as establishment of database, issuance of annual report, etc.
Evaluation of Progress	Checking development process in above system	Checking of development process in above system
Implementation Agencies	MPWT, WREA	
Environmental Education	(1) Environmental education activities as a pilot project (2) Conducting training of trainers (TOT) (3) Environmental education activities in increased model communities in line with the construction of wastewater treatment facilities	(1) Conducting training of trainers (TOT) (2) Environmental education activities in increased model communities in line with the construction of wastewater treatment facilities
Evaluation of Progress	Monitoring progress of people's awareness and participation	Monitoring progress of people's awareness and participation
Implementation Agencies	PTI, District Education Offices	

All of the related government agencies recognize the importance of water environment improvement. The situations in budgetary allocation, however, are not favorable, particularly, the budgetary constraints to construct necessary facilities. Thus the budget related to water environment improvement shall be allocated effectively to the core agencies/actors, such as PTI, MPWT and so on. Furthermore, various donors and international NGOs are keen on supporting the environmental improvement activities and projects, so that the government agencies should implement the related projects effectively by referring to the above action plan and by avoiding the overlapping of projects, and should conduct monitoring activities and legal system improvement, simultaneously.

CHAPTER 5. PRE-FEASIBILITY STUDY

5.1 Background, Study Objectives and Selection of Study Area

5.1.1 Background and Study Objectives

The Draft Master Plan for Improvement of Water Environment in Vientiane City has given the Community Based Sanitation (CBS) the highest priority among the possible countermeasures for wastewater treatment systems. For the period of June to December 2010, one CBS in Thonkankham Village and one SBS (School Based Sanitation) in Khualuang Primary School have been constructed as pilot projects.

Under the above-mentioned situation, the pre-feasibility study (Pre-F/S) has been conducted for smoothly extending the CBS coverage and achieving efficient wastewater improvement through the installation of CBS/SBS. The study objectives were:

(1) To collect information on the present sanitary conditions and communal sewer conditions to discuss the improvement direction of sanitation as well as water environment;

(2) To propose suitable measures to keep a good balance between sanitary improvement in a household level and improvement on water environment along the drainage canal;

(3) To set up remedial measures against water quality deterioration of surface water along the selected drainage canal in conformity with the site conditions; and

(4) To propose a realistic approach to popularize the above measures to the drainage basin in near future.

5.1.2 Selection of Study Area

The study area shall be selected paying attention to the following criteria:

(1) Urgency: Seriously deteriorated water quality in the canal;

(2) Remediable possibility: Easy installation of countermeasures;

(3) Immediate appearance of improvement effects: Small catchment or uppermost of the drainage system; and

(4) Visibility of improvement effects: Noticeable improvement to the citizens.

In due consideration of the above criteria, the drainage basins of Hong Pasak and Hong Thong were selected as the most seriously deteriorated canals in Vientiane. Through a comparative study between the two basins, the Hong Pasak drainage basin was selected as the priority area for the pre-feasibility study.

As for the Hong Pasak drainage basin, the upper part was set up as the study area (see **Fig. 5.1)** in due consideration of the possible study period, available human resources and suitable scale of implementation. As a result, Sub-drainage Basins 12 and 13 were selected for the Pre-F/S. As tabulated in **Table 5.1**, the selected study area makes up 34% in area and 42% in population of the entire Hong Pasak drainage basin.

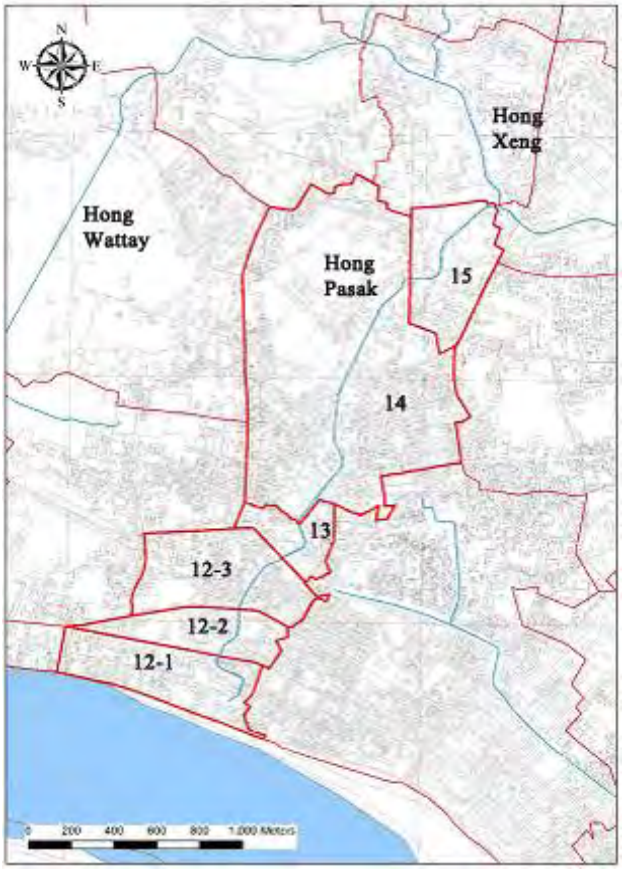


Fig. 5.1 Hong Pasak Drainage Basin

Table 5.1 Sub-Drainage Basin and Population in Hong Pasak Drainage Basin

Sub-Drainage Index	Drainage Area (km^2)	Population in 2009	Remarks
12-1	0.24	1,368	Drainage Area: 34% Population: 42%
12-2	0.15	1,147	
12-3	0.28	2,407	
13	0.10	847	
Sub-Total	0.77	5,769	Total Area for Pre-F/S
14	1.24	6,971	
15	0.23	865	
Basin Total	2.24	13,605	

5.2 Sanitary Conditions in the Priority Area

5.2.1 Sampling Data

A total of 856 houses/buildings were collected as samples by sub-contract work. The breakdown of data are as summed up in the table below in accordance with type of sanitary facilities; namely, toilet type. The collected samples cover around 90% of the entire houses/buildings in the target area based on ocular examination. Furthermore, the population coverage of 85% was estimated by comparing the figures of population in **Tables 4.1** and **4.2** (= 4,878/5,769). Based on the results, the samples cover 85 to 90% of all houses/buildings in the target area.

Table 5.2 Sampling Data from the Upper and Middle Reaches of Hong Pasak

	Sanitary Facilities	Houses/Buildings		Number of Residents
		Number	Percentile	
Residential House	Soak Pit	364	57	3,295
	Septic Tank	271	42	
	Others	6	1	
	Sub-Total	641	100	
Commercial Building	Soak Pit	88	41	1,583
	Septic Tank	116	54	
	Others	11	5	
	Sub-Total	215	100	
Total	Soak Pit	452	53	4,878
	Septic Tank	387	45	
	Others	17	2	
	Total	856	100	

5.2.2 Sanitary Conditions

As tabulated in **Table 5.2**, significant differences in sanitary condition could not be recognized between residential house and commercial building. The installation ratio of soak pit or septic tank is similar to around 50% each in residential houses as well as commercial buildings. One of the reasons might be that respondents do not have enough knowledge about the differences between a soak pit and a septic tank in terms of principal features and the treatment process of human waste. As a whole, sanitary conditions in the area were clarified, that 98% of households and buildings have some kind of toilet.

5.3 Possibilities of Improvement on Water Environment

Examined in the sub-contract survey and site inspection were the possibilities of water environment improvement through the installation of small-scale wastewater treatment systems such as SBS and CBS. After a detailed site survey, it was clarified that a simple wastewater treatment plant with local interceptors to collect wastewater from lateral drains is the most suitable water environment improvement measure, since a lateral drainage network was already installed through the preceding project of UNHABITAT.

5.3.1 Preliminary Design

(1) Location of Wastewater Treatment Plants and Interceptors

Based on the survey results, **Fig. 5.2** summarizes the location of eight wastewater treatment plants and their interceptors.

(2) Preliminary Design of WTP and Interceptors

The wastewater treatment system along Hong Pasak consists of three components: (1) wastewater treatment plants (WTP), (2) interceptors (including discharging pipes from WTPs) and (3) control boxes.

The WTPs employs an anaerobic treatment method which consists of 3 processes (sedimentation tank, anaerobic reactor and anaerobic filter), with design conditions and typical cross section as shown in **Table 5.3** and **Fig. 5.3**.

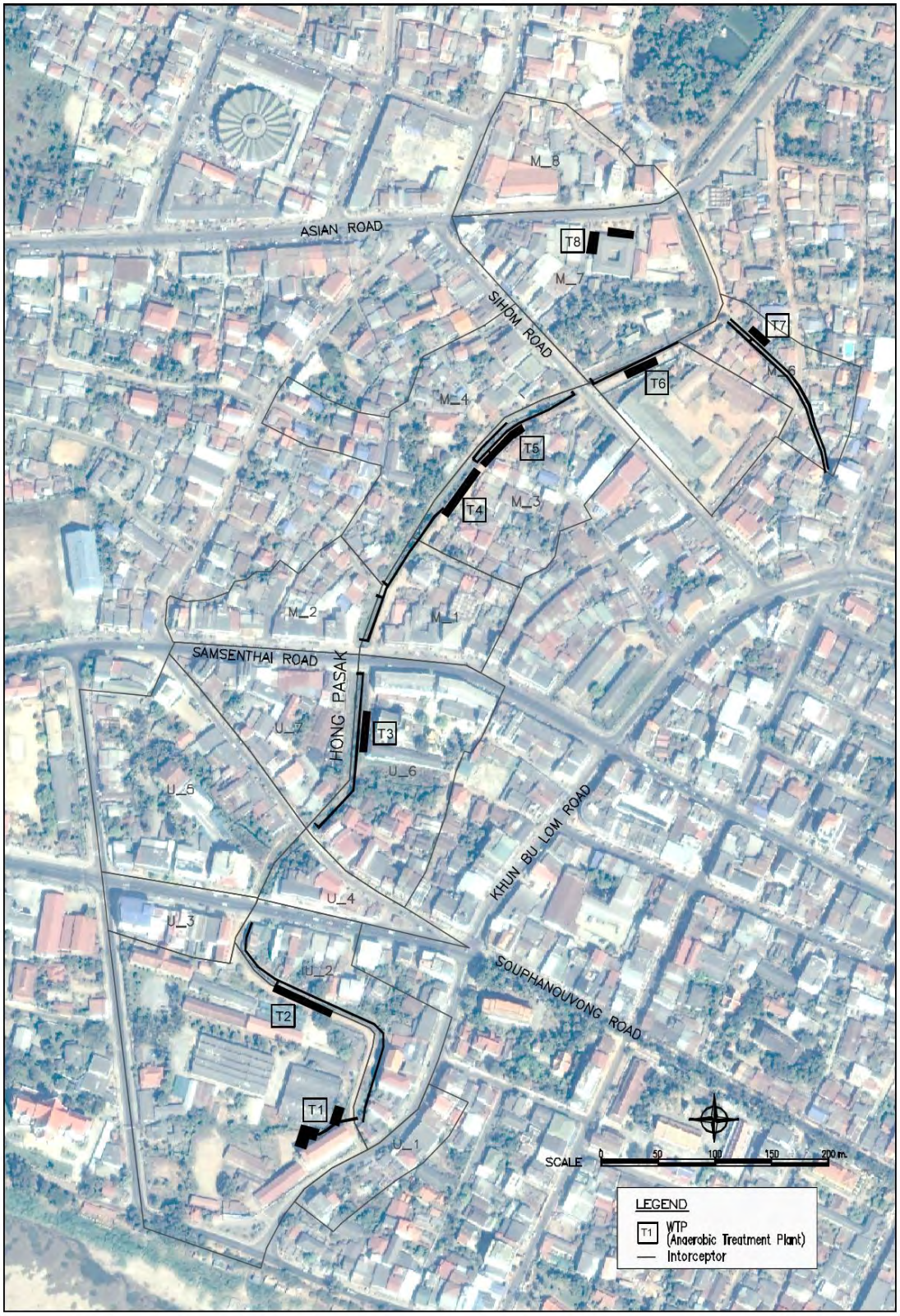


Fig. 5.2 Locations of WTP and Interceptor

Table 5.3 Design Conditions for WTP

Item		Unit	Description	Remarks
Wastewater per capita (Daily maximum)	Pakpasak College	l/d/person	230	1)
	Others		270	2)
Design HRT (Hydraulic retention time)	Sedimentation Tank	hr	12	
	Anaerobic Reactor	hr	24	
	Anaerobic Filter	hr	12	
	Total	hr	48	

1) 170 l/d/person / 0.75 = 230 l/d (assumed ratio of daily average/daily maximum is 1/0.75)
2) 170 l/d/person x 1.2 (including commercial wastewater) / 0.75 = 270 l/d

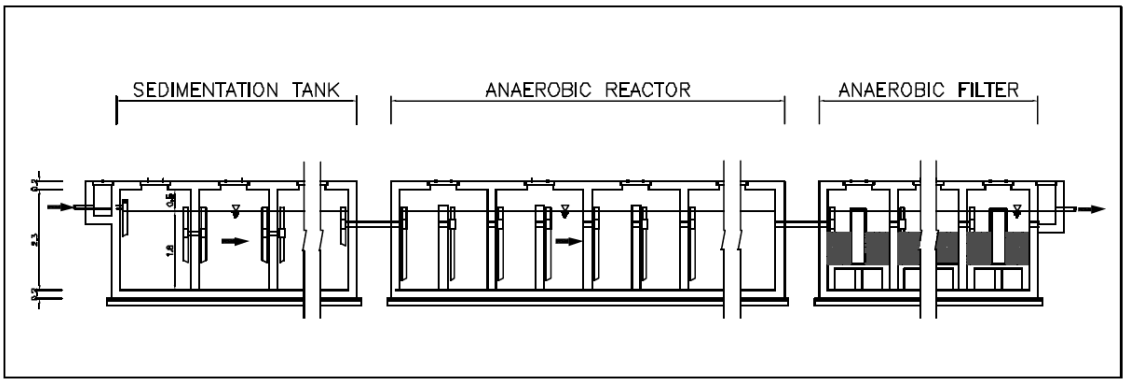


Fig. 5.3 Typical Cross Section of WTP (Anaerobic Treatment Plant)

As a reference, the plan and typical section of two WTPs (T1 and T5) are presented in **Fig. 5.5** to **5.6**.

5.3.2 Water Quality Improvement Effects

Effects by water quality improvement were evaluated using the water quality model. The evaluation was made under the following conditions:

(1) WTPs cover 80% of the core area where wastewater is discharged directly, and 10% of fringe area in population;

(2) Installation rate of septic tank is set at 100%; and

(3) BOD removal rate of WTPs is set at 85%.

Fig. 5.4 presents the estimated water quality (BOD) along Hong Pasak with/without WTPs in the target year 2020. According to the figure, BOD in the area along Hong Pasak will be reduced to about 10 mg/l.

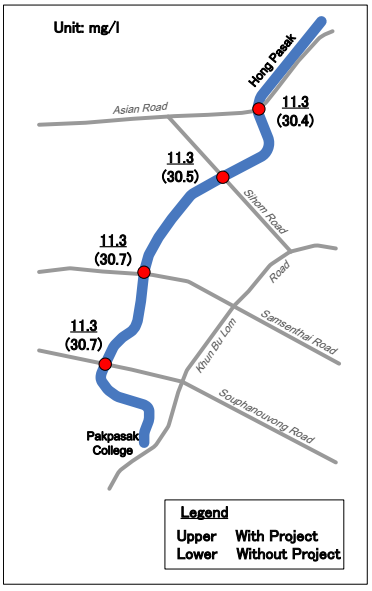


Fig. 5.4 BOD Estimated With/Without Project

5.3.3 Cost Estimate

The total cost of the wastewater treatment system estimated in the Pre-Feasibility Study is about 1.28 million US dollars as shown in **Table 5.4**.

Table 5.4 Cost Estimate for Wastewater Treatment System in the Pre-F/S Area

Unit: US dollar

	WTP	Interceptor	Control Box	Total	Remarks
Direct Cost					
T1	177,185	6,000	520	183,705	
T2	111,715	15,600	780	128,095	
T3	72,640	12,000	780	85,420	
T4	96,430	10,800	715	107,945	
T5	96,430	10,800	715	107,945	
T6	65,040	6,000	455	71,495	
T7	43,495	21,000	1,170	65,665	
T8	119,320	3,600	390	123,310	
Others [1)]	111,715	0	0	111,715	
Total	893,970	85,800	5,525	985,295	
Indirect Cost (30% of Direct Cost)				295,590	
Grand Total				1,280,885	

[1)] Contingency equivalent to construction cost of WTP with capacity of 80 m^3/day

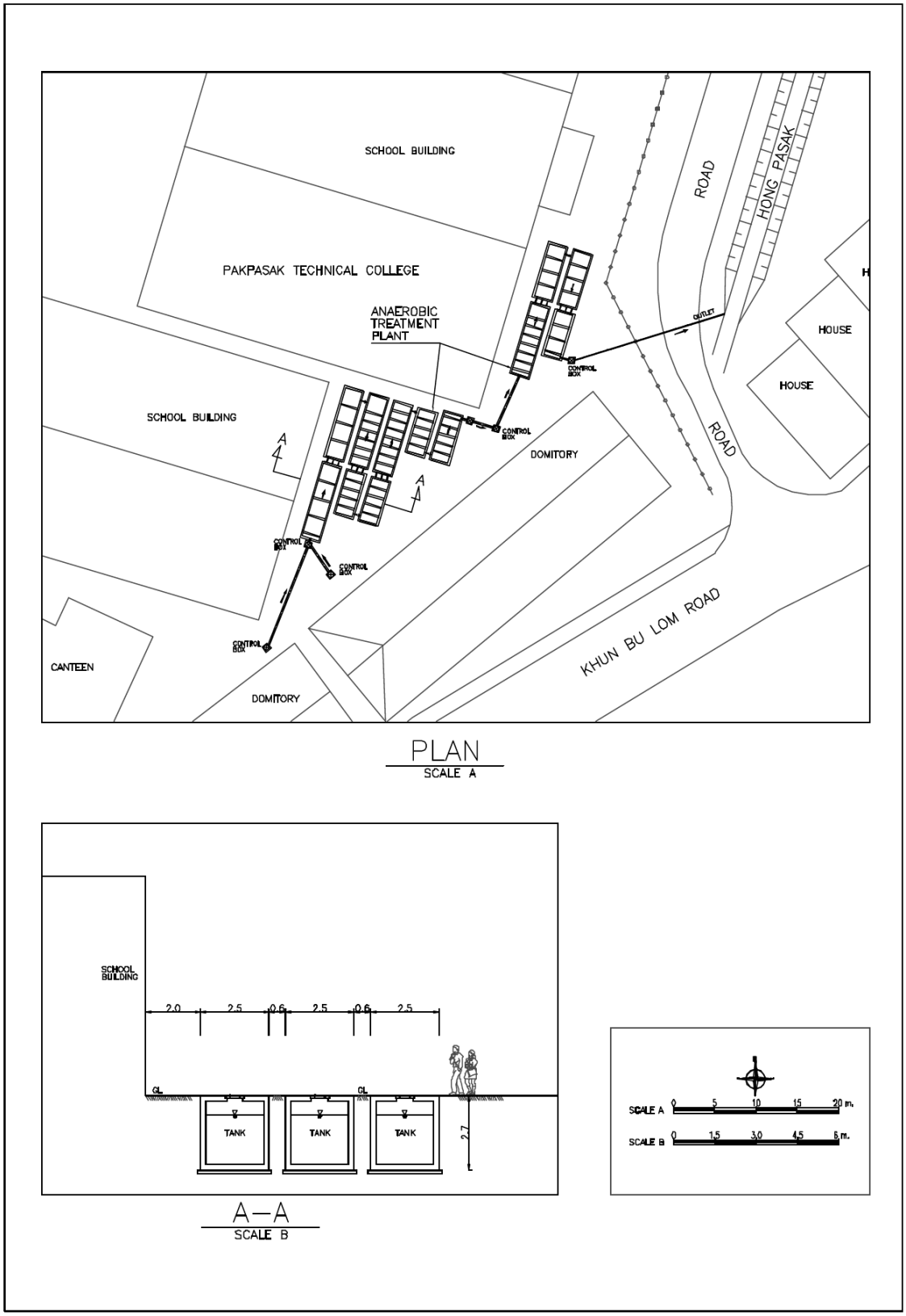


Fig. 5.5 Plan and Typical Cross Section of WTP (T1)

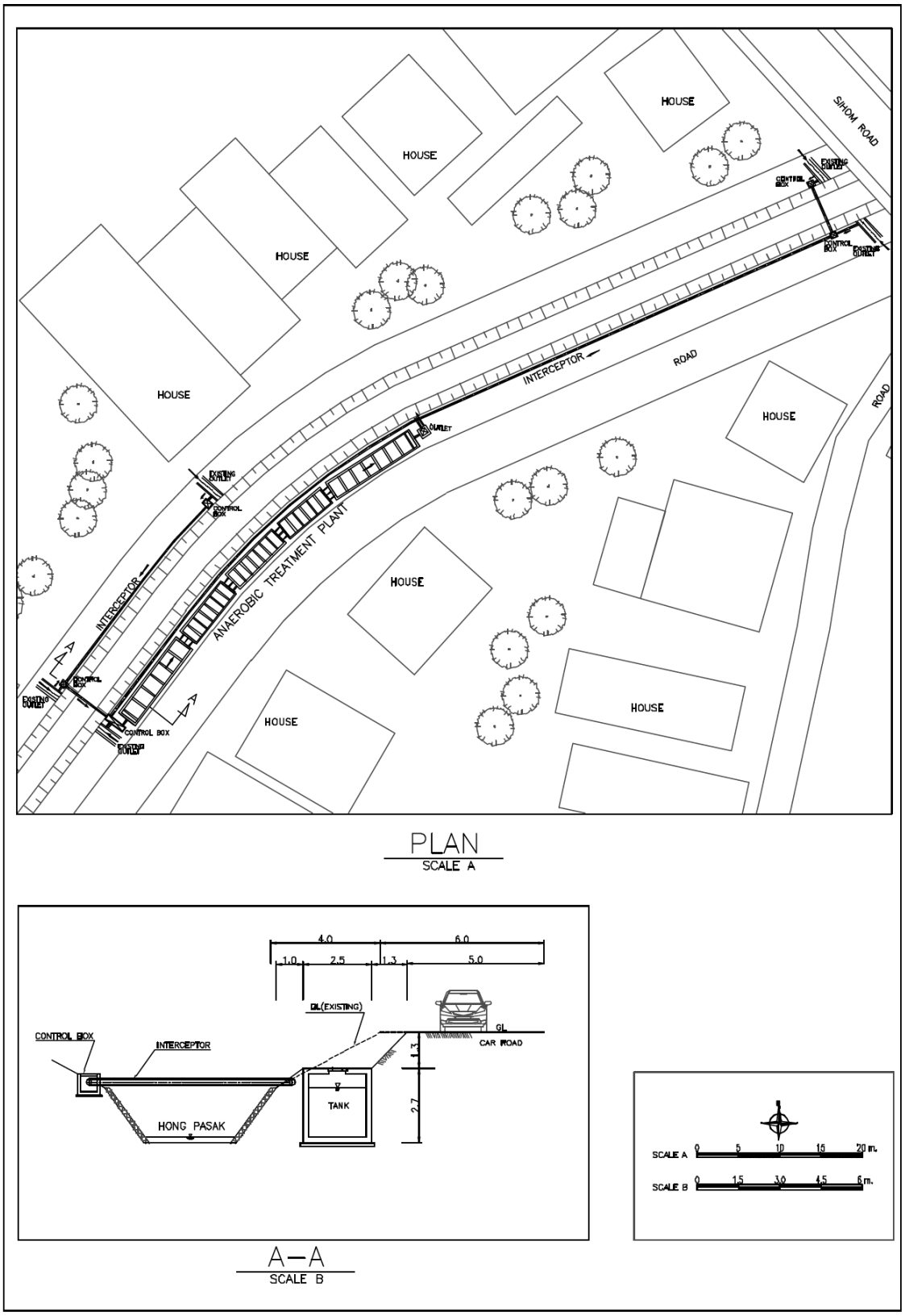


Fig. 5.6 Plan and Typical Cross Section of WTP (T5)

CHAPTER 6. RECOMMENDATIONS

In the course of the study period of 30 months, various points and issues have been clarified. Most of these issues were incorporated in the Master Plan as the issues to be solved or improved.

Urbanization in Vientiane City has progressed rapidly, and as a result the natural environment in urban areas has deteriorated simultaneously. Fortunately, however, the remaining natural environment still remains remediable. However, it is urgent to conserve the remaining ones and to restore the lost ones to their functional state. The issues are summarized below, together with the proposals to resolve them, and it is expected that these will be implemented in order to attain the desired improvement of the water environment in Vientianne.

(1) Early Implementation of Proposed Structural Water Environment Improvement Plan

Rapid urbanization in Vientiane has been progressing in a very fast pace. As repeatedly described, water environment improvement measures shall consist of integrated manmade treatment facilities combined with the natural purification function of marshes, ponds and rivers as natural assets to Vientiane people from the physical improvement viewpoint. In this regard, the first step of improvement works consisting of information and educational campaign as well as publicity shall be started as early as possible to boost the understanding of all entities concerned on the importance of conserving the precious environment. The process could be viewed as the enhancement of people's awareness on water environmental improvement.

(2) Prevention of Concrete Covering of Drainage Canal Systems

The Hong Thong canal receives wastewater and rainwater from the most congested areas of Vientiane, similar to Hong Pasak. Hong Thong joins with Hong Khoua Khao near the Nong Chanh Marsh, and then changes its name to Hong Ke.

Hong Thong is covered with concrete slabs in almost all its stretches. Although concrete covering is one of the alternatives to make people look away from the offensive odor and the deteriorated scenery of the worsened water quality, the difficulty of improving the water environment will come out due to the invisibility of the existing condition of water quality as well as the inability of conducting improvement works and monitoring their effects. Under the present circumstances, conducting the possible improvement measures for water environment in a step-by-step manner is recommendable rather than removing the deteriorated environment from the urban residents' eye.

(3) Conservation of Marshes/Wetlands

Wastewater discharged from the urban areas flows down through the drainage system to the That Luang Marsh. The Mak Hiao River receives the surface water from the marsh, runs through the Na Khay Marsh and various pond stretches, and finally joins the Mekong mainstream. Even with the natural purification function of wetlands and ponds along the river course and the dilution by natural runoff and irrigation tail water, the BOD concentration of 3 mg/l could still appear at the river mouth of Mak Hiao even in the year 2020, although this BOD concentration is still regarded as good water quality.

Rapid urbanization, however, has been progressing in/around the That Luang Marsh, so that it is urgent to conserve the marsh areas and to restore their natural water purification function from the urbanization of Vientiane. The remaining marshes in the urban areas, such as Nong Chanh, Nong Bo, and Nong Tha, shall be conserved as well. Unless such urgent conservation measures are

taken, a similar urbanization process where wide existing marshes were reclaimed into urban areas in the past would occur in the remaining marshes in Vientianne.

(4) Strengthening of Administrative Guidance

There are noticeable water pollution sources in the Study Area. Some small-scale enterprises discharge highly polluted wastewater, and the neighboring residents complain of the offensive odor and accumulated sludge. Therefore, the strengthening of administrative guidance by the responsible agency is necessary to solve such issues.

The various enterprises have to follow the effluent standards through the installation of proper devices for wastewater treatment and by following the administrative guidance religiously. To attain the situation of clean water quality, efforts by various stakeholders such as residents and government organizations alike are indispensable. Through these well-functioning efforts, the related governments would gain high reliability from the residents.

(5) Strengthening of Monitoring Activities and Maintenance of the Drainage Network

A major part of the drainage canals had been improved with concrete lining, mainly with support from the Asian Development Bank (ADB) in the 2000's. However, sediment had accumulated on the bottom of canals due to inflow of sediment with small particles from the surrounding areas, and various plants have also grown on the accumulated sediment. These plants have some purification functions against water quality deterioration composed of acceleration of settling of suspended solids and contact oxidation by bio-film attached to the plants.

The City Government of Vientiane as administrator of the drainage canal system shall be able to conduct maintenance work on the drainage system without any donors' technical and financial support. The management work shall consist of (a) dredging/removal of accumulated sediment from the bottom of canals, if necessary; (b) proper management of vegetation in the canals based on site monitoring in due consideration of their natural purification functions; and (c) clarification of encountered issues based on periodical water quality monitoring in cooperation and coordination with WREA.