In the above figure, the green areas are reserved areas, set aside for forest, swamp, and paddy fields. The green area was defined by the Vientiane Urban Development Master Plan (VUDMP) and these areas will not require water supply and are excluded from the future service area.

In Thangone and Thadeua, there are small scale existing treatment plants and these service areas will be consolidated during the 2nd Stage, since these existing treatment plants are very small scale and their capacity will not be able to meet future water demands in the respective area.

4.4 Water Demand Projection

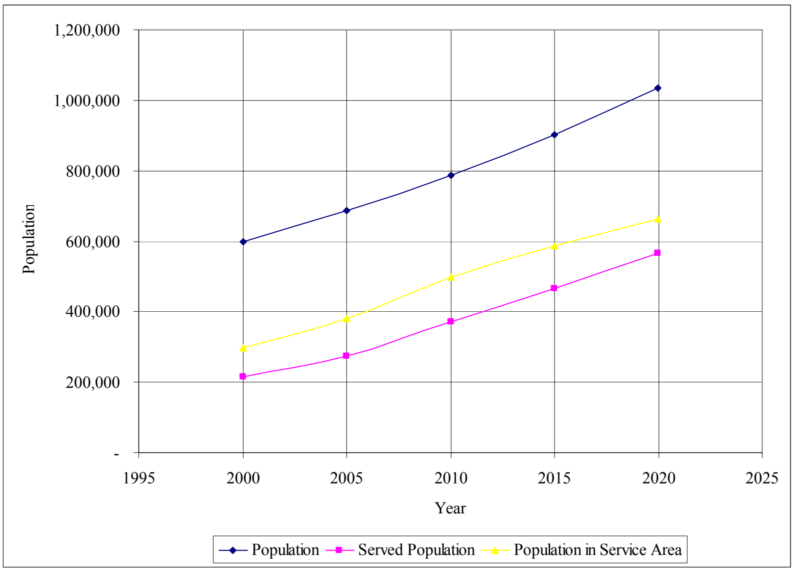
4.4.1 Domestic Water Demand

Future domestic water demand is calculated from the served population and the per capita water consumption. The served population is calculated from the total population and the service ratio of respective villages. The service ratio is estimated from the existing service ratio and expansion of the service area mentioned above. The service ratio and the calculated served population in the respective villages are shown in Annex. Table 44-1 and Figure 44-1 show a summary of the population, served population and population in service areas which is the total population of villages included in the service area.

Table 44-1 Future Population and Served Population

Year	2000	2005	2010	2015	2020
Population	599,000	687,084	788,165	902,716	1,034,521
Served Population	215,522	275,567	370,269	466,981	564,648
Population in Service Area	297,575	380,342	499,737	586,710	662,441

Figure 44-1 Future Population and Served Population



From the total population and the served population, which is the calculated respective service ratio in each village, the average service ratios in the capital city and service areas are calculated as shown in Table 44-2 and Figure 44-2.

Table 44-2 Average Service Ratio in Capital City and Service Area

	2000	2005	2010	2015	2020
Service Ratio in Capital City	36%	40%	47%	52%	55%
Service Ratio in Service Area	72.4%	72.5%	74.1%	79.6%	85.2%

Figure 44-2 Average Service Ratio in Capital City and Service Area

As shown in the figure above, the service ratio in service areas will increase slowly until 2010 because of expansion of the service area, which means there will be an increase of the total population in the service area. The service ratio in the service area will reach about 80 % in 2015, which is the target service ratio of the urban development plan.

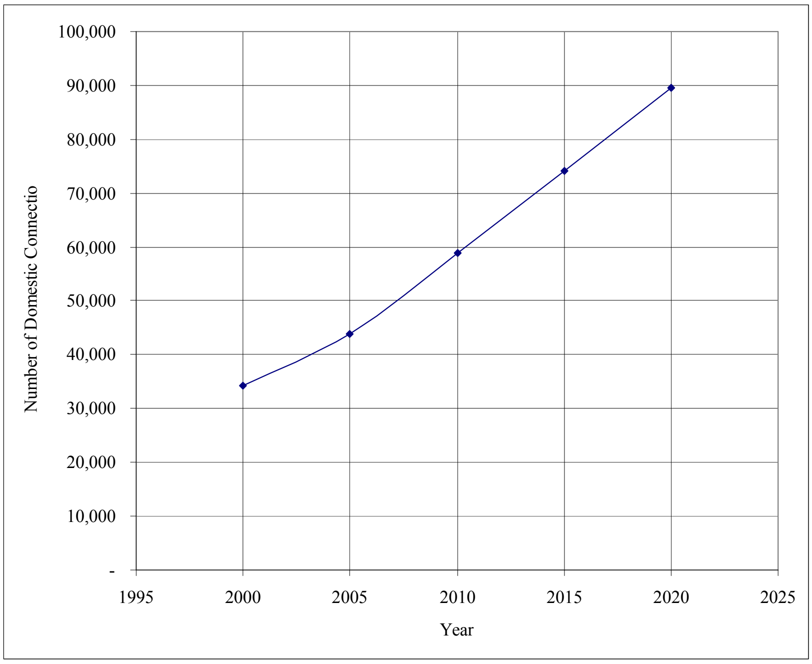
Household size was obtained from the results of a survey carried out by NPVC meter readers and a household survey conducted by the JICA Study Team. The average household size is 6.3 people per family and this figure is used in the master plan.

From the served population, the number of domestic connections was obtained, as shown in Table 44-3 and Figure 44-3. This number was reached by dividing the served population by the household size, 6.3. The incremental number of connection increases is in the range of 9,500 to about 15,000 per five years and therefore the annual increase of domestic connections is in the range of 1,900 to 3,000. From the past records of house connection increases, the annual average connection increase is about 3,000 and the expected connection increase is within the past experiences of the NPVC.

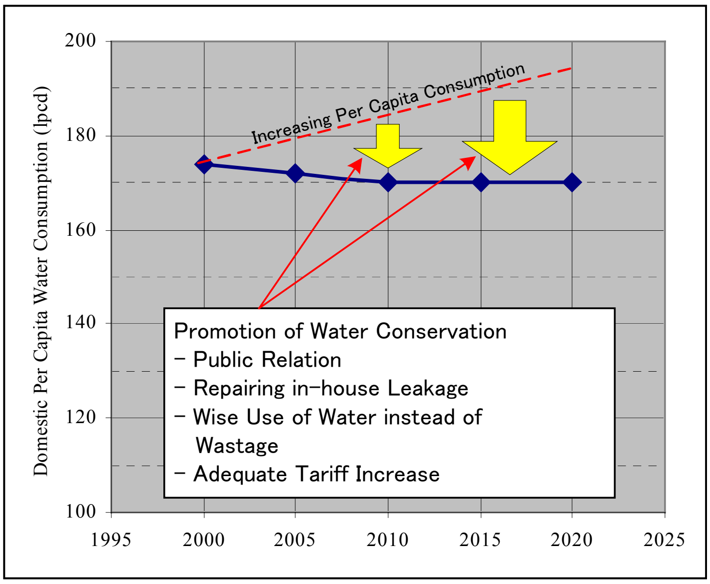
Table 44-3 Number of Domestic Connection

	2000	2005	2010	2015	2020
Number of Domestic Connection	34,210	43,741	58,773	74,124	89,627
Incremental (per 5 years)		9,531	15,032	15,351	15,503

Figure 44-3 Number of Domestic Connection



Domestic per capita water consumption, 174 lpcd, was calculated from the data of past water consumption as described in the previous chapter. The per capita water consumption might be rather high compared with statistics of other Southeast Asian countries, and in this master plan, the per capita water consumption is assumed to be lower than the current figure, although the per capita water consumption would usually be expected to increase in the future according to the upgrading of living standards as shown on right figure. In the master plan, the per capita consumption in 2005 is planned to be 172 lpcd and 170 lpcd after 2010. The basis of assuming a decreasing per capita consumption in the future is as follows:



- According to the results of household survey by the JICA Study Team, 22.7 % of household have in-house leakages and these in-house leakages will be repaired by promoting public relation activities by the NPVC.
- According to the results of the household survey, 90.7 % households which are connected to the public water supply services, replied that they aware of the necessity for water conservation, and the effect of water conservation in reducing the per capita water consumption.
- There will be effects on the per capita water consumption caused by periodic tariff increases.

Projections of the served population, per capita water demand and domestic water demand is as shown on Table 44-4.

Table 44-4 Served Population, Per Capita Water Demand and Total Domestic Water Demand

	2000	2005	2010	2015	2020
Served Population (person)	215,522	275,567	370,269	466,981	564,648
Per Capita Consumption (lpcd)	174	172	170	170	170
Total Domestic Demand (m3/day)	37,501	47,398	62,946	79,387	95,990

4.4.2 Non-Domestic Water Demand

Table 44-5 shows the past record of non-domestic water consumption from 1996 to 2003. As shown in the table below, the past annual average increase rate for this group was 4.04 %.

Table 44-5 Past Record of Non-Domestic Water Consumption

	1996	1997	1998	1999	2000	2001	2002	2003
Non-Domestic Water Consumption (x1,000 m3/year)	9,490	9,398	10,311	10,362	11,294	11,702	12,111	12,519
Annual Average Increasing Ratio								4.04%

According to the urban development plan of Vientiane Capital City, a new industrial area is planned in the eastern central part of the capital city and will occupy about 3,000 ha. The access road to the industrial area is already constructed and the Vientiane Capital City is promoting development in the area. Furthermore, construction of a railway from the Friendship Bridge to the industrial area is planned. Non-domestic water consumption, not only for the new industrial area, but also in the existing industrial areas is estimated to increase by at a higher rate than the past rate of increase..

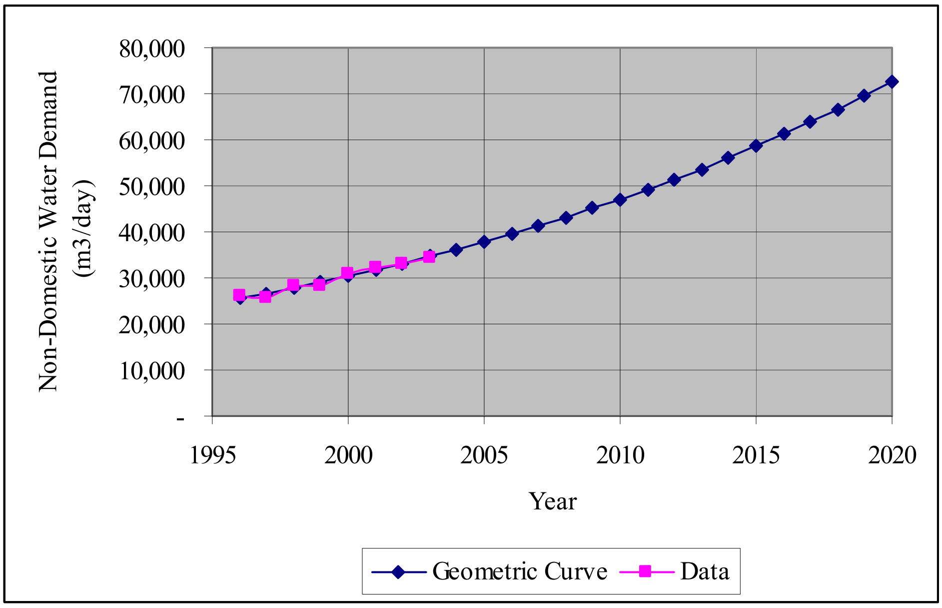
Non-domestic water demand will include demand from commercial businesses and other, institutions. Water demand for these categories will grow according to the increase in population and industrial development.

For the projection of non-domestic water demand in the future, the study team applied a geometrical curve and the rate of increase was calculated to be 4.47 %. The results of the calculations shows a slightly higher ratio than the past increase rate, 4.04 %. Table 44-6 and Figure 44-4 show future non-domestic water demand calculated from the geometrical curve.

Table 44-6 Future Non-Domestic Water Demand

	2000	2005	2010	2015	2020
Non-Domestic Water Demand (m3/day)	30,361	37,780	47,011	58,499	72,793

Figure 44-4 Future Non-Domestic Water Demand



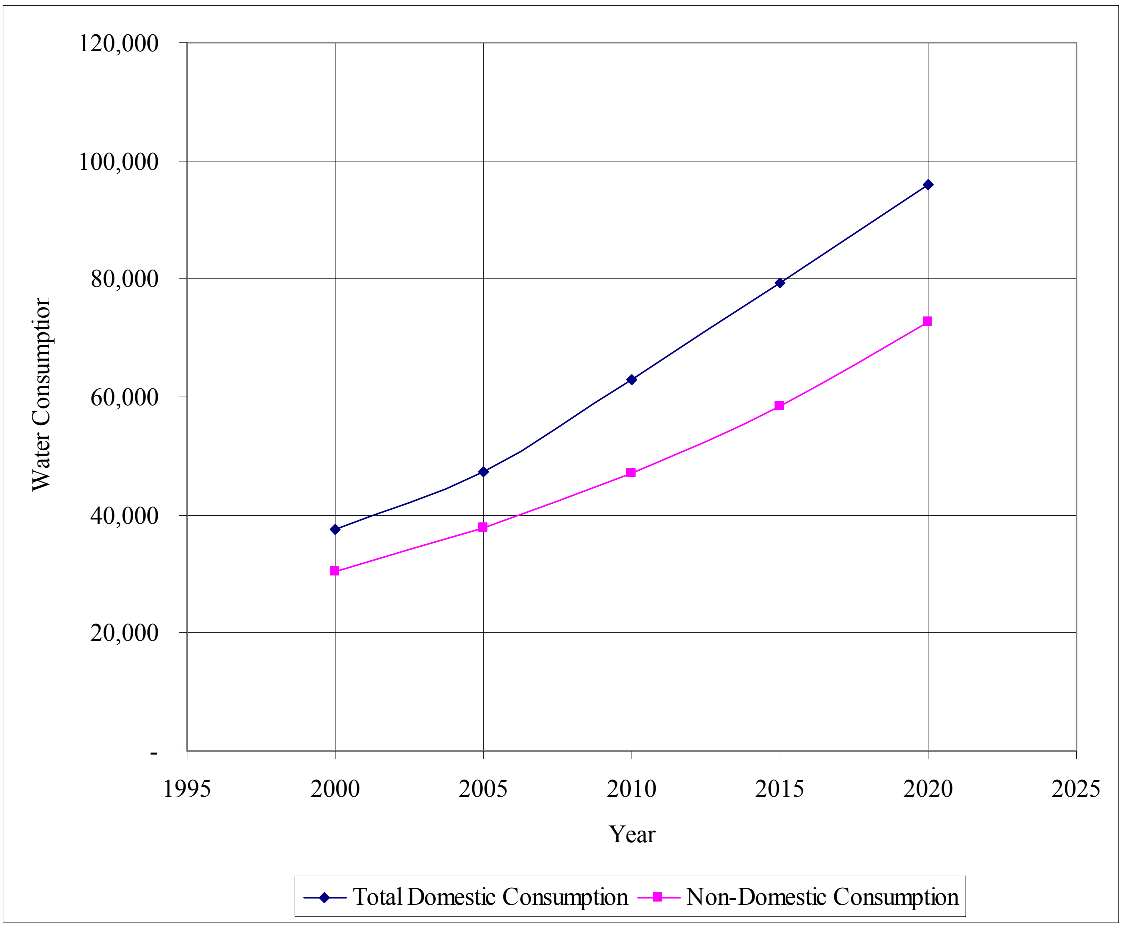
4.4.3 Total Water Demand

Total water demand is calculated from the summation of domestic and non-domestic water demand. Total water demand is as shown on Table 44-7 and Figure 44-5.

Table 44-7 Total Water Demand

	2000	2005	2010	2015	2020
Total Domestic Demand (m3/day)	37,501	47,398	62,946	79,387	95,990
Non-Domestic Demand (m3/day)	30,361	37,780	47,011	58,499	72,793
Total Water Demand (m3/day)	67,862	85,177	109,957	137,885	168,783

Figure 44-5 Domestic and Non-Domestic Water Demand



The daily average water demand is calculated from the total water demand shown above, and the future unaccounted-for water rate. As described in the proceeding section, the unaccounted-for water rate will be reduced from 33% in 2000, 28% in 2005 and 25% after 2010. The definition of unaccounted-for water (UFW) is difference between total water quantity of distributed and total water quantity of metered at customers' connections. Therefore, water quantity equivalent to water bill which is not paid by customer is not included in the UFW. Needless to say, the water quantity which is not paid by the customer should also be reduced as reduction of the UFW.

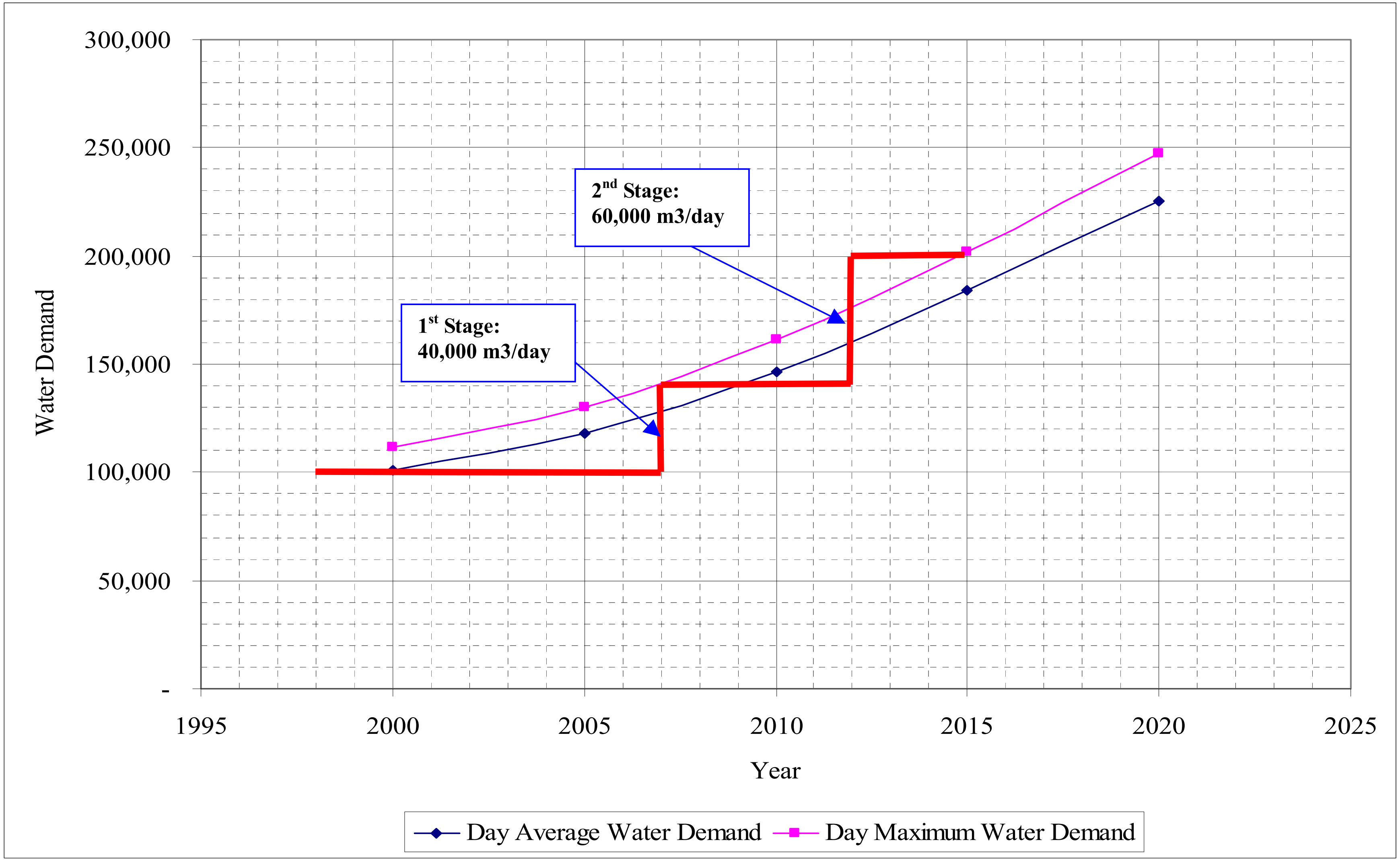
Peak factor, which is the ratio of daily maximum water demand and the daily average water demand is calculated as 1.1 from the records of water distributed from two the existing treatment plants in 2001. In this master plan, the peak factor, 1.1, is applied for calculations of the daily maximum water demand.

Table 44-8 shows the summary of projected water demand, and Figure 44-6 shows the daily average and daily maximum water demand.

Table 44-8 Summary of Water Demand Projection

	Unit	2000	2005	2010	2015	2020
Population	person	599,000	687,084	788,165	902,716	1,034,521
Served Population	person	215,522	275,567	370,269	466,981	564,648
Service Ratio	%	36.0%	40.1%	47.0%	51.7%	54.6%
Population in Service Area	person	297,575	380,342	499,737	586,710	662,441
Service Ratio in Service Area	%	72.4%	72.5%	74.1%	79.6%	85.2%
Number of Domestic Connection	nos.	34,210	43,741	58,773	74,124	89,627
Number of Non-domestic Connection	nos.	5,095	6,340	7,889	9,817	12,215
Total Number of Connection	nos.	39,305	50,081	66,662	83,940	101,842
Served Population (Incremental)	person		60,046	94,702	96,712	97,667
Number of Domestic Connection (Incremental)	nos.		9,531	15,032	15,351	15,503
Per Capita Consumption	lpcd	174	172	170	170	170
Total Domestic Water Demand	m3/day	37,501	47,398	62,946	79,387	95,990
Non-Domestic Water Demand	m3/day	30,361	37,780	47,011	58,499	72,793
Total Water Demand	m3/day	67,862	85,177	109,957	137,885	168,783
UFW Ratio	%	33%	28%	25%	25%	25%
Day Average Water Demand	m3/day	101,286	118,302	146,609	183,847	225,044
Day Maximum Water Demand	m3/day	111,415	130,132	161,270	202,232	247,548

Figure 44-6 Day Average and Day Maximum Water Demand



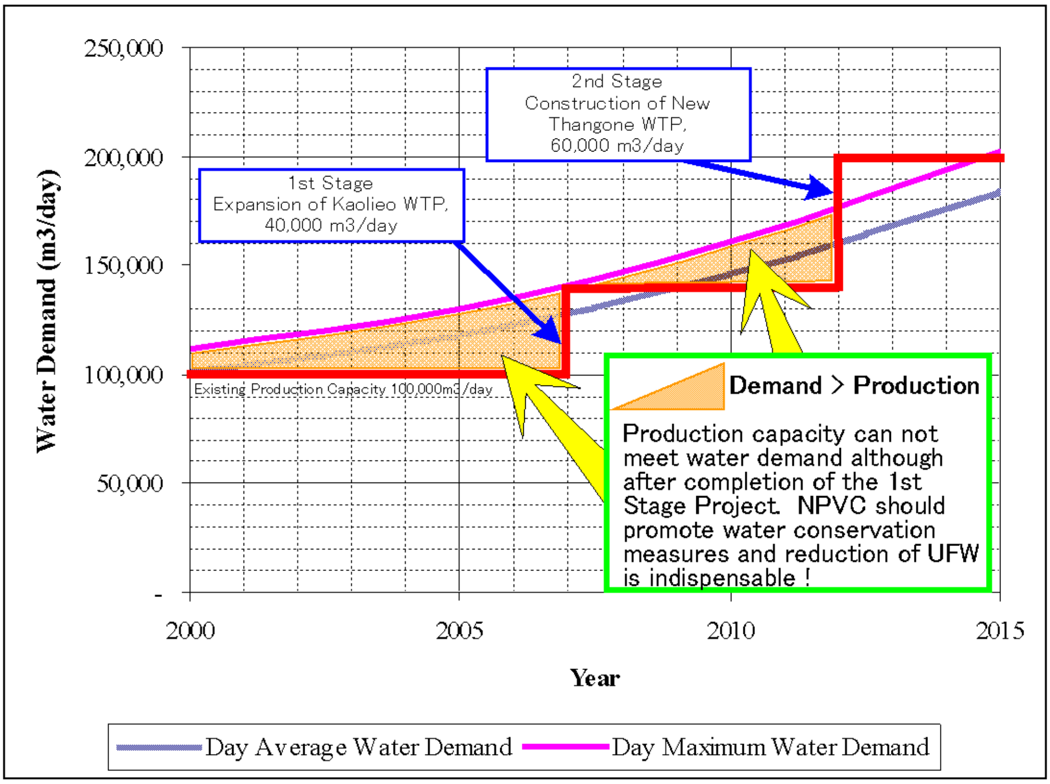
In this Figure 44-6, the staged expansion of water supply capacity is also shown. Expansion of the water supply capacity will be implemented in two stages. The 1st Stage of expansion will be 40,000 m3/day, to meet the daily maximum water demand in 2007, and the 2nd Stage will be 60,000 m3/day.

1st Stage:	Expansion of 40,000 m3/day
2nd Stage:	Expansion of 60,000 m3/day

The 1st Stage will be completed in 2007 and this timing is estimated from the implementation schedule as discussed in Section 4.10. The 2nd Stage implementation will be completed in 2012 and the daily maximum water demand in 2015, the target year of the study, will be met by the completion of the 2nd Stage.

The scale of the 1st Stage Project was decided considering the adequate scale of the project among international lending agencies to avoid difficulties finding funding sources by the Lao PDR. As shown on Figure 44-7, even after completion of the 1st Stage Project, the daily maximum water demand will not be satisfied, and water shortage situation will continue until completion of the 2nd Stage. Therefore, it is strongly recommended that the NPVC promote water conservation activities through adequate public relation campaigns, and to reduce the UFW by using intensive measures against the UFW.

Figure 44-7 Relation between Demand and Production Capacity



On the other hand, the scale of the 2nd Stage may be rather large for international lending agencies, or the Lao PDR's own funding, even though the economic and financial viability is confirmed as described in the following section. Therefore, in order to adapt the 2nd Stage Project to an appropriate capital investment scale, efforts on water conservation and reduction of the UFW are indispensable to the NPVC. After completion of the 1st Stage Project, a feasibility study will be required to implement the 2nd Stage. During the feasibility study for the 2nd Stage, the scale of the 2nd Stage will be reviewed. If it is the case that the maximum water demand is reduced by the promotion of water conservation and reduction of the UFW, as estimated by the study, the implementation of the 2nd Stage will be divided into two phases, each with a capacity of 30,000 m3/day or to be reduced to 50,000 m3/day from 60,000 m3/day as shown in Annex 22. Modification of the scale of the 2nd Stage in this manner will reduce the financial impacts to the NPVC.

4.5 Comparative Study of Alternatives

4.5.1 Concept of Future Water Supply Facility Planning

The purpose of the study is to prepare a master plan and to conduct a feasibility study on the priority project which will be drawn from the results of the master plan to meet future water demand.

However, during the Phase 1 Study: Reconnaissance Survey, some problems were found in the existing water supply system. The study team considered that it is indispensable to restore the existing system to be able to function efficiently before the system expansion.

Among existing problems the NPVC is facing, significant problems are identified as follows, besides the shortage of production capacity to meet water demand.

- Deterioration of the Kaolieo Treatment Plant
- Lack of distribution facilities in the Chinaimo Treatment Plant even though a certain amount of water is directly distributed from the plant

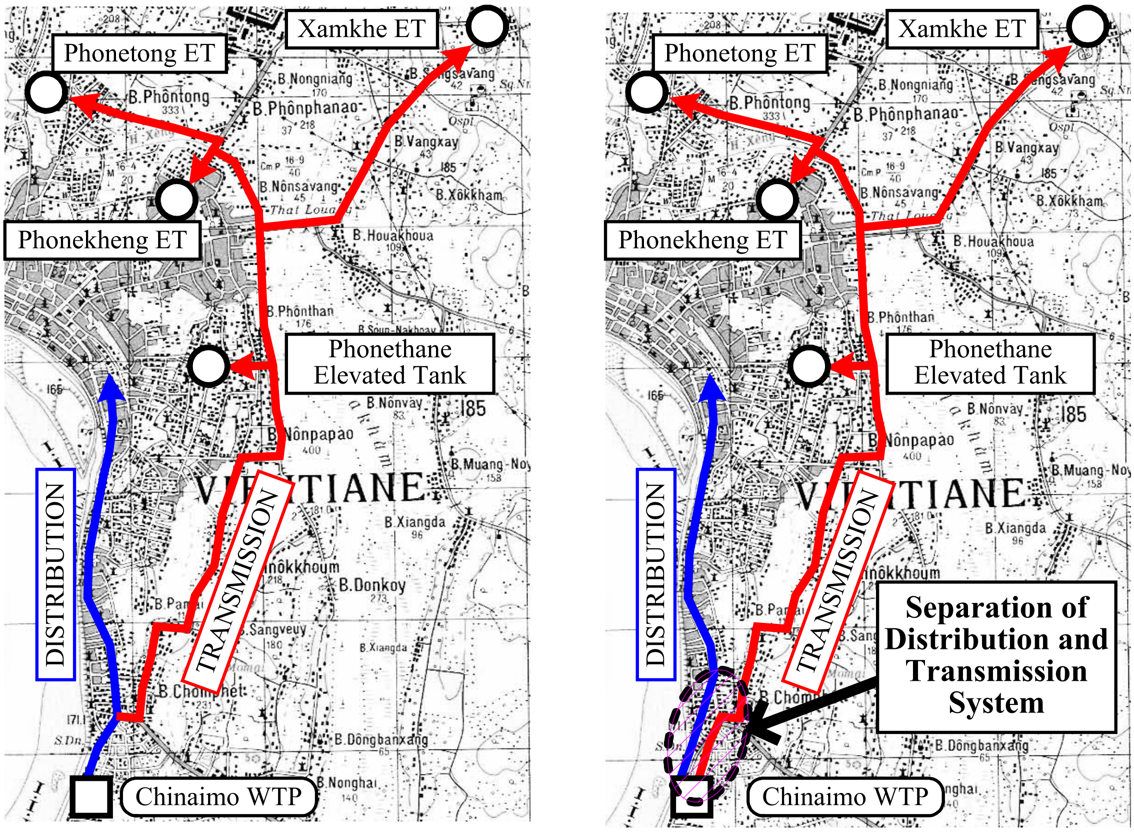
The Kaolieo Treatment Plant, which has a capacity of 20,000 m3/day, was originally constructed in 1963, with rehabilitation works implemented in 1983. 20 years has past since the last refurbishment and not only structural deterioration, but also electro-mechanical equipment malfunction or deterioration was found on inspection. Conditions of the existing Kaolieo Treatment plant are detailed in Chapter 3. In order to secure water supply to the existing service area from the Kaolieo Treatment Plant under such situations, the study team consider that rehabilitation work for the Kaolieo Treatment Plant is indispensable. Furthermore, the pipeline expansion from the Kaolieo Treatment Plant is an on-going project using the financial support of the AFD, hence, production at the Kaolieo Treatment Plant should be secured future decades.

The Chinaimo Treatment Plant was originally designed for water to be transmitted to elevated tanks and reservoirs throughout the town. Therefore, the total capacity of the pumps in the Chinaimo Treatment Plant is 80,000 m3/day, the same as the plant capacity. This means that the plant is not able to distribute water which has hourly fluctuations. Accordingly, the capacity of reservoirs is about 3,000 m3, equivalent to less than 1 hour of plant production capacity.

Although the plant was designed only for transmitting water to the elevated tanks and reservoirs, distribution lines are branched from the transmission pipeline to distribute water directly to the town. The amount of the distribution is about 50 % of treated water, 40,000 m3/day. Because of the mixture of distribution systems and transmission systems at the Chinaimo Treatment Plant, the distribution system can not meet hourly fluctuations and the transmission system becomes unstable, depending on the quantity of distributed water, as pointed out in the previous chapter.

Given these conditions, it is considered that the separation of the systems is indispensable to achieve a stable distribution and transmission system of delivering water. Figure 45-1 shows the present and proposed distribution and transmission systems of the Chinaimo Treatment Plant. For this separation, expansion of reservoir capacity (a new reservoir adjacent to existing one), the installation of distribution pumps to meet hourly fluctuations of the demand, and the installation of an independent transmission main line from the plant to the branch point of existing transmission pipelines are is required. For the transmission system, existing pumps will be utilized.

Figure 45-1 Distribution and Transmission System of Chinaimo Treatment Plant



Existing Distribution and Transmission System

Proposed Distribution and Transmission System

The capacity of the new additional reservoir will be 10,000 m3, equivalent to 6 hours of 50% of the plant capacity, 40,000 m3/day. Since the effective depth of the existing reservoir and pump suction pit are rather shallow, 2.7 m, the new reservoir will occupy a large space in the plant if the system is designed to the same hydraulic conditions. Therefore, the new reservoir and additional distribution pumping systems are planned to have separate hydraulic conditions to save land space.

As discussed above, facility planning will put the first priority on the following works to restore the existing system to the condition that it should be in, and then the system expansion will be considered.

- Rehabilitation of the existing Kaolieo Treatment Plant
- Separation of distribution and transmission system at the existing Chinaimo Treatment Plant

4.5.2 Review of the NPVC Master Plan

The NPVC Master Plan recommends the construction of a new treatment plant in Thangone which will have a capacity of 50,000 m3/day in Phase 1. The plan also recommends installing transmission pipelines in Phase 2 of the plan, and expansion of the existing Kaolieo Treatment Plant to 40,000 m3/day (an additional 20,000 m3/day expansion) in Phase 3. This will achieve a total capacity of 170,000 m3/day (Chinaimo: 80,000 m3/day, Kaolieo: 40,000 m3/day, Thangone: 50,000 m3/day). However, the hydraulic network analysis, for the short term plan, targeted for 2005, when completed all phases from Phase 1 to 3, included in the NPVC Master Plan, production capacities of three treatment plants are as follows:

Existing Chinaimo Treatment Plant	897.591 l/sec (77,552 m3/day)
Expanded Kaolieo Treatment Plant	461.574 l/sec (39,880 m3/day)
New Thangone Treatment Plant	230.895 l/sec (19,949 m3/day)

At the Chinaimo and Kaolieo Treatment Plants, the production outputs of the plants are similar in their design capacity and expanded capacity. However for the new Thangone Treatment Plant, water flow from the plant is about 20,000 m3/day, less than half (40%) of the design capacity. Unfortunately, the NPVC master plan does not explain this ambiguous point and if this is the case, the new Thangone Treatment Plant will have 60% idling capacity and the actual water production will be 140,000 m3/day in total (Chinaimo: 80,000 m3/day, Kaolieo: 40,000 m3/day, Thangone: 20,000 me/day). This total output is absolutely the same as the planned plant capacity of the 1st Stage proposed by the JICA Study Team.

According to information from the NPVC, the capacity of the new Thangone Treatment Plant was revised at30,000 m3/day, unfortunately the revised master plan has not been prepared, and details concerning the changes of plant capacity are not available.

A comparative study of several alternatives was not conducted, and the reason why the construction of Thangone Treatment Plant was proposed as the first priority in the NPVC master plan, was not clearly discussed in the plan. However, the master plan did point out the following advantages of the new Thangone Treatment Plant.

(1) Water quality (turbidity) is much better than that of the Mekong River
(2) The scale of treatment facility will be smaller than the existing two plants because of low turbidity
(3) The planned location of the plant is ideal considering water supply to the northern parts of the capital city where low water pressure and intermittent supply are common problems. It is also an area that will be developed as new housing and industrial areas.
(4) A dual-source water supply system can be established and the risk of accidents at the water source is lower than the existing single-source water supply system which relies entirely on the Mekong River.

(1) Available water quality (turbidity) is much better than from the Mekong River

This advantage will be evaluated in aspect of costs required for chemicals (O/M costs) in the following cost comparison. Lower turbidity will require fewer coagulants compared with the amounts of coagulants used at the existing two treatment plants.

(2) The scale of the treatment facility will be smaller than the existing two plants because of low turbidity

This advantage will be evaluated in view of construction costs of the treatment plant in the following cost comparison. Lower turbidity will require less capacity (shorter detention time) of water in the sedimentation basin compared with existing two treatment plants.

(3) The location of the plant will be ideal considering water supply to the northern part is suffering low water pressure and intermittent supply, and is an area that will be developed as new housing and industrial areas.

This advantage will be evaluated in view of the installation costs of transmission and distribution pipelines in the following cost comparison as all pipe network systems for all alternatives are planned to secure water distribution in same service area. If the location of the new Thangone Treatment Plant is ideally situated to supply water to the northern part of the capital city, pipe installation costs will be low compared with other alternatives.

(4) A dual-source water supply system can be established and the risk of accidents at the water source is lower compared to the existing single-source water supply system which relies entirely on one source, the Mekong River.

With the construction of the new Thangone Treatment Plant, the Vientiane water supply system will have access to two water supply sources, the Mekong River for the existing two plants, and the Nam Ngum River for the new treatment plant. Reduction of risk in water source accidents will be reduced by the introduction of a new water source for the Vientiane water supply system.

There are two kinds of accidents possible in the treatment of raw water, accidents with the quality of water, and accidents that affect the quantity of water. Quality accidents may occur by the discharging of toxic substances into the river. However, since the construction of the first treatment plant at Kaolieo in 1964, no such quality accidents have occurred. Although it can never be said that such quality accidents will never occur in the huge international river basin, such toxic substances will be diluted because of the size of the river basin and the huge amount of water flow of the Mekong River.

Water quantity accidents are about the availability of raw water for the treatment plants and, in particular, concern the eventuality when water flow becomes too low for the treatment plants to be able to access the water supply. However, there have been no such quantity accidents in the last 40 years in the case of the Mekong River. According to the data of water flow from the Mekong River in Vientiane from 1960 to 2001, the minimum flow was observed in 1999 and the flow rate at that time was 598 m3/sec. In the water demand forecast of the JICA study, the total amount of water in 2020 is forecasted to be about 250,000 m3/day (2.9 m3/sec), and if the total water requirement is taken from the Mekong River, it is equivalent to 0.5 % of the minimum flow in the last 40 years.

At the new Thangone Treatment plant, the advantages of a dual-source water supply system are obvious. However, as mentioned above, the probability of risks of water quality accidents and water quantity accidents are very low. The study team considers that these risks are not an imminent threat and which should make the introduction of additional investments unnecessary.

4.5.3 Screening of Alternatives

The water supply system of Vientiane Capital City, which is facing a shortage of its supply capacity, should be developed continuously and gradually to meet the increasing water demand. According to the water demand projection described in Chapter 4.4, the water supply capacity should be increased up to 200,000m3/day by 2015, twice the existing water supply capacity.

Alternative locations for expansion of the production capacity are as follows;
- Expansion of the existing Chinaimo Treatment Plant,
- Expansion of the existing Kaolieo Treatment Plant, and
- Construction of new Thangone Treatment Plant.

For the comparative study of these alternatives, it is necessary to examine these alternatives from a multi-dimensional aspect to include social, environmental, technical, and economical view points. Furthermore, organization, management, financial condition, and human resource development should be carefully examined for sound NPVC management in future. For the above three alternatives, preliminary comparison and evaluation methods are as shown in Table 45-1.

As is shown in Table 45-1, although each alternative has advantages and disadvantages, significant factors to exclude certain alternatives from the comparative study were not found except in the case of the 60,000 m3/day expansion in the existing Chinaimo Treatment Plant.

The expansion of capacity in each stage is discussed above and as follows;

1st Stage:	Expansion of 40,000 m3/day
2nd Stage:	Expansion of 60,000 m3/day

Alternatives are selected considering a combination of the above alternative locations and stages of expansion. For the 1st Stage, capacity expansion of 40,000 m3/day, three alternatives are considered as follows.

- Alternative C (Chinaimo): Expansion of the existing Chinaimo Treatment Plant (40,000 m3/day),
- Alternative K (Kaolieo): Expansion of the existing Kaolieo Treatment Plant (40,000 m3/day), and
- Alternative T (Thangone): New Construction of a treatment plant at Thangone (40,000 m3/day)

Table 45-1 (1/2) Preliminary Comparison and Evaluation of Alternatives

	Chinaimo Treatment Plant	Kaolieo Treatment Plant	Thangone Treatment Plant	Evaluation Method
Raw Water Source	Mekong River	Mekong River	Nam Ngum River	
Quantity	Enough and secured	Enough and secured	Enough and secured	No difference among alternatives
Quality in aspect of Chemicals Required	High turbidity in rainy season, and more chemicals will be required	High turbidity in rainy season, and more chemicals will be required	Low turbidity on average and less chemicals will be required	Difference of raw water turbidity will be evaluated in aspect of chemical costs (O/M costs) in following cost comparison
Quality in aspect of capacity of sedimentation basin	Same detention period as existing facility will be required	Same detention period as existing facility will be required	Capacity of sedimentation basin can be reduced compared with existing facilities	Difference of treatment facilities will be evaluated in view of construction costs in following cost comparison
Water Level [1)]	Max. +170.64 m, Min. +158.11 m, Fluctuation = 12.53m	Max. +170.64 m, Min. +158.11 m, Fluctuation = 12.53m	Max. +169.00 m, Min. +154.48 m, Fluctuation = 14.52m	No difference among alternatives Water fluctuation in Nam Ngum River is rather bigger than the one of Mekong River, however, construction costs of the intake facilities will not be affected by the small difference and judged no difference among alternatives
Intake Facilities	Intake Pump replacement will be required	Additional Intake facilities will be required	New Intake facilities will be required	Difference of intake facilities will be evaluated in aspect of construction costs in following cost comparison
Treatment Plant				
Location	South of the town centre	West of town centre	North of town centre	Location of plant will be evaluated from the aspect of pipe installation costs of pipelines and operation costs (electricity costs) in following cost comparison

1) Data of Mekong River obtained from 1991 to 2002, data of Nam Ngum River obtained from 1990 to 2002

Table 45-1 (2/2) Preliminary Comparison and Evaluation of Alternatives

	Chinaimo Treatment Plant	**Kaolieo Treatment Plant**	**Thangone Treatment Plant**	**Evaluation Method**
Land space for expansion or new construction	Space for 40,000 m3/day expansion will be available within the existing plant premises. Expansion of 60,000 m3/day will not be able to be accommodated within the existing plant premises.	Space for 40,000 m3/day and 60,000 m3/day expansion will be available within the existing plant premises. However, in the case of 60,000 m3/day expansion, no space for a distribution reservoir will be available	Proposed site of plant is occupied by Thangone Irrigation College, Ministry of Agriculture and Forestry. Other land space will be provided according to the information from WASA, but not yet confirmed.	60,000 m3/day expansion in Chinaimo Treatment Plant should be excluded from alternative. In case of 60,000 m3/day expansion in Kaolieo, an additional distribution centre outside of the plant will be required and this will be evaluated as construction costs in following cost comparison. According to the information form WASA, land space for new Thangone will be acquired but the time taken for land acquisition is not yet known.
Distribution and Transmission System	Additional pipelines are required	Additional pipelines are required. Distribution centre will be required in the case of a 60,000 m3/day expansion	Additional pipelines and distribution centre will be required	Difference of distribution and transmission system will be evaluated from the aspect of pipe installation costs, construction costs of distribution centre, and operation costs (electricity costs) in following cost comparison
Booster Pumping Station	Improvement will be required	Improvement will be required	Improvement will not be required when capacity is 40,000 m3/day expansion	Difference of booster pumping stations will be evaluated from the aspect of improvement costs of booster pumping stations, and operation costs (electricity costs) in following cost comparison
Power Supply	No problem	No problem	No problem	No difference among alternatives
Chemical Supply	No problem	No problem	No problem	No difference among alternatives
Staff required for Plant Operation and Maintenance	Additional staff required is less than 10 staff, OJT at existing plant is possible	Additional staff required is less than 10 staff, OJT at existing plant is possible	New organization for new plant should be established with about 35 staff. Recruiting and freshmen training will be required	Difference of staff required will be evaluated from the aspect of operation costs (salary) in following cost comparison In the case of Thangone, recruiting and freshmen training should be completed before completion of new plant construction.

For the 2nd Stage, there will be several alternatives in combination with the 1st Stage alternatives as shown in Table 45-2.

Table 45-2 Alternatives by Combination of Locations and Stages

<table>
<tr><th rowspan="2">Alternatives</th><th colspan="2">1st Stage at Chinaimo</th><th colspan="2">1st Stage at Kaolieo</th><th colspan="2">1st Stage at Thangone</th></tr>
<tr><th>1st Stage
2007</th><th>2nd Stage
2012</th><th>1st Stage
2007</th><th>2nd Stage
2012</th><th>1st Stage
2007</th><th>2nd Stage
2012</th></tr>
<tr><td>C-1</td><td rowspan="2">40,000</td><td></td><td></td><td></td><td></td><td>60,000</td></tr>
<tr><td>C-2</td><td></td><td></td><td>60,000</td><td></td><td></td></tr>
<tr><td>K-1</td><td></td><td></td><td rowspan="2">40,000</td><td></td><td></td><td>60,000</td></tr>
<tr><td>~~K-2~~</td><td></td><td>~~60,000~~</td><td></td><td></td><td></td></tr>
<tr><td>~~T-1~~</td><td></td><td>~~60,000~~</td><td></td><td></td><td rowspan="3">40,000</td><td></td></tr>
<tr><td>T-2</td><td></td><td></td><td></td><td>60,000</td><td></td></tr>
<tr><td>T-3</td><td></td><td></td><td></td><td></td><td>60,000</td></tr>
</table>

On the table shown above, alternatives K-2 and T-1 are the plans which would enable an expansion of 60,000 m3/day in Chinaimo Treatment Plant, in the 2nd Stage. However, there is no space for an expansion of 60,000 m3/day at the Chinaimo Treatment Plant, since expansion of the reservoir for distribution will take place as discussed in the previous section.

Because of a limitation of land space available in the Chinaimo Treatment Plant, alternatives K-2 and T-1 were omitted from further study of available alternatives. The screened alternatives for comparison are shown on Table 45-3.

Table 45-3 Screened Alternatives for Comparative Study

<table>
<tr><th rowspan="2">Alternatives</th><th colspan="2">1st Stage at Chinaimo</th><th colspan="2">1st Stage at Kaolieo</th><th colspan="2">1st Stage at Thangone</th></tr>
<tr><th>1st Stage
2007</th><th>2nd Stage
2012</th><th>1st Stage
2007</th><th>2nd Stage
2012</th><th>1st Stage
2007</th><th>2nd Stage
2012</th></tr>
<tr><td>C-1</td><td rowspan="2">40,000</td><td></td><td></td><td></td><td></td><td>60,000</td></tr>
<tr><td>C-2</td><td></td><td></td><td>60,000</td><td></td><td></td></tr>
<tr><td>K-1</td><td></td><td></td><td>40,000</td><td></td><td></td><td>60,000</td></tr>
<tr><td>T-2</td><td></td><td></td><td></td><td>60,000</td><td rowspan="2">40,000</td><td></td></tr>
<tr><td>T-3</td><td></td><td></td><td></td><td></td><td>60,000</td></tr>
</table>

4.5.4 Methodology of Comparative Study

The flow of the comparative study for the screened alternatives is as follows:

1. Facility Planning for each alternative
2. Preliminary cost estimates for the planned facilities for each alternative
3. Conversion of financial costs to economic costs
4. Calculation of the Net Present Value
5. Selection of the best alternative by the least cost method
6. Evaluation of the selected best alternative

4.5.5 Facility Planning for Each Alternative

(1) Treatment Plant

In order to meet the treatment capacity for future demand in 2015, the total capacity of the plants should be 200,000 m3/day. This means that the capacity of 100,000 m3/day in the three treatment plants should be increased by the year 2015. This should be done in two stages, 40,000 m3/day in 2007 and 60,000 m3/day in 2012. As mentioned, there are basically three options for the increase of treatment capacity and the alternatives to be compared are combinations of these three options.

- Expansion of Chinaimo Treatment Plant
- Expansion of Kaolieo Treatment Plant
- Construction of New Treatment Plant in Thangone Area

The treatment process for each option is same as for the existing Chinaimo Treatment Plant, which is as follows:

- Rapid Mixing: Gravitational force mixing by weir
- Flocculation: Up and down baffling type
- Sedimentation: Horizontal flow with launder trough
- Filtration: Rapid sand filtration, simultaneous air and water backwash

1) Chinaimo Treatment Plant

Expansion of the Chinaimo Treatment Plant is considered only for the 1st Stage, 40,000 m3/day as mentioned in the previous section. For expansion of the treatment plant, additional intake structures will not be required but the replacement of intake pumps will be required. The Chinaimo Treatment Plant expansion is for Alternatives C-1 and C-2.

2) Kaolieo Treatment Plant

The same treatment process used at the existing Chinaimo Treatment Plant should be applied for expansion of the Kaolieo Treatment Plant. As the existing intake tower, at the opening of the intake gate, does not have enough capacity, additional intake facilities for expansion should be considered. For the case of a 60,000 m3/day expansion in 2nd Stage, since land space for an additional distribution reservoir is not available within the plant premises, construction of distribution centre in the town is planned. The expansion of the 1st Stage, 40,000 m3/day is for the Alternative K-1 and the expansion of the 2nd Stage, 60,000 m3/day is for the Alternatives C-2 and T-2.

3) Thangone Treatment Plant

The treatment process used in the Thangone Treatment Plant is as same as that used at the existing Chinaimo Treatment Plant. The capacity of the sedimentation basin, in other words the detention time of water in the basin, is planned to be less than the Chinaimo Treatment Plant because of the lower turbidity of water from the Nam Ngum River.

A construction of 40,000 m3/day plant in the 1st stage is for Alternatives T-2 and T-3 and a construction of 60,000 m3/day plant in the 2nd stage is for Alternatives C-1, K-1 and T-3.

In the case of Thangone Treatment Plant, some sludge treatment facilities will be required since the Nam Ngum River water is utilized for irrigation purposes downstream of the planned plant location.

Unfortunately Thangone Irrigation College, Ministry of Agriculture and Forestry is in the planned location of the Thangone Treatment Plant. However, according to consultations with the agency concerned, alternative land space will be available in Thangone area for expansion of the treatment plant.

(2) Clear Water Transmission and Distribution Trunk Mains

1) Conditions for Network Analysis

Pipe network models for each stage and for each alternative were developed and hydraulic analyses were conducted using WaterCAD. Conditions of the hydraulic network analyses are as follows:

- Formula for friction loss calculation： Hazen-Williams Formula
- C value for all pipes: 110
- Velocity Range: 1.0 m/s – 1.5 m/s
- Minimum Residual Pressure at junction: 1.5 kg/cm2 (15 m)
- Hourly peak factor for domestic demand is estimated at 1.4. Half of non-domestic demand is assumed to be the same hourly peak factor as domestic. For the remaining non-domestic

demand, hourly peak factors are not applied since non-domestic customers have their own reservoir.

The basis of calculations of the hourly peak factor are shown in Annex-15. The overall hourly peak factor, the average of domestic and non-domestic demand is calculated as 1.3.

2) Demand Allocation to the Junctions

Domestic water demand is allocated to each junction based on the location of villages near the junction. The population, service ratio, served population and water demand for each village is calculated as described in the previous section.

Non-domestic water demand is allocated to junctions in three different ways. First of all, the major large 50 consumers which consume water at a rate of more than 2,000 m3/month were identified and plotted on the map. From the map, water consumption of these large consumers was allocated to junctions nearby. As a second step, 20 % of the remaining non-domestic water demand is allocated to the junctions which are located in the future industrial areas. In the third step, the remaining non-domestic water demand is allocated to all junctions correlating to the population covered by each junction.

4.5.6 Alternatives Compared

The results of the alternative study for five alternatives, C-1, C-2, K-1, T-2 and T-3, are summarised in the following and detailed in Annex 16.

(1) Alternative C-1

1) Intake and Treatment Plant

<u>1st Stage (Expansion of the existing Chinaimo Water Treatment Plant)</u>

- Intake Facilities: Use of the existing intake structure, replacement of 4 of 6 existing pumps
- Treatment Plant: Expansion of 40,000 m3/day

<u>2nd Stage (Construction of New Thangone Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities on the Nam Ngum River
- Treatment Plant: Construction of 60,000 m3/day

Expansion of 40,000 m3/day at the existing Chinaimo Treatment Plant for the 1st Stage and a new treatment plant of 60,000 m3/day at Thangone for the 2nd Stage are considerations for Alternative C-1. Water supply system for Alternative C-1 is shown in Figure 45-2. Detailed specifications of treatment facilities for Alternative C-1 are attached to Annex 14.

2) Pipelines

<u>1st Stage</u>

- Clear Water Transmission Pipelines: Installation of 2.2 km of pipelines
- Booster Pumping Stations: Improvement of the Km6 Booster Pumping Station
- Distribution Trunk Mains: Installation of 30.8 km of pipelines

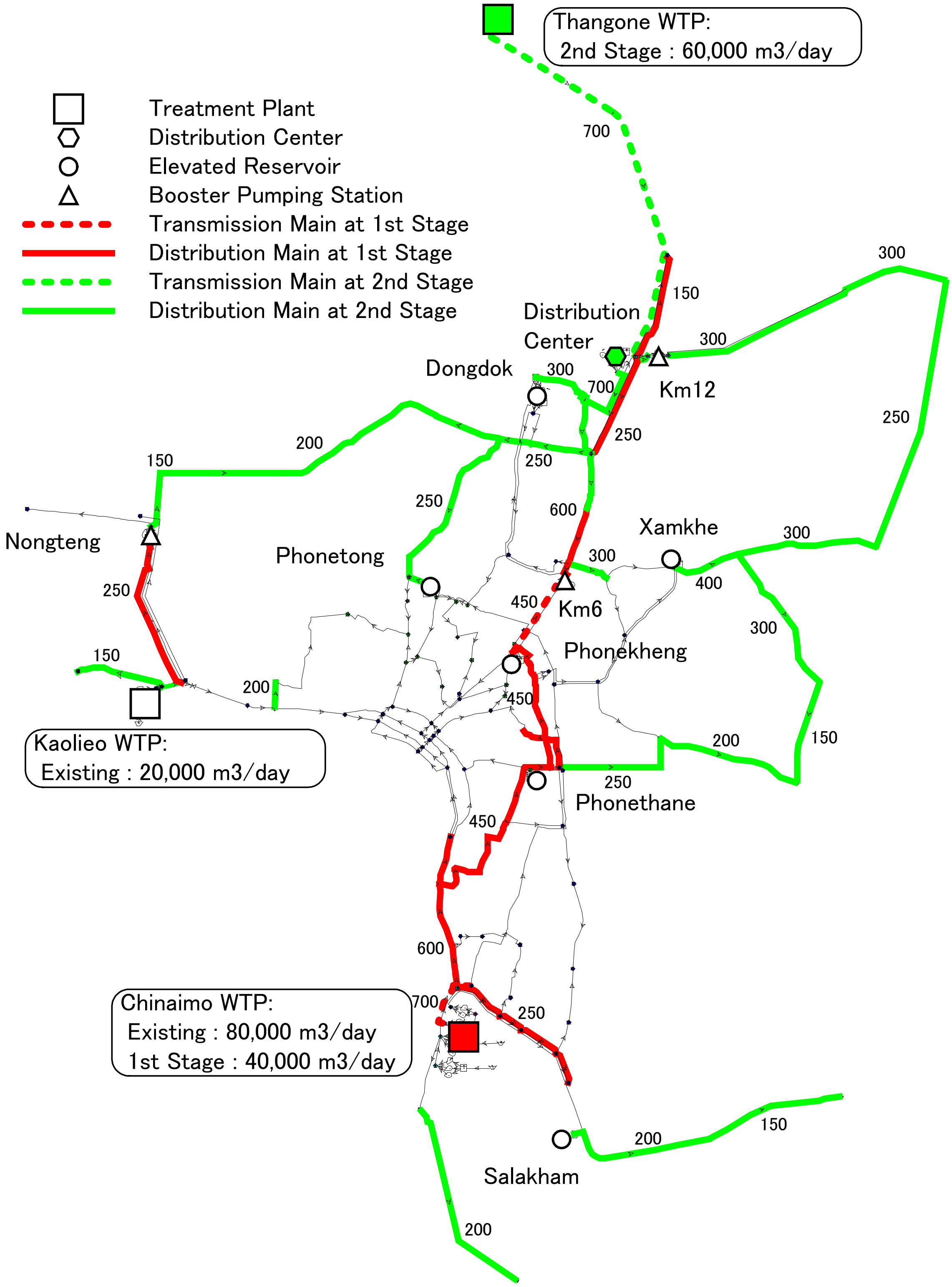
<u>2nd Stage</u>

- Clear Water Transmission: Installation of 10.6 km of pipelines
- Distribution Centre: Construction of a new distribution centre for 60,000 m3/day
- Booster Pumping Stations: Improvement of the Km12 Booster Pumping Station
- Distribution Trunk Mains: Installation of 74.1 km of pipelines

Improvement of the Km6 booster pumping station (BPS) in the 1st Stage will be for securing the water supply to the northern part of Vientiane, especially the Dongdok area. Improvement of Km12 BPS in the 2nd Stage will be mainly for the water supply to the new industrial area in the eastern part of the City.

For the 2nd Stage, clear water is to be transmitted from the new Thangone Treatment Plant to a distribution centre and from there, to consumers. The distribution centre is proposed to be constructed near the junction of National Roads 10 and 13 in the northern part of the city, near the Dongdok area.

Figure 45-2 Water Supply System for Alternative C-1



3) Costs (Construction, O/M)

Based on the results of facility planning as mentioned above for Alternative C-1, preliminary cost estimates have been conducted for the alternative comparison, and the results of these cost estimates are as shown in Table 45-4 in US Dollars. It should be noted that common costs for the following works are excluded from the costs of the alternative comparison.

- Rehabilitation of the existing Kaolieo Treatment Plant
- Separation of distribution and transmission systems of the existing Chinaimo Treatment Plant
- Installation costs of small diameter distribution pipelines, house connections
- Engineering costs, contingencies, administrative costs
- Annual operation and maintenance costs for the existing system

Table 45-4 Preliminary Cost Estimates for Alternative C-1

(x 1,000 US$)

Alternative C-1	Total	Foreign	Local
1. Construction Cost	56,514	39,297	17,217
1.1 Treatment Plants	22,209	14,257	7,952
Expansion of Chinaimo T.P.	8,782	5,564	3,218
Construction of Thangone T.P.	13,427	8,693	4,734
1.2 Clear Water Transmission Pipelines	7,930	6,535	1,395
For the 1st Stage	409	337	72
For the 2nd Stage	7,521	6,198	1,323
1.3 Distribution Center	4,376	2,984	1,392
For the 1st Stage	-	-	-
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	1,103	901	202
For the 1st Stage	737	607	130
For the 2nd Stage	366	294	72
1.5 Distribution Trunk Mains	20,896	14,620	6,276
For the 1st Stage	8,802	6,490	2,312
For the 2nd Stage	12,094	8,130	3,964
2. Operation and Maintenance Cost	6,407	1,208	5,199
2.1 Electricity	5,067	-	5,067
Expanded Chinaimo T.P.	2,194	-	2,194
Thangone T.P.	1,030	-	1,030
Distribution Center	809	-	809
Booster Pump Station	1,034	-	1,034
2.2 Chemical Cost	1,208	1,208	-
Expanded Chinaimo T.P.	895	895	-
Alum	620	620	-
Polymer	18	18	-
Chlorine	257	257	-
Thangone T.P.	313	313	-
Alum	154	154	-
Chlorine	159	159	-
2.3 Salary	132	-	132
Treatment Plant	132	-	132
Expanded Chinaimo T.P.	36	-	36
Thangone T.P.	96	-	96
Total Costs	62,921	40,505	22,416

(2) Alternative C-2

1) Intake and Treatment Plant

1st Stage (Expansion of Existing Chinaimo Water Treatment Plant)

- Intake Facilities: Use of the existing intake structure, replacement of 4 of the 6 existing pumps
- Treatment Plant: Expansion of 40,000 m3/day

2nd Stage (Expansion of Kaolieo Water Treatment Plant)

- Intake Facilities: Construction of new intake facilities from the Mekong River
- Treatment Plant: Construction expansion facilities of 60,000 m3/day

For this alternative, C-2, an expansion capacity of 40,000 m3/day at the existing Chinaimo Treatment Plant for the 1st Stage is considered as the same as Alternative C-1. A new treatment plant of 60,000 m3/day at the existing Kaolieo Treatment Plant is considered for the 2nd Stage. Water supply system for Alternative C-2 is shown in Figure 45-3. Detailed specifications of the treatment facilities for alternative C-2 are attached to Annex-14.

2) Pipelines

1st Stage

- Clear Water Transmission Pipelines: Installation of 2.2 km of pipelines
- Booster Pumping Stations: Improvement of the Km6 Booster Pumping Station
- Distribution Trunk Mains: Installation of 26.3 km of pipelines

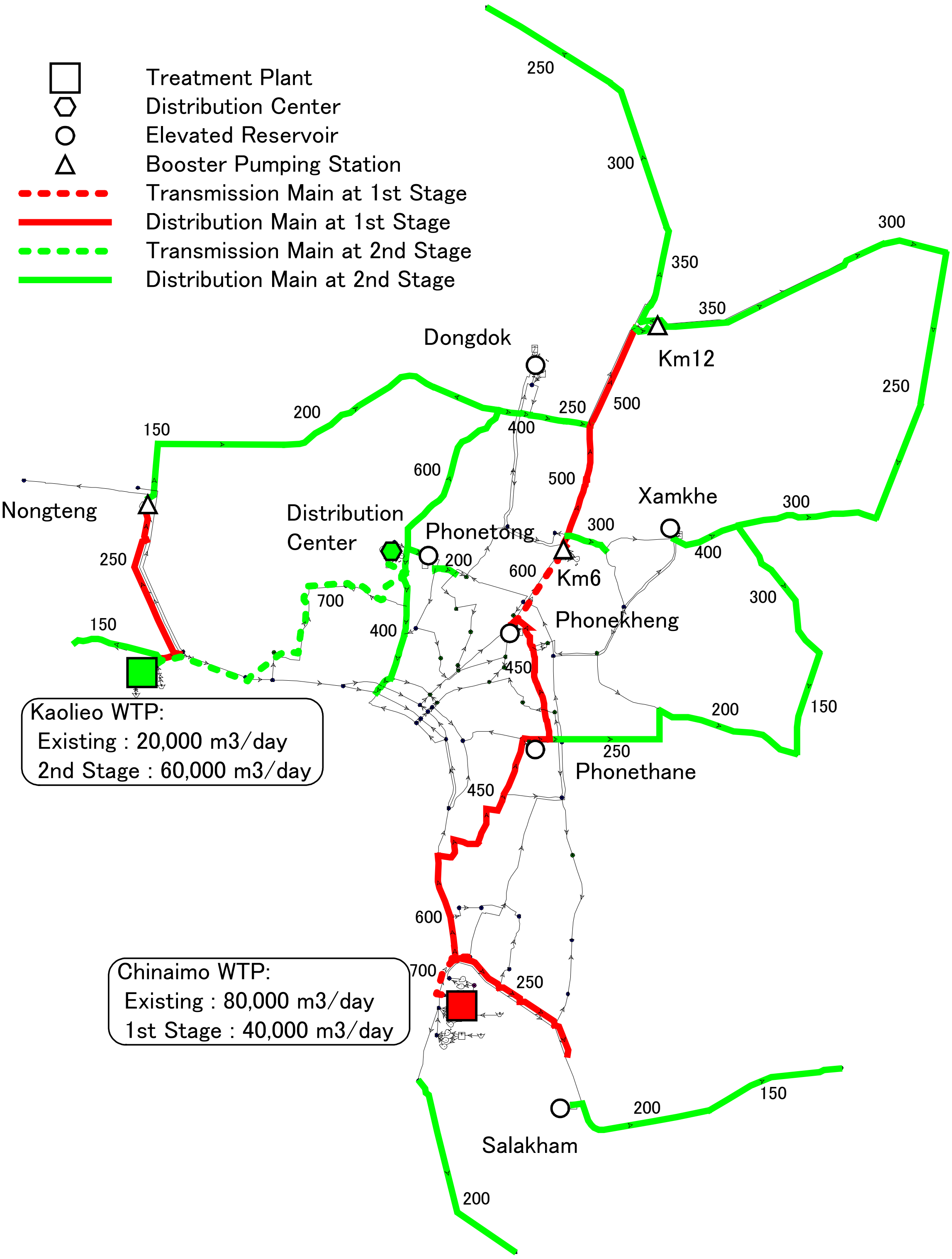
2nd Stage

- Clear Water Transmission: Installation of 9.9 km of pipelines
- Distribution Centre: Construction of new distribution centre capable of 60,000 m3/day
- Booster Pumping Stations: Improvement of the Km6 BP station
- Booster Pumping Stations: Improvement of the Km12 BP station
- Distribution Trunk Mains: Installation of 85.1 km of pipelines

Improvement of the Km6 BP station in the 1st Stage and 2nd Stage will be for securing water supply to the northern part of Vientiane, especially the Dongdok area. Improvement of the Km12 BP station in the 2nd Stage will be mainly for the water supply to the new industrial area in the eastern part of the City.

In the 2nd Stage, clear water will be transmitted from the Kaolieo Treatment Plant to a distribution centre and then distributed from the distribution centre to consumers. The distribution centre is proposed to be constructed in the Phonetong area in the northern part of downtown of central Vientiane.

Figure 45-3 Water Supply System for Alternative C-2



3) Costs (Construction, O/M)

Based on the results of facility planning for alternative C-2, preliminarily cost estimates have been conducted for the alternative comparison. The results of the cost estimates are shown on Table 45-5 in United State Dollars.

Table 45-5 Preliminary Cost Estimates for Alternative C-2

(x 1,000 US$)

Alternative C-2	Total	Foreign	Local
1. Construction Cost	59,789	41,817	17,972
1.1 Treatment Plants	22,209	14,257	7,952
Expansion of Kaolieo T.P.	13,427	8,693	4,734
Expansion of Chinaimo T.P.	8,782	5,564	3,218
1.2 Clear Water Transmission Pipelines	7,447	6,137	1,310
For the 1st Stage	409	337	72
For the 2nd Stage	7,038	5,800	1,238
1.3 Distribution Center	4,376	2,984	1,392
For the 1st Stage	-	-	-
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	1,611	1,321	290
For the 1st Stage	737	607	130
For the 2nd Stage	874	714	160
1.5 Distribution Trunk Mains	24,146	17,118	7,028
For the 1st Stage	9,950	7,590	2,360
For the 2nd Stage	14,196	9,528	4,668
2. Operation and Maintenance Cost	6,732	1,297	5,435
2.1 Electricity	5,383	-	5,383
Expanded Kaolieo T.P.	846	-	846
Expanded Chinaimo T.P.	2,194	-	2,194
Distribution Center	809	-	809
Booster Pump Station	1,534	-	1,534
2.2 Chemical Cost	1,297	1,297	-
Expanded Kaolieo T.P.	402	402	-
Alum	384	384	-
Polymer	10	10	-
Chlorine	8	8	-
Expanded Chinaimo T.P.	895	895	-
Alum	620	620	-
Polymer	18	18	-
Chlorine	257	257	-
2.3 Salary	52	-	52
Treatment Plant	52	-	52
Expanded Kaolieo T.P.	16	-	16
Expanded Chinaimo T.P.	36	-	36
Total Costs	66,521	43,114	23,407

(3) Alternative K-1

1) Intake and Treatment Plant

1st Stage (Expansion of Existing Kaolieo Water Treatment Plant)

- Intake Facilities: Construction of new intake facilities in the Mekong River
- Treatment Plant: Expansion of 40,000 m3/day

2nd Stage (Construction of the new Thangone Water Treatment Plant)

- Intake Facilities: Construction of new intake facilities in the Nam Ngum River
- Treatment Plant: Construction of 60,000 m3/day

Production capacity expansion of 40,000 m3/day at the existing Kaolieo Treatment Plant for the 1st Stage, and a new treatment plant with a capacity of 60,000 m3/day at Thangone for the 2nd Stage are considered for this alternative, K-1. Water supply system for Alternative K-1 is shown in Figure 45-4. Detailed specifications of the treatment facilities for alternative K-1 are attached to Annex 14.

2) Pipelines

1st Stage

- Clear Water Transmission Pipelines: Installation of 2.2 km of pipelines
- Booster Pumping Stations: Improvement of the Km6 BP station
- Distribution Trunk Mains: Installation of 24.2 km of pipelines

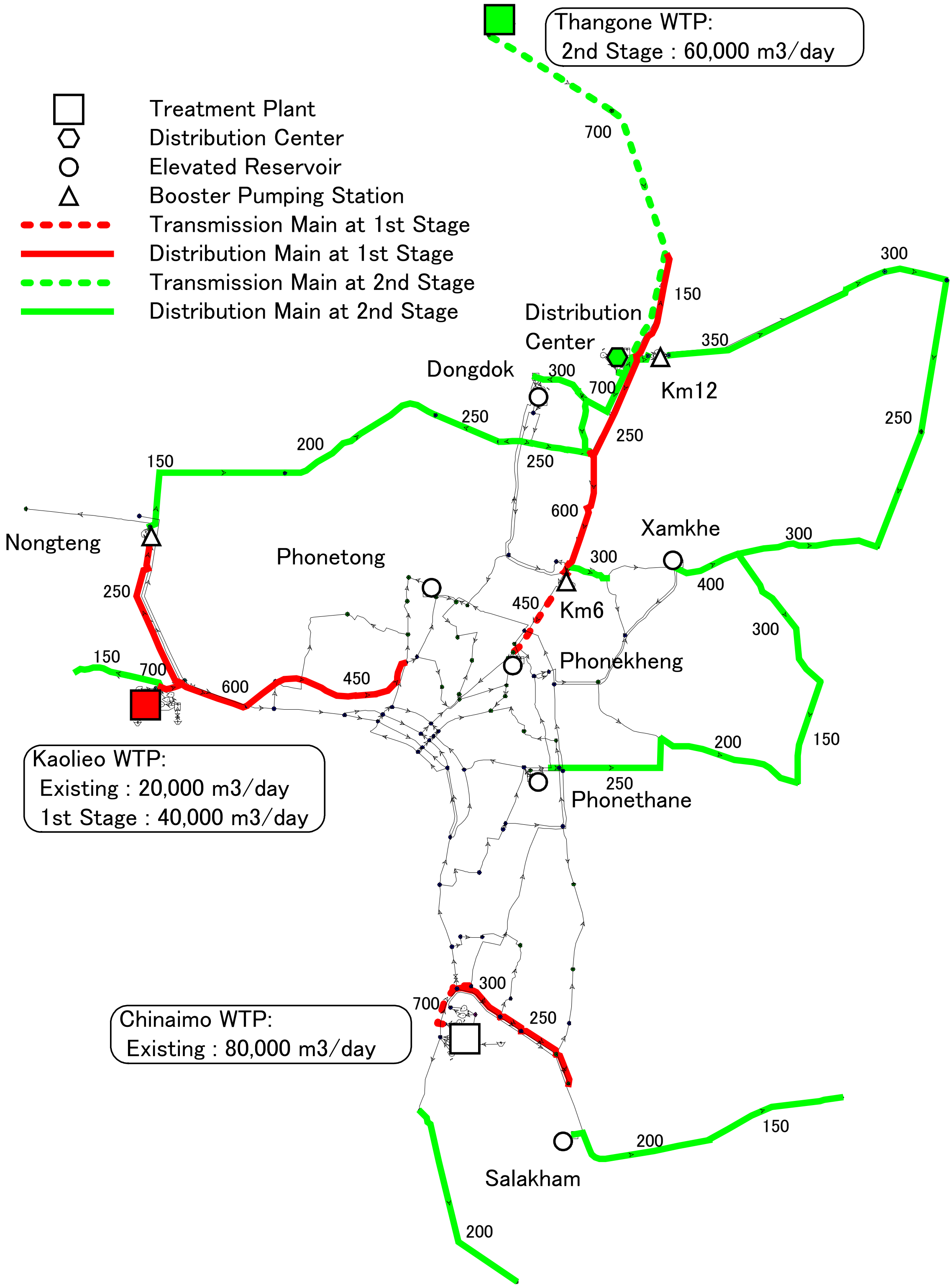
2nd Stage

- Clear Water Transmission: Installation of 10.6 km of pipelines
- Distribution Centre: Construction of a new distribution centre with a capacity of 60,000 m3/day
- Booster Pumping Stations: Improvement of the Km12 BP station
- Distribution Trunk Mains: Installation of 73.6 km of pipelines

Improvement of the Km6 BP station in the 1st Stage will secure water supply to the northern part of Vientiane, especially the Dongdok area. Improvement of the Km12 BP station in the 2nd Stage will be mainly for water supply to the new industrial area in the eastern part of the City.

In the 2nd Stage, it is planned for clear water to be transmitted from the new Thangone Treatment Plant to a distribution centre and then distributed to the consumers. The distribution centre is proposed to be constructed near the junction of National Roads 10 and 13 in northern part of the city and near the Dongdok area.

Figure 45-4 Water Supply System for Alternative K-1



3) Costs (Construction, O/M)

Based on the results of facility planning for alternative K-1, preliminarily cost estimates have been conducted for the alternative comparison. The results of the cost estimates are as shown in Table 45-6 in US Dollars.

Table 45-6 Preliminary Cost Estimates for Alternative K-1

(x 1,000 US$)

Alternative K-1	Total	Foreign	Local
1. Construction Cost	54,835	37,497	17,338
1.1 Treatment Plants	23,051	14,455	8,596
Expansion of Kaolieo T.P.	9,624	5,762	3,862
Construction of Thangone T.P.	13,427	8,693	4,734
1.2 Clear Water Transmission Pipelines	7,930	6,535	1,395
For the 1st Stage	409	337	72
For the 2nd Stage	7,521	6,198	1,323
1.3 Distribution Center	4,376	2,984	1,392
For the 1st Stage	-	-	-
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	1,103	901	202
For the 1st Stage	737	607	130
For the 2nd Stage	366	294	72
1.5 Distribution Trunk Mains	18,375	12,622	5,753
For the 1st Stage	7,219	5,342	1,877
For the 2nd Stage	11,156	7,280	3,876
2. Operation and Maintenance Cost	6,157	1,208	4,949
2.1 Electricity	4,817	-	4,817
Expanded Kaolieo T.P.	1,944	-	1,944
Thangone T.P.	1,030	-	1,030
Distribution Center	809	-	809
Booster Pump Station	1,034	-	1,034
2.2 Chemical Cost	1,208	1,208	-
Expanded Kaolieo T.P.	895	895	-
Alum	620	620	-
Polymer	18	18	-
Chlorine	257	257	-
Thangone T.P.	313	313	-
Alum	154	154	-
Chlorine	159	159	-
2.3 Salary	132	-	132
Treatment Plant	132	-	132
Expanded Kaolieo T.P.	36	-	36
Thangone T.P.	96	-	96
Total Costs	60,992	38,705	22,287

(4) Alternative T-2

1) Intake and Treatment Plant

<u>1st Stage (Construction of the new Thangone Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities in the Nam Ngum River
- Treatment Plant: Capacity of 40,000 m3/day

<u>2nd Stage (Expansion of Kaolieo Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities in the Mekong River
- Treatment Plant: Expansion of 60,000 m3/day

A new treatment plant with a capacity of 40,000 m3/day at Thangone for the 1st Stage and capacity expansion of 60,000 m3/day at the existing Kaolieo Treatment Plant for the 2nd Stage are considered for this alternative, T-2. Water supply system for Alternative T-2 is shown in Figure 45-5. Detailed specifications of the treatment facilities for alternative T-2 are attached to Annex 14.

2) Pipelines

<u>1st Stage</u>

- Clear Water Transmission Pipelines: Installation of 10.6 km of pipelines
- Distribution Trunk Mains: Installation of 22.7 km of pipelines
- Distribution Centre: Construction of a new distribution centre with a capacity of 40,000 m3/day

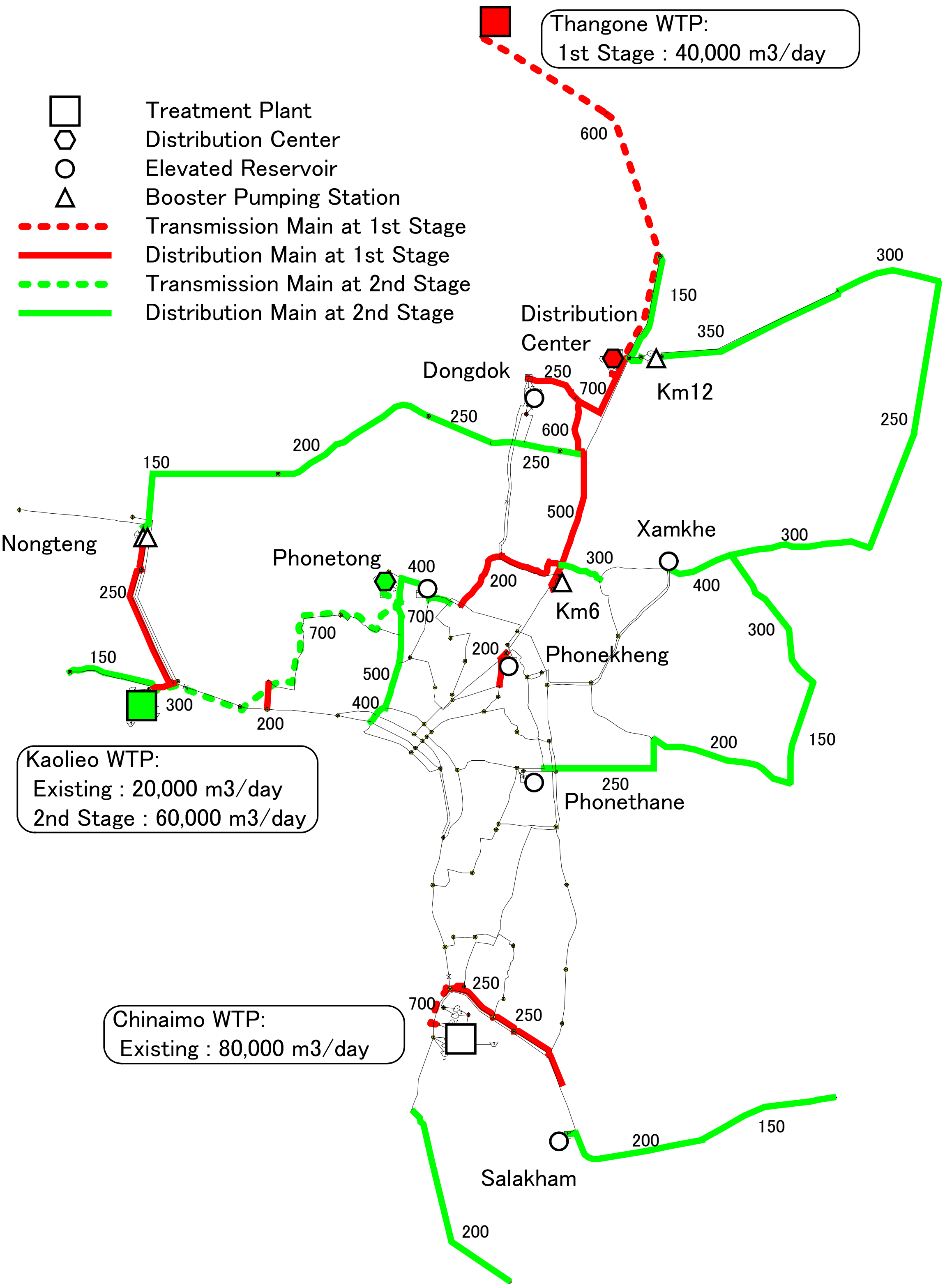
<u>2nd Stage</u>

- Clear Water Transmission: Installation of 9.9 km of pipelines
- Distribution Centre: Construction of a new distribution centre with a capacity of 60,000 m3/day
- Booster Pumping Stations: Improvement of the Km12 BP station
- Distribution Trunk Mains: Installation of 71.9 km of pipelines

For this alternative, improvement of the Km6 BP station in the 1st Stage will not be required because the water supply to the northern area of the city can be covered from the new distribution centre which will be located near the junction of National Road No. 10 and 13. Improvement of the Km12 BP station in the 2nd Stage will be necessary mainly for water supply to the new industrial area in the eastern part of the city.

For the 2nd Stage, clear water is transmitted from the Kaolieo Treatment Plant to a distribution centre and then distributed to consumers. The distribution centre is proposed to be constructed in the Phonetong area in the northern part of the downtown central Vientiane.

Figure 45-5 Water Supply System for Alternative T-2



3) Costs (Construction, O/M)

Based on the results of facility planning for alternative T-2, preliminary cost estimates have been conducted for the alternative comparison. The results of the cost estimates are as shown in Table 45-7 in US Dollars.

Table 45-7 Preliminary Cost Estimates for Alternative T-2

(x 1,000 US$)

Alternative T-2	Total	Foreign	Local
1. Construction Cost	59,882	41,493	18,389
1.1 Treatment Plants	22,979	14,875	8,104
Expansion of Kaolieo T.P.	13,427	8,693	4,734
Construction of Thangone T.P.	9,552	6,182	3,370
1.2 Clear Water Transmission Pipelines	13,494	11,003	2,491
For the 1st Stage	6,456	5,203	1,253
For the 2nd Stage	7,038	5,800	1,238
1.3 Distribution Center	7,882	5,348	2,534
For the 1st Stage	3,506	2,364	1,142
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	366	294	72
For the 1st Stage	-	-	-
For the 2nd Stage	366	294	72
1.5 Distribution Trunk Mains	15,161	9,973	5,188
For the 1st Stage	5,228	3,694	1,534
For the 2nd Stage	9,933	6,279	3,654
2. Operation and Maintenance Cost	6,852	907	5,945
2.1 Electricity	5,713	-	5,713
Expanded Kaolieo T.P.	846	-	846
Thangone T.P.	1,780	-	1,780
Distribution Center	2,398	-	2,398
Booster Pump Station	689	-	689
2.2 Chemical Cost	907	907	-
Expanded Kaolieo T.P.	402	402	-
Alum	384	384	-
Polymer	10	10	-
Chlorine	8	8	-
Thangone T.P.	505	505	-
Alum	248	248	-
Chlorine	257	257	-
2.3 Salary	232	-	232
Treatment Plant	232	-	232
Expanded Kaolieo T.P.	16	-	16
Thangone T.P.	216	-	216
Total Costs	66,734	42,400	24,334

(5) Alternative T-3

1) Intake and Treatment Plant

<u>1st Stage (Construction of New Thangone Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities in the Nam Ngum River
- Treatment Plant: Construction of 40,000 m3/day

<u>2nd Stage (Expansion of Thangone Water Treatment Plant)</u>

- Intake Facilities: Use of existing intake structure, addition of pumps
- Treatment Plant: Expansion of 60,000 m3/day

A new treatment plant with a capacity of 40,000 m3/day at Thangone for the 1st Stage and capacity expansion of 60,000 m3/day at same Thangone Treatment Plant for the 2nd Stage are considered for this alternative, T-3. Water supply system for Alternative T-3 is shown in Figure 45-6. Detailed specifications of the treatment facilities for alternative T-3 are attached to Annex 14.

2) Pipelines

<u>1st Stage</u>

- Clear Water Transmission Pipelines: Installation of 10.6 km of pipelines
- Distribution Centre: Construction of a new distribution centre with a capacity of 40,000 m3/day
- Distribution Trunk Mains: Installation of 22.7 km of pipelines

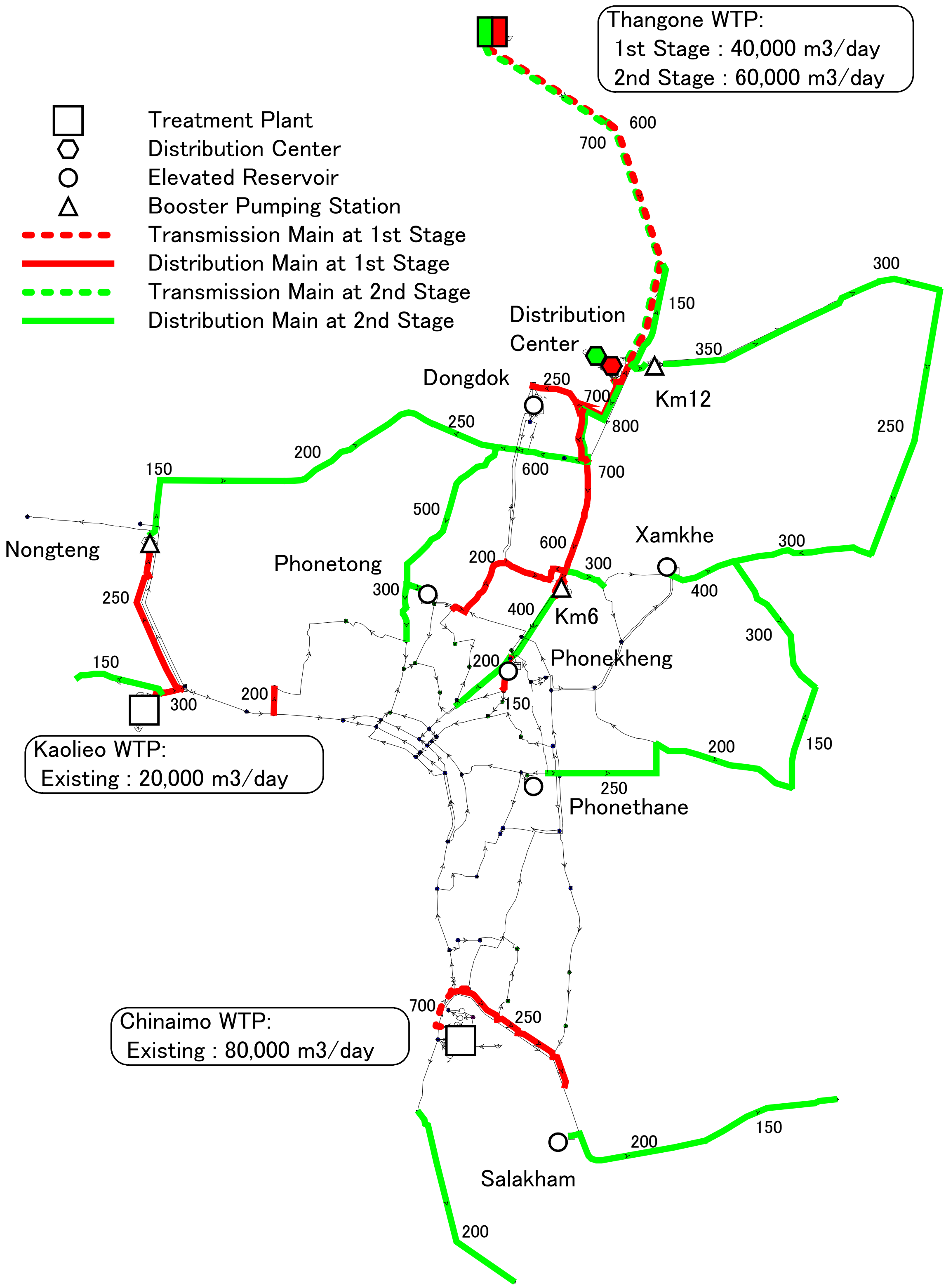
<u>2nd Stage</u>

- Clear Water Transmission: Installation of 10.6 km of pipelines
- Distribution Centre: Expansion of the distribution centre for 60,000 m3/day
- Booster Pumping Stations: Improvement of the Km6 and Km12 BP stations
- Distribution Trunk Mains: Installation of 87.9 km of pipelines

For both of the 1st and 2nd Stages, clear water will be transmitted from the new Thangone Treatment Plant to a distribution centre and then distributed to consumers. The distribution centre is proposed to be constructed in the Dongdok area near the junction of the National Roads No.10 and No.13 in the northern part of the city.

For this alternative, improvement of the Km6 BP Station in the 1st Stage will not be required because the water supply to northern area of the City can be covered directly from the new distribution centre. However, in the 2nd Stage, improvement of the Km6 BP Station will be required for supply to the downtown from the distribution centre. Improvement of the Km12 BP Station in the 2nd Stage will be necessary mainly for water supply to new industrial area in the eastern part of the City.

Figure 45-6 Water Supply System for Alternative T-3



3) Costs (Construction, O/M)

Based on the results of facility planning for alternative T-3, preliminarily cost estimates have been conducted for the alternative comparison. The results of the cost estimates are as shown in Table 45-8 in US Dollars.

Table 45-8 Preliminary Cost Estimates for Alternative T-3

(x 1,000 US$)

Alternative T-3	Total	Foreign	Local
1. Construction Cost	67,127	47,556	19,571
1.1 Treatment Plants	22,367	14,666	7,701
Construction of Thangone T.P. (1st Stage)	9,552	6,182	3,370
Construction of Thangone T.P. (2nd Stage)	12,815	8,484	4,331
1.2 Clear Water Transmission Pipelines	13,977	11,401	2,576
For the 1st Stage	6,456	5,203	1,253
For the 2nd Stage	7,521	6,198	1,323
1.3 Distribution Center	7,882	5,348	2,534
For the 1st Stage	3,506	2,364	1,142
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	677	546	131
For the 1st Stage	-	-	-
For the 2nd Stage	677	546	131
1.5 Distribution Trunk Mains	22,224	15,595	6,629
For the 1st Stage	5,876	4,268	1,608
For the 2nd Stage	16,348	11,327	5,021
2. Operation and Maintenance Cost	7,159	818	6,341
2.1 Electricity	6,109	-	6,109
Thangone T.P. (1st Stage)	1,780	-	1,780
Thangone T.P. (2nd Stage)	966	-	966
Distribution Center	2,398	-	2,398
Booster Pump Station	965	-	965
2.2 Chemical Cost	818	818	-
Thangone T.P. (1st Stage)	505	505	-
Alum	248	248	-
Chlorine	257	257	-
Thangone T.P. (2nd Stage)	313	313	-
Alum	154	154	-
Chlorine	159	159	-
2.3 Salary	232	-	232
Treatment Plant	232	-	232
Thangone T.P. (1st Stage)	216	-	216
Thangone T.P. (2nd Stage)	16	-	16
Total Costs	74,286	48,374	25,912

4.5.7 Comprehensive Comparison

(1) Technical Aspects (Construction, O/M)

As mentioned in Table 45-1 “Preliminary Comparison and Evaluation of Alternatives”, significant factors to exclude certain alternatives from the preliminary alternative comparison were not found.

1) Intake Facilities

In case of the 40,000 m3/day expansion of the existing Chinaimo Treatment Plant during the 1st Stage, alternatives C-1 and C-2, additional intake structures will not be required because the existing intake facility was designed and constructed for a capacity of 120,000 m3/day. This advantage, is reflected in the cost comparison.

2) Quality of Raw Water

The quality of raw water from the Nam Ngum River is much better than from the Mekong River because the lower turbidity from the Nam Ngum requires less use of coagulants. Proposed treatment plants for alternative T-2 in both the 1st Stage and 2nd Stage, will be constructed at Thangone and take raw water from the Nam Ngum River. On the other hand alternative C-2 would expand the existing two treatment plants on the Mekong River. This advantage is, however, is reflected in the cost comparison.

3) Conformity to Other Projects

The AFD Project for pipeline installation works are on-going and will be completed in 2004. The service area will be expanded by this project, but no water supply will be secured, especially in the Nongteng and Phonegtong areas. For supplying water to these areas, expansion of the existing Kaolieo Treatment Plant in the 1st Stage, Alternative K-1, has advantages.

4) Human Resources

If a new treatment plant is constructed in the 1st Stage, a new organisation for the new plant should be established with about 35 staff including engineers and skilled operators. Employment and training of these staff members should be treated as a priority. Therefore, Alternatives T-2 and T-3 have disadvantage comparing with other alternatives. This advantage is, however, is reflected in the cost comparison.

5) Land Space Availability

If the new treatment plant is constructed in the 1st Stage, new land space of about 2 ha for the new plant should be provided within a few years. Land space for alternatives C-1, C-2 and K-1 are available within the existing plant premises. Therefore, alternatives T-2 and T-3 have disadvantages compared with the other alternatives.

6) Suspension of Water Supply

During the rehabilitation of the existing Kaolieo Treatment Plant in the 1st Stage, the plant should periodically stop its operations and water supply services should be suspended. In the case of alternative K-1, after completion of the 40,000 m3/day expansion, the existing Kaolieo Treatment Plant can interrupt its operations, making the rehabilitation work much easier.

(2) Preliminary Cost Estimates for Planned Facilities for Each Alternative

Based on the result of facility planning for each alternative, preliminary cost estimates for each alternative are summarized on Table 45-9 in US$ and are also shown in Japanese Yen, converted from the US$ amount. The exchange rate used in these calculations is based on the Japanese Yen to US$ as 119 yen to the Dollar, as of April 30, 2003. The Figures 45-7 to 9 shows the cost comparison for the 1st Stage, 2nd Stage and the combined total of the two stages.

Table 45-9 Preliminary Cost Estimates for Each Alternative

In US$

(x 1,000 US$)

Construction Cost	C-1	C-2	K-1	T-2	T-3
1st Stage					
Treatment Plants	8,782	8,782	9,624	9,552	9,552
Clear Water Transmission Pipelines	**1,234**	**1,678**	**1,234**	**6,456**	**6,456**
Distribution Center	0	0	0	3,506	3,506
Booster Pump Station	737	737	737	0	0
Distribution Trunk Mains	**7,977**	**8,681**	**6,394**	**5,228**	**5,876**
Sub-total	18,730	19,878	17,989	24,742	25,390
	(741)	(1,889)	0	(6,753)	(7,401)
2nd Stage					
Treatment Plants	13,427	13,427	13,427	13,427	12,815
Clear Water Transmission Pipelines	7,521	7,038	7,521	7,038	7,521
Distribution Center	4,376	4,376	4,376	4,376	4,376
Booster Pump Station	366	874	366	366	677
Distribution Trunk Mains	12,094	14,196	11,156	9,933	16,348
Sub-total	37,784	39,911	36,846	35,140	41,737
	(2,644)	(4,771)	(1,706)	0	(6,597)
Total	**56,514**	**59,789**	**54,835**	**59,882**	**67,127**
	(1,679)	**(4,954)**	**0**	**(5,047)**	**(12,292)**

In Japanese Yen

(x 1,000 yen)

Construction Cost	C-1	C-2	K-1	T-2	T-3
1st Stage					
Treatment Plants	1,045,058	1,045,058	1,145,256	1,136,688	1,136,688
Clear Water Transmission Pipelines	146,846	199,682	146,846	768,264	768,264
Distribution Center	0	0	0	417,214	417,214
Booster Pump Station	87,703	87,703	87,703	0	0
Distribution Trunk Mains	949,263	1,033,039	760,886	622,132	699,244
Sub-total	2,228,870	2,365,482	2,140,691	2,944,298	3,021,410
	(88,179)	(224,791)	0	(803,607)	(880,719)
2nd Stage					
Treatment Plants	1,597,813	1,597,813	1,597,813	1,597,813	1,524,985
Clear Water Transmission Pipelines	894,999	837,522	894,999	837,522	894,999
Distribution Center	520,744	520,744	520,744	520,744	520,744
Booster Pump Station	43,554	104,006	43,554	43,554	80,563
Distribution Trunk Mains	1,439,186	1,689,324	1,327,564	1,182,027	1,945,412
Sub-total	4,496,296	4,749,409	4,384,674	4,181,660	4,966,703
	(314,636)	(567,749)	(203,014)	0	(785,043)
Total	**6,725,166**	**7,114,891**	**6,525,365**	**7,125,958**	**7,988,113**
	(199,801)	**(589,526)**	**0**	**(600,593)**	**(1,462,748)**

119 yen/$ as of April 30 2003

Note: Figures shown in brackets are a deviation from the alternative which shows the minimum cost. It should be noted that construction costs shown in the above table are costs only for alternative comparison. Common costs for all alternatives such as rehabilitation of the Kaolieo Treatment Plant, improvement of the Chinaimo Treatment Plant (including expansion of reservoir, additional distribution pumps, and installation of transmission pipelines), small diameter distribution pipelines, house connections, contingencies, and administration costs are excluded from the construction costs for alternative comparison. Therefore, construction costs shown above do not represent Total Project Costs.

Figure 45-7 Preliminary Cost Estimates for Each Alternative : 1st Stage

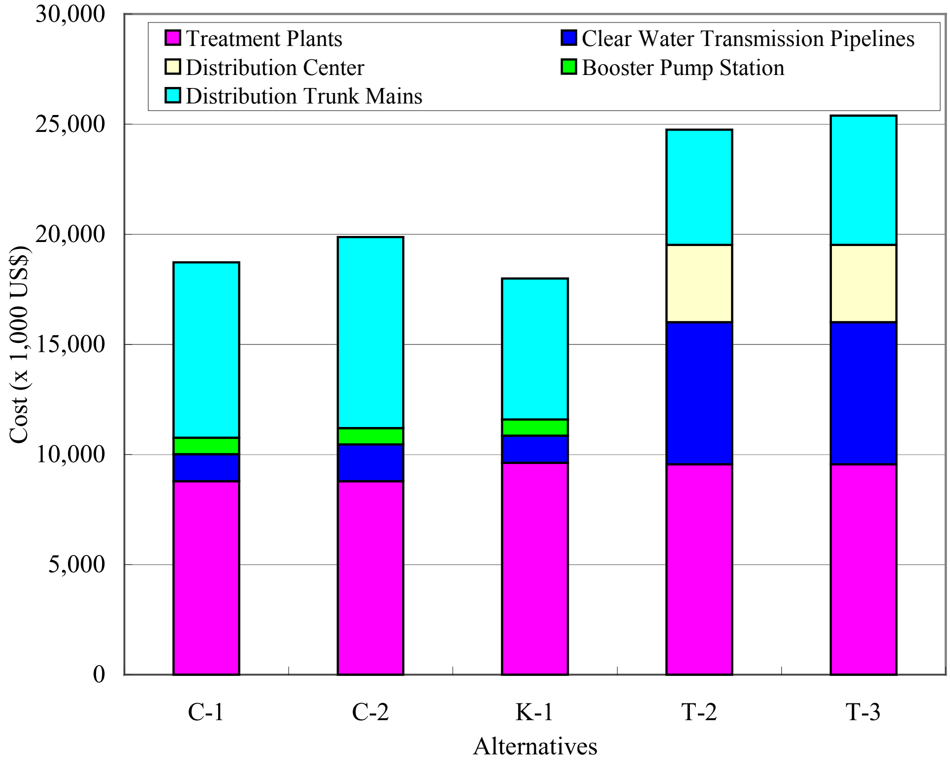


Figure 45-8 Preliminary Cost Estimates for Each Alternative : 2nd Stage

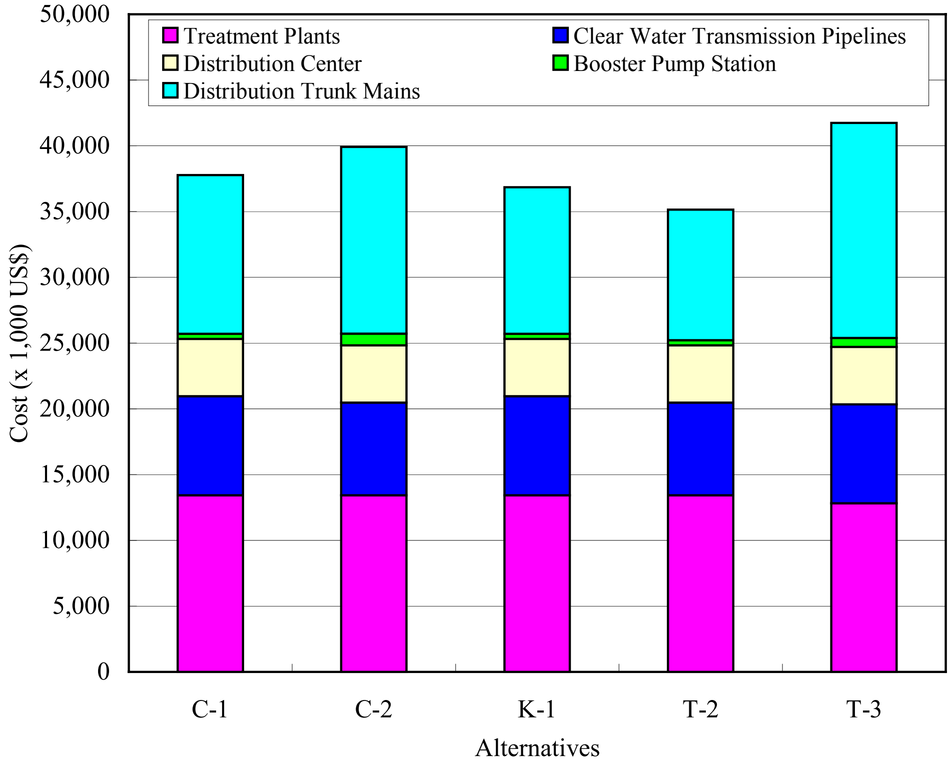
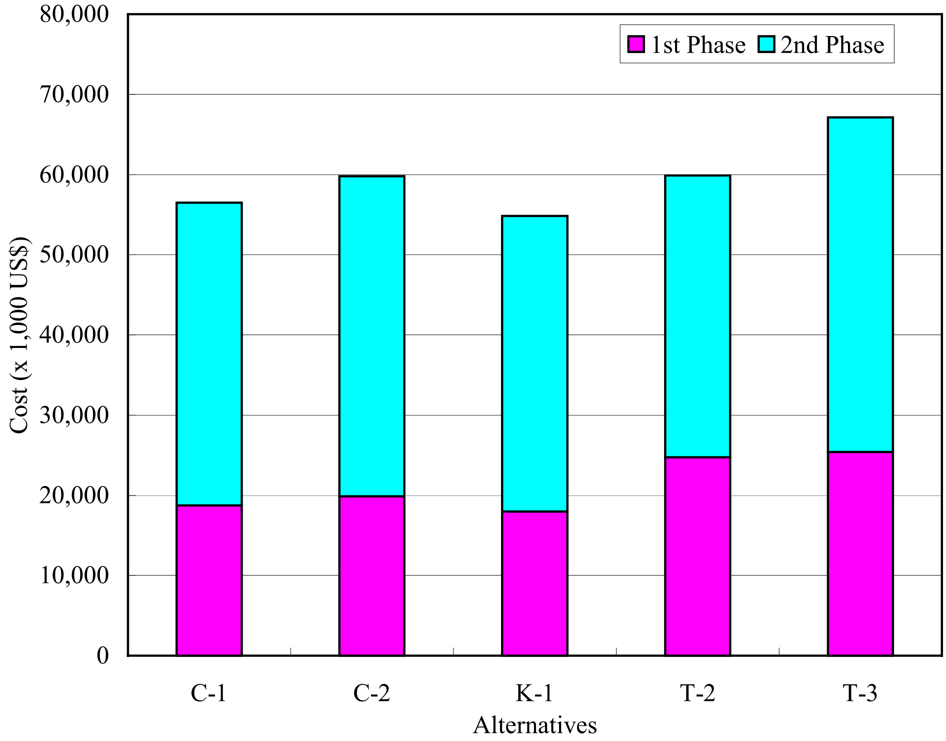


Figure 45-9 Preliminary Cost Estimates for Each Alternative : Two Stage Total

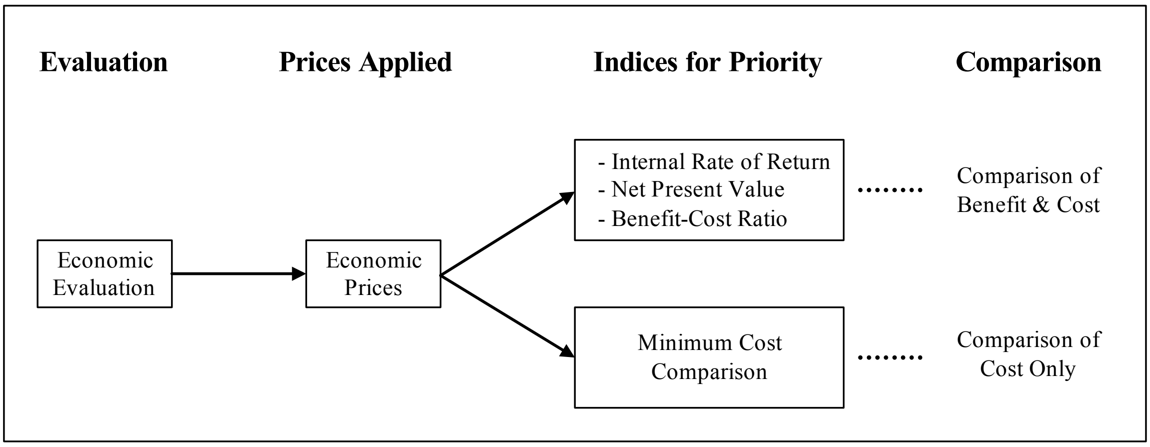


It should be noted that the construction costs shown in the above table and figures are costs only for the comparison of alternatives. Common costs for all alternatives such as rehabilitation of the Kaolieo Treatment Plant, improvement of the Chinaimo Treatment Plant (including expansion of reservoir, additional distribution pumps, and installation of transmission pipelines), small diameter distribution pipelines, house connections, contingencies, and administration costs are excluded from the construction costs for alternative comparison. Therefore, construction costs shown above **do not represent Total Project Costs**.

(3) Economic Evaluation

There are five alternatives for the comparative study, as discussed in the engineering discussion. In this section, these alternatives are analysed from an economic point of view. Then the best alternative is selected through a process of economic evaluation. The benefits of the respective alternatives are considered to be equal. Thus, a method of "minimum cost comparison" is considered the way to select the best alternative, instead of a general comparison of benefits and cost. As shown in Figure 45-10 below, the best alternative is selected from the minimum cost comparison from among all the alternatives. The costs are evaluated in economic terms. Economic costs and financial costs are discussed in detail in Section 4.11. The project costs are originally estimated based on market prices, so they have to be converted to economic prices applying conversion factors. In addition, operation and maintenance (O&M) costs are also converted to economic costs in the same procedure. Results of the conversion from the financial costs to the economic costs for each alternative are attached in Annex 16.

Figure 45-10 Project Evaluation Methodology

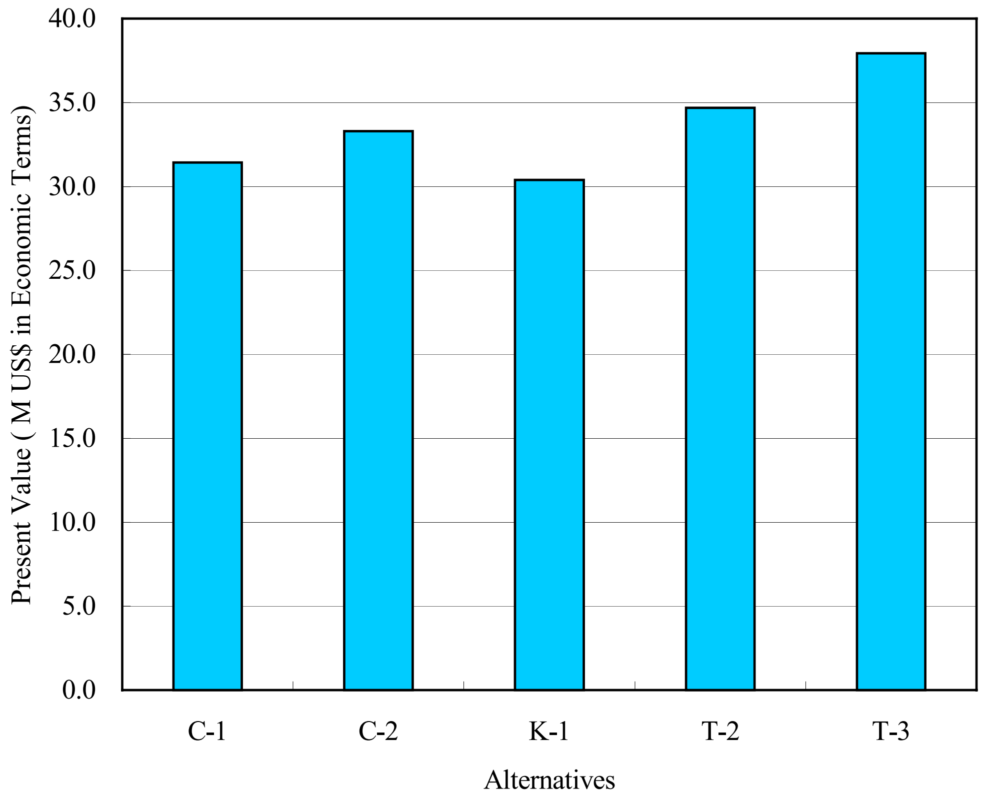


The present values of the respective alternatives are tabulated in Section 4.5.6. The present value is calculated applying the discount rate of 12% and the evaluation period of 30 years after the completion of the projects. These calculations are summarised in Table 45-10 and Figure 45-11. Accordingly, the alternative, K-1 is selected as the best project among the five alternatives, from an economic point of view.

Table 45-10 Present Values of Alternatives

	Alternative	Present Value (US$ Million in Economic Terms)	Index (K-1 = 100)
1.	C-1	31.4	103
2.	C-2	33.3	110
3.	K-1	30.4	100
4.	T-2	34.7	114
5.	T-3	37.9	125

Figure 45-11 Net Present Value of Each Alternative



(4) Influence by the Delay of Distribution System Improvement

In addition to the comparative study of alternatives, influence which will be caused by the delay of distribution system improvement has been analyzed focusing on the 1st Stage Projects. Before the commencement of the Study, the study demarcation was agreed among the Lao PDR side, AFD, and JICA. According to the agreement, JICA would solely establish a master plan. Then the feasibility studies would be conducted by the JICA on intake, water treatment plant, and transmission facilities, and on the other hand the AFD would conduct feasibility study on distribution system. Since there is no financial commitment made by any donor at the moment, there is a possibility of time lag of completion of implementation. In case, implementation of the distribution system improvement was delayed, incremental treated water could not be distributed effectively.

In order to minimize such bad influence which will be caused by the time lag of the implementations, the required distribution mains to distribute water from the proposed treatment plant and from transmission mains were identified as counter measures for each alternative. The required distribution mains will not be the same as the distribution mains which were planned at the alternative study, because the required distribution mains for this analysis are only for the 1st Stage and diameter of pipes were decided without consideration of the development under the 2nd Stage. The alternatives examined here were, therefore, only three alternatives, Alternatives C: expansion of the existing Chinaimo WTP, Alternative K: expansion of the existing Kaolieo WTP, and Alternative T which will be newly constructed at Thangone area.

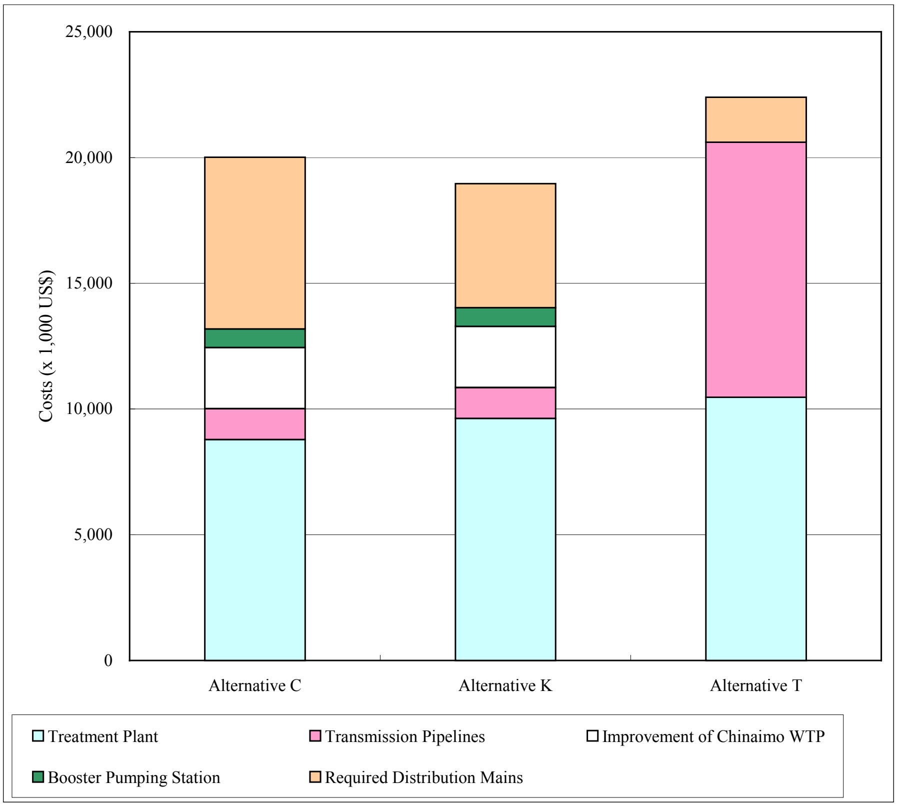
Costs required for the required distribution mains which will be required to accommodate incremental production capacity are added to the construction costs and total costs are compared as shown on Figure 45-12. As the results of the analysis, Alternative K is evaluated as the plan which would be the least influenced by the delay of the implementation of the distribution system improvement. Details of the analysis are described in Annex 20.

(5) Selection of the Best Alternative by the Least Cost Method

As described in the previous section, the least cost alternative and the lowest influenced alternative is alternative K-1. Alternative K-1 is therefore selected as the best alternative plan. It is therefore recommended to implement water supply system development by the best option, alternative K-1.

Figure 45-12 Results of the Analysis

x 1,000 US$	Alternative C	Alternative K	Alternative T
Treatment Plant	8,782	9,624	10,461
Transmission Pipelines	1,234	1,234	10,144
Improvement of Chinaimo WTP	2,433	2,433	0
Booster Pumping Station	737	737	0
Required Distribution Mains	6,829	4,936	1,792
Total	20,014	18,964	22,397



4.5.8 Detailed Features of the Best Alternative

(1) Features of the Best Alternative

1) Treatment Facilities

<u>1st Stage (Expansion of the existing Kaolieo Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities in the Mekong River

- Treatment Plant: Capacity expansion of 40,000 m3/day

<u>2nd Stage (Construction of the new Thangone Water Treatment Plant)</u>

- Intake Facilities: Construction of new intake facilities in the Nam Ngum River

- Treatment Plant: Construction facilities capable of producing 60,000 m3/day

Treatment and processing is planned to be the same as those at the existing Chinaimo Treatment Plant. Detailed features of the treatment facilities are shown in Table 45-11.

Table 45-11 Detailed Features of Treatment Plant for the Best Alternative

First Stage		Expansion of 40,000 m3/day	Second Stage		Construction of 60,000 m3/day
Planned Components of Expansion of Kaolieo Treatment Plant			Planned Components of Construction of Thangene Treatment Plant		
Intake Facility	Intake Structure	Construction of New Intake	Intake Facility	Intake Structure	Construction of New Intake
	Intake Pump	15.3 m3/min ×65 kW×3 Units		Intake Pump	15.3 m3/min ×140 kW×4 Units
Raw Water Transmission Pipe		D700 mm×L40 m, Ultrasonic Flow Meter	Raw Water Transmission Pipe		D900 mm×L530 m, Ultrasonic Flow Meter
Receiving Well & Mixing Well	Receiving Well!	1 Basin, D.T.=2.3 min.	Receiving Well & Mixing Well (Same Size for Direct Filtration)	Receiving Well	1 Basin (1 Basin), D.T.=2.4 min.
	Mixing Well	1 Basin, D.T.=1.0 min.		Mixing Well	1 Basin (1 Basin), D.T.=1.0 min.
Flocculation & Sedimentation Basin	Flocculation Basin	Up and Down Flow Baffle Channel 2 Units/Basin×2 Basins, D.T.=28.3 min.	Flocculation & Sedimentation Basin	Flocculation Basin	Up and Down Flow Baffle Channel 2 Units/Basin×3 Basins, D.T.=27.1 min.
	Sedimentation Basin	Horizontal Flow /w Launder Trough, 2 Basins D.T.=2.40 hr, Ave.Velocity=0.36 m/min.		Sedimentation Basin	Horizontal Flow /w Launder Trough, 3 Basins D.T.=2.00 hr, Ave.Velocity=0.37 m/min.
Filtration Facility	Filter Basin	A=78.0 m2×4 Basins, V=141 m/d	Filtration Facility	Filter Basin	A=78.1 m2×6 Basins, V=141 m/d
	Filter Washing Equipment	B.W.P.: 47.0m3/min×70kW×2 Units A.B.P.: 94.6m3/min×90kW×2 Units		Filter Washing Equipment	B.W.P.: 47.0m3/min×70kW×2 Units A.B.P.: 94.6m3/min×90kW×2 Units
Filtered Water Measurement & Chlorine Mixing Chamber	Measurement Chamber	1 Basin, D.T.=1.8 min.	Filtered Water Measurement & Chlorine Mixing Chamber	Measurement Chamber	1 Basin, D.T.=1.8 min.
	Mixing Chamber	1 Basin, D.T.=0.7 min.		Mixing Chamber	1 Basin, D.T.=0.7 min.
Clear Water Reservoir	Clear Water Reservoir	V=10,000 m3	Clear Water Reservoir	Clear Water Reservoir	V=5,000 m3
	Piping	D700mm, D600mm		Piping	D900mm
Distribution Pumping Facility	Distribution Pump Building	A=250 m2	Transmission Pumping Facility	Transmission Pump Building	A=320 m2
	Distribution Pump	12.1 m3/min ×67m×195 kW×4 Units		Transmission Pump	10.5 m3/min ×42.5m×110 kW×5 Units
Chemical Feeding Facility	Chemical Feeding Equipment	Installation of Equipment and Solution Tank	Chemical Feeding Facility	Chemical Feeding Equipment	Installation of Equipment and Solution Tank
	Chemical Building	In preparation for Administration Building		Chemical Building	In preparation for Administration Building
Electrical Equipment Facility	Power Receiving Facility	Power Receiving and Transformer Equip.	Electrical Equipment Facility	Power Receiving Facility	Power Receiving and Transformer Equip.
	Power Supply Facility	Power Supply Equipment		Power Supply Facility	Power Supply Equipment
	Emergency Generator	Generator Cap. for 1/3of Dis. Pump Cap.		Emergency Generator	Generator Cap. for 1/3 of Tran. Pump Cap.
	Instrumentation Equipment	Monitoring, Supervising and Controlling		Instrumentation Equipment	Monitoring, Supervising and Controlling
Administration Building		A=300m2×2F	Administration Building		A=300m2×2F,
Laboratory		In preparation for Administration Building	Laboratory		In preparation for Administration Building
Landscaping and Others		Including demolition & relocation of existing housings	Landscaping and Others		

2) Pipelines

1st Stage

- Clear Water Transmission Pipelines: Installation of 2.2 km of pipelines, see Table 45-15
- Booster Pumping Stations: Improvement of the Km6 BP station, see Table 45-12
- Distribution Trunk Mains: Installation of 24.2 km of pipelines, see Table 45-15

2nd Stage

- Clear Water Transmission: Installation of 10.6 km of pipelines, see Table 45-16
- Distribution Centre: Construction of a new distribution centre with a capacity of 60,000 m3/day, see Table 45-13
- Booster Pumping Stations: Improvement of Km12 BP station, see Table 45-14
- Distribution Trunk Mains: Installation of 73.6 km of pipelines, see Table 45-16

Table 45-12 Improvement of Km6 Booster Pumping Station in the 1st Stage

Planned Components of Facility		
Booster Pumping Facility	Pump House	A=45 m2
	Transmission Pump	4.8 m3/min. x 50 m x 57 kW x 2 Units
	Distribution Pump	6.0 m3/min. x 50 m x 72 kW x 3 Units
Electrical Equipment Facility	Power Receiving Facility	Power Receiving and Transformer Equipment
	Power Supply Facility	Power Supply Equipment
	Emergency Generator	Generator Capacity for 1/3 of Trans. & Dis. Pump Capacity
	Instrumentation Equipment	Monitoring, Supervising and Controlling
Landscaping and Others		Including demolition of the existing housing

Table 45-13 Construction of Distribution Centre in the 2nd Stage

Planned Components of Facility		
Clear Water Reservoir	Clear Water Reservoir	V=10,000 m3
	Piping	D900mm
Distribution Pumping Facility	Distribution Pump Building	A=320 m2
	Distribution Pump	13.5 m3/min ×67m×217 kW×5 Units
Electrical Equipment Facility	Power Receiving Facility	Power Receiving and Transformer Equipment
	Power Supply Facility	Power Supply Equipment
	Emergency Generator	Generator Cap. for 1/3 of Distribution Pump Capacity
	Instrumentation Equipment	Monitoring, Supervising and Controlling
Landscaping and Others		

Table 45-14 Improvement of Km12 Booster Pumping Station in the 1st Stage

Planned Components of Facility		
Booster Pumping Facility	Pump House	A=25 m2
	Distribution Pump	3.3 m3/min. x 60 m x 48 kW x 3 Units
Electrical Equipment Facility	Power Receiving Facility	Power Receiving and Transformer Equipment
	Power Supply Facility	Power Supply Equipment
	Emergency Generator	Generator Capacity for 1/3 of Distribution Pump Capacity
	Instrumentation Equipment	Monitoring, Supervising and Controlling
Landscaping and Others		Including demolition of the existing housing

Table 45-15 Pipeline Length by Diameters in the 1st Stage

	Distribution	Transmission	Total
Dia mm	Length m	Length m	Length m
150	2,840	0	2,840
200	0	0	0
250	9,450	0	9,450
300	1,380	0	1,380
350	320	0	320
400	0	0	0
450	4,890	2,220	7,110
500	0	0	0
600	4,660	0	4,660
700	680	575	1,255
800	0	0	0
900	0	0	0
Total	24,220	2,795	27,015

Table 45-16 Pipeline Length by Diameters in the 2nd Stage

	Distribution	Transmission	Total
Dia mm	Length m	Length m	Length m
150	13,260	0	13,260
200	18,160	0	18,160
250	16,770	0	16,770
300	14,270	0	14,270
350	5,880	0	5,880
400	1,790	0	1,790
450	0	0	0
500	0	0	0
600	650	0	650
700	2,860	10,580	13,440
800	0	0	0
900	0	0	0
Total	73,640	10,580	84,220

(2) Evaluation of the Selected Best Alternative

Selected alternative K-1, as the best alternative has the following advantages.

- The premises of the Kaolieo Treatment Plant can accommodate plant expansion in the 1st Stage without any additional land acquisition.
- After the 1st Stage of expansion of 40,000 m3/day, the capacity of the Kaolieo Treatment Plant will become 60,000 m3/day and the balance of production of the two existing treatment plants, Kaolieo at 60,000 m3/day and Chinaimo at 80,000 m3/day, will be adequate since the central Vientiane area is located between the two existing treatment plants.
- Water supply will be secured to the expanding service area, where pipe installation work is already in progress, financed by the AFD, in the northern part of the Kaolieo Treatment Plant in the 1st Stage
- After completion of the 40,000 m3/day expansion under the 1st Stage, rehabilitation of the existing plant will become much easier since the existing plant can stop its operations for rehabilitation.
- A sufficient raw water source is secured for the future.
- A minimum of additional staff for treatment plant operation will be required for the 1st Stage.
- Necessary arrangements for land acquisition for the 2nd Stage Thangone Treatment Plant will proceed during the 1st Stage. As the planned location of the new Thangone Treatment Plant is in the Irrigation College premises, the Ministry of Agriculture and Forest and will need time to find and procure more land in Thangone area.
- Recruiting and training staff for the new Thangone Treatment Plant will proceed during the 1st Stage.
- Chemical costs will be saved upon completion of new Thangone Treatment Plant in the 2nd Stage
- A dual-source water supply system will be established upon completion of the new Thangone Treatment Plant in the 2nd Stage

4.6 Reduction of Unaccounted-for Water

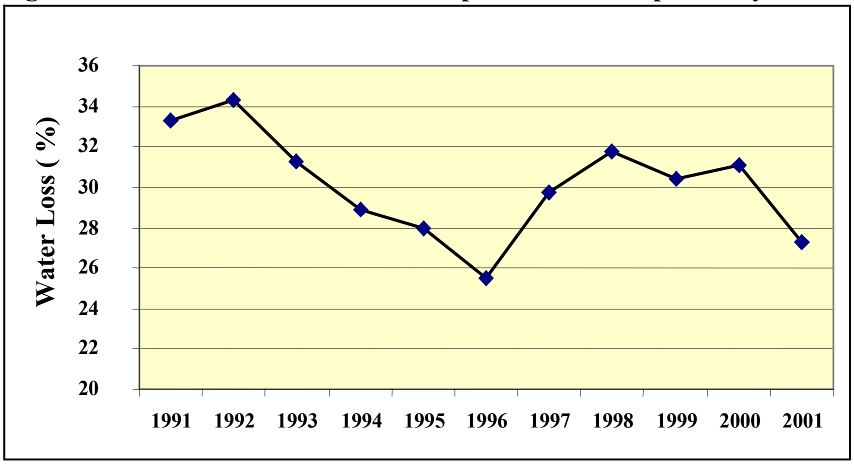
4.6.1 On-going Project for the Reduction of Unaccounted-for Water

(1) Water Loss in Nam Papa Vientiane Capital City

In 2002, the government of the Lao PDR and the French Development Agency concluded a project for the extension of the potable water supply network in Vientiane. The report prepared by a part of the project, the Leak Detection Campaign and Reduction Unaccounted-for Water of Nam Papa Vientiane Capital City, mentions that the losses in terms of volumes of unaccounted-for water represented about 30% of the water transmitted to the distribution network. Figure 46-1 shows the water loss since 1991.

The report mentioned that the figure showed a change when losses increased in 1997 which might be caused by the commissioning of the second phase of the Chinaimo Water Treatment Plant. The NPVC continues their leakage repair works.

Figure 46-1 Water Loss in Nam Papa Vientiane Capital City



Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

(2) Leak Detection Campaign and Reduction of Unaccounted-for Water by the French Development Agency (AFD)

Leak Detection Campaign and Reduction of Unaccounted-for Water, a part of the project for the extension of the potable water supply network in Vientiane, aimed at achieving the following two main objectives:

- To reduce the unaccounted-for water ratio from 30% to 25% in one or more pilot areas
- To establish a two-year action plan for reducing the unaccounted-for water ratio in the whole of Vientiane

The project was executed in the following 4 phases:

- Phase 1 (January 2002): Mission establishment, preliminary review and assessment, commencement of field activities.
- Phase 2 (February 2002): Preliminary field surveys and laboratory tests for completing the preliminary diagnosis and assessment, breakdown of losses by type, purchase of devices, staff training.
- Phase 3 (March, April and May 2002): Actions to reduce unaccounted-for water in the pilot zones. Newly purchased devices such as an acoustic correlator to be used during this stage.
- Phase 4 (May 2002): Assessment of the results and elaboration of a two-year action plan for the reduction of unaccounted-for water in the whole of Vientiane.

The following are the major points achieved through the project:

1) Zoning for Experimentation (Pilot Zones)

Five (5) pilot zones were chosen representing the situation in various districts of the city. The Five (5) pilot zones were formed as follows: two (2) zones in the Sisattanak branch office territory of the NPVC, and one (1) zone in each Sikhottabong, Xaisettha – Xaithani, and the Chanthabuli branch office territory. The total length of pipes and total number of connections of the five (5) zones were 125 km and 11,581 respectively. The main features of the zones are shown in Annex 17.

2) Leak Detection and Repair

Intensive leak detection was conducted in each zone. In addition, 1,600 customers were sampled and surveyed.

The result is summarized below:

- 624 places of leakage were detected,
- Among the 624 places of leakage, 74 leaks were detected along streets, and 550 leakages were detected at connections.
- Among the 624 detected places of leakage, 564 leakages were judged as small and 60 leakages were judged as large,
- From the 1,600 customers surveyed, 116 places of leakage out of were detected at connections.
- 74 % of the total leakages were repaired,
- An average of 4.1 places of leakage were detected for every one km of pipe, and
- Among the 4.1 places per km, an average of leakages from 3.6 places was judged as small and 0.5 places were judged as large.

Details of the leakage detected are shown in Annex 17.

All of the leakages detected were visible to an observer. Detection of invisible leakages by using equipment such as acoustic correlators, leak detectors etc. will be conducted after all of the visible leakages are repaired because the equipment is used to detect sound of leakage from leaking points, and with the present conditions, the volume of sounds are low due to low pressure in the pipelines.

3) Water Meter Investigation

Water meter investigations in each zone were conducted by testing on site, as well as by calibrating meters on a test bench in the NPVC workshop. In addition, consumption profiles were also surveyed with data logger for both small and large meters.

The result of investigation is summarized below:

- Anomalies were found with 1,059 water meters,
- 61 % of the anomalies were corrected,

The details of investigation results are shown in Annex 17.

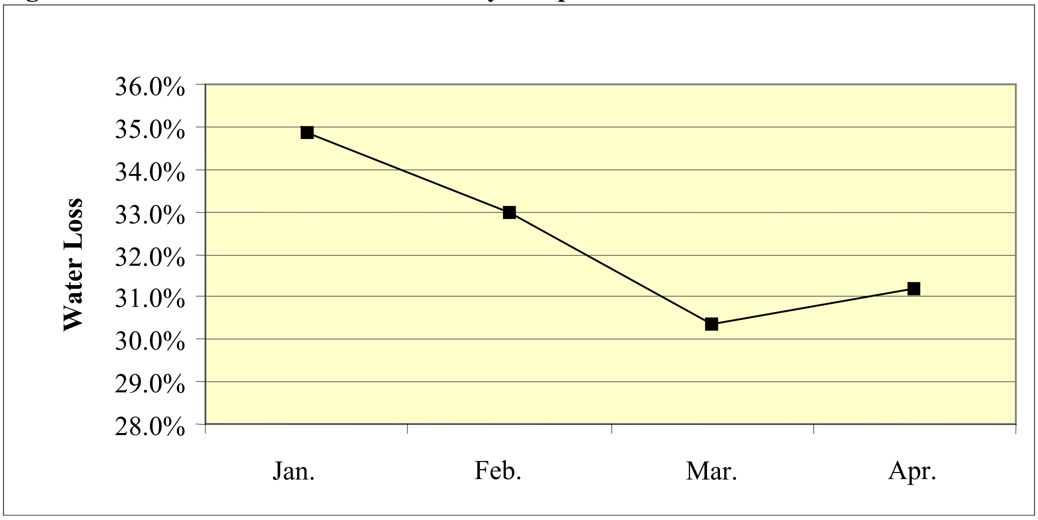
Investigation for water meters of large consumers who consumed more than 2,000m^3/month concluded that: (i) meters were not properly installed, (ii) there was a lack of accessories and fittings for the meter, and (iii) there was a lot of leakage from service pipes of large consumers, especially government authorities and institutions.

An investigation of 6 water meters of 15 mm diameter also showed that the size of the water meter was larger than the appropriate size because 24 % of the water consumed was below the transition flow rate (Qt). The transition flow Qt is a limit of permissible error specified by the standards for measuring and more error will occur in the measurement below the Qt.

4) Results of the project

The intensive detection of leakage and repairing works in the pilot zones resulted in an improvement of the UFW ratio as shown in Figure 46-2.

Figure 46-2 Water Loss from January to April in 2002



Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

The project concluded that the estimated volume of water saved by repairing visible leakages in the pilot zones was 138,000 m3/month or 3.9 % of the production volume. Analysis of leakage summarised the following breakdown of the UWF ratio, an average of 32.4 % as follows:

- Invisible leakage (19.1 %)
- Unreported visible leakage (7.0 %)
- Commercial loss and water meter error (4.7 %)
- Reported leakage and others (1.6 %)

If the NPVC repaired all visible leakages and some invisible leakages, the UFW ratio would be below 25 %.

4.6.2 Strategy for UFW Reduction

(1) Action plan for two years 2003 and 2004

The 5-month UFW reduction project concluded that it should be possible to reduce the ratio of UFW down to 25% by the end of 2004, provided that following conditions are effectively implemented:

a) Implementation of various sub-projects aiming for a reduction of physical and commercial losses (including metering losses)

b) Institutional strengthening of the NPVC including these various components of the organisation: a more adapted organization, improvement of the management information system (including the billing system), improved monitoring, staff training and responsibility.

The details of the action programme are explained in Annex 17.

(2) NPVC's Works for Reduction of UFW

The two year action plan consists of two major elements, reduction of physical and commercial loss, and restoration of the institution of the NPVC. The tasks required for the reduction of physical and commercial losses are mainly leak detection and repair, and replacement of defective water meters. The tasks required for the systematic improvement of the NPVC are providing technical assistance and training to NPVC staff and plans to sustain the implementation of the UFW reduction program. In addition, procurement of equipment and tools for leakage detection, and the procurement and installation of district meters are also planned in the two year action plan. Thus, the two year action plan is a preparatory plan to put the UFW reduction works carried out by the NPVC on track. The staff of existing sections or the newly established department for UFW reduction in the NPVC will be trained through the action plan and should continue to attend to their duties after the completion of the action plan.

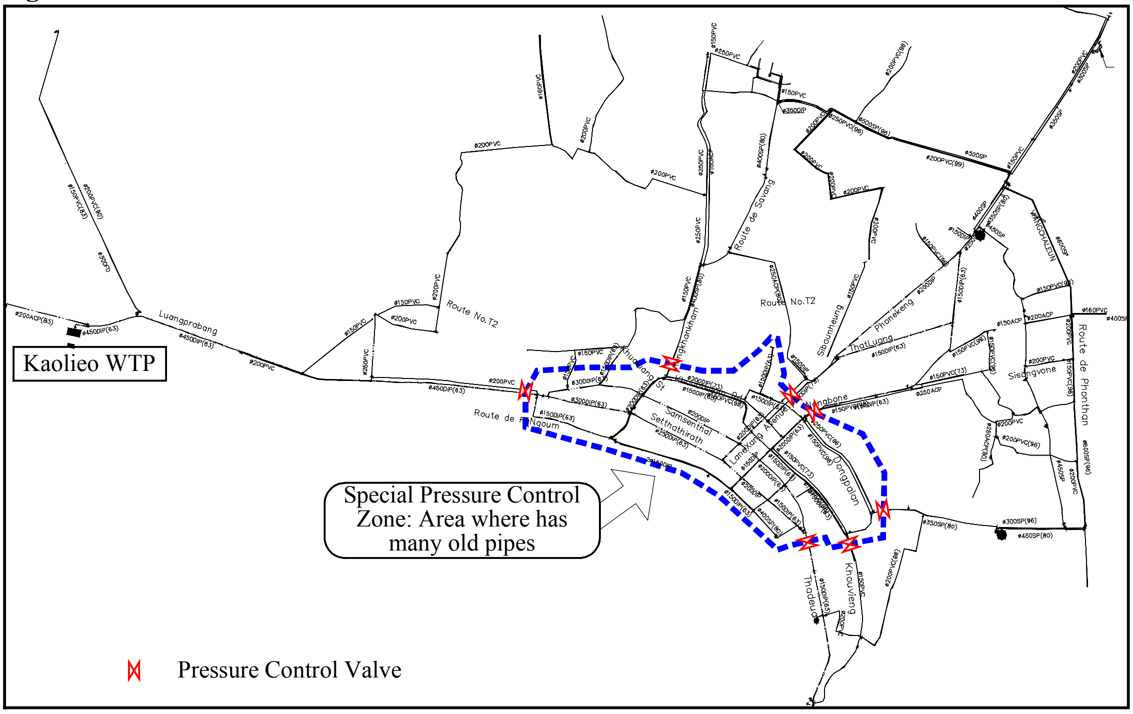
During the execution of works for leakage detection and repairs, the NPVC should extend the zoning area to adopt UFW reduction methods such as district metering, waste metering and the Step Test. Details of these methods are described in Annex 17. The five pilot zones were implemented during the 5 month intensive project in 2002 by the NPVC with the assistance of the AFD for data collection. In principle, zones should be formed and the schedule for the initial steps for the UFW reduction program in these zones should be: District Metering, followed by Waste Metering and, then the Step Test. Thus, district metering is proposed as an important component of the action plan, with waste metering and the Step Test to be applied in future.

4.6.3 Future UFW Level

As detailed above, it is recommended that the NPVC apply the methods widely used for detection of water loss such as District Metering, Waste Metering, and Step Test. However, those UFW reduction methods require modifications of the network i.e. zoning and provision of devises (valves) for isolation of the zones, the districts, and pipes for the Step Test. Zoning should be planned in accordance with the degree of development of the area. However, the improvement works, including repair leakages, has just started. Furthermore, implementation of the action plan for 2003 and 2004 has been delayed for a further year.

Although the establishment of zoning to measure leakage and to prioritize the UFW control area will require some time, a special zone can be established where water pressure can be effectively controlled. This can take place during the 1st Stage of the project implementation. The special pressure control zone is planned to be in central part of the city where the main pipelines were installed in the early 1960s, concurrent with the construction of the Kaolieo Treatment Plant. After the 1st Stage of the project is completed, the residual pressure of the service area will be increased to achieve a stable water supply, and the UFW level may actually increase because of the pressure increase. To avoid such a situation and to minimize increasing the UFW, during the establishment of the special pressure control zone, it is recommended that pressure control valves be installed on the zone boundary as illustrated in Figure 46-3.

Figure 46-3 Installation of Pressure Control Valves



After completion of the 1st Stage, in 2007, of the water supply system development works formulated by this Master Plan as well as the on-going pipe network expansion works, mostly new pipe installation, the pressure of the networks will be improved. However, the pressure improvement will cause more leakage in the network as shown in Figure 46-1, and mentioned above, and as a consequence, will require more repair works.

Towards the target year for completion of the 2nd Stage, 2012, repair works on leakages caused by pressure improvements resulting from the 1st Stage will be required. This will also happen after the completion of the 2nd Stage, and consequently repair works will be made during the 3rd Stage, target year 2015. However, leakage detection in the second and 3rd Stages will be conducted by using equipment such as an acoustic correlator and leak detector, or the Step Test, since most of visible leakage detected rather easily i.e. will be repaired in the early stages i.e. the 1st Stage. The estimated progress of UFW reduction in the second and 3rd Stages will be small, while the cost of detection will be higher than in the 1st Stage.

Taking the above mentioned situations into consideration, works for the reduction of UFW will be:

(1) 1st Stage (from the present to 2007)

- Visible leakage repairs (mains and service pipes to house connections)
- Zoning and installation of district meters (the pilot zones and newly formed zones)
- Replacement of defective water meters

(2) 2nd Stage (2008 to 2012)

- Invisible leakage repairs (mains and service pipes to house connections) detected by the district metering, waste water metering, the Step Test, and technical testing and equipment
- Zoning and installation of district meters (in the zones newly formed in the 2nd Stage)
- Replacement of defective water meters

(3) 3rd Stage (2013 to 2015)

- Invisible leakage repair, detected by the district metering, waste water metering, the Step Test, and use of technical testing and equipment
- Zoning and installation of district meters (in the zones newly formed in the 3rd Stage)

Taking account of the situation, development stages, and repair works mentioned above into consideration, the UFW ratio is estimated as follows:

Table 46-1 Expected UFW Ratio

Stage	Implementation Year	Development Works	Expected UFW Ratio
(Present)	2003	Network Pipes	33
First	Present to 2007	Treatment Plant, Network Pipes	28
Second	2008 to 2012	Treatment Plant, Network Pipes	25*
Third	2012 to 2015	Network Pipes	25

Note: *= Before commencement of the operation of the water treatment and distribution facilities, the estimated UFW is 25 %. However, the ratio will increase for a short period due to the pressure increase after commencement of the operation.

4.7 Operation and Maintenance

4.7.1 Organization and Institutional Aspect

The organization of the NPVC was reformed in April 2003 and consists of an administrative council, a board of directors, a general manager, 3 deputy general managers, 8 sections, 4 treatment plant and operation sections, 4 branch offices, a training centre, and a drinking water factory as described in Chapter 3.1. The total number of employees of the NPVC is 425 persons including 103 people employed on a contract base. The 4 sections for treatment and plant operations are directed by a deputy general manager who oversees the technical and production operations of the NPVC, and a total of 89 staff. The number of staff for the treatment plants, Chinaimo, Kaolieo, Thadeua, and Thangone are 35, 35, 14, and 5, respectively. In addition, the Construction and Maintenance section and the Survey and Design section are also under the direction of the same deputy general manager.

The proposed facilities to be constructed in the 1st Stage are:

- Expansion of production capacity of the Kaolieo WTP with a capacity of 40,000 m^3/day,
- Rehabilitation of the existing facilities in the Kaolieo WTP,
- Improvement of transmission and distribution facilities in the Chinaimo WTP,
- Improvement to the Km 6 booster pumps,
- Installation of transmission mains for 2.2 km, and
- Installation of distribution mains for 24.2 km.

The water treatment process of the expansion of Kaolieo WTP will be principally the same as the existing i.e. flocculation, horizontal sedimentation, and rapid sand filtration. However, the type of treatment facilities for the expanded works of the Kaolieo WTP will be similar to those of the Chinaimo WTP i.e. hydraulic mixing, flocculation by up-down flow, horizontal sedimentation basins with sludge extraction pits, and rapid sand filters by washing with air and water. For the improvement of transmission and distribution facilities, the present use of pumping facilities i.e. the combined functions of the transmission and distribution pipelines will be reorganised in order to apply the appropriate pumping facilities to their specified use. The characteristics of the flow of transmission pumping systems are different from that of distribution pumping systems namely, in distribution systems, the flow fluctuates, and in transmission systems, the flow is constant. After the pipelines are reorganised to their intended specifications, the operation of the pumps will be easier. and more efficient. Therefore, the operation of the Kaolieo and Chinaimo WTP's will be achieved by the present NPVC staff without difficulty.

With the extension of the mains pipe, the newly installed pipes will have less leakages and therefore will require less maintenance costs to the secondary and tertiary pipes, in consideration of the characteristics of secondary and tertiary pipes. The increase of water supply capacity by improved main pipes will require an extension of the secondary and tertiary pipes which are branched or connected to houses.

For the 2^{nd} Stage, the proposed works are as follows:

- Construction of a new WTP at Thangone with a capacity of 60,000 m^3/day,
- Construction of a distribution centre with pumping facilities,
- Improvement to the Km 12 booster pumps,
- Installation of transmission mains for 10.6 km, and
- Installation of distribution mains for 73.6 km.

A new operation team for the new treatment plant at Thangone, and the distribution centre will be required. However, the water treatment process of the new WTP will be similar to the Chinaimo WTP in the treatment of raw water. The operation of the new distribution centre will also be similar to those of the distribution facilities in the existing WTP's. Therefore, before completion of the second stage, the NPVC should organise new operation teams for the new facilities and provide on the job training to staff that have moved from the existing facilities or other sections, or who are newly employed staff by using the existing water works facilities currently in operation. It is expected that the organisation and training will be conducted without difficulty for the NPVC.

In addition, to deal with increasing customer connections, the NPVC should increase staffing for meter reading in line with the expansion of the water supply system.

4.7.2 Financial Aspect

The financial status of the NPVC in the past five years between 1998 and 2002 is summarised as:

- Concerning water rates, unit production costs during the four years from 1998 to 2001 were larger than the average unit prices. The average unit prices after tax were much smaller than the corresponding unit production costs. This is the reason why the NPVC recorded a final net deficit for the three years from 1999 to 2001.
- In December 2001, a new tariff was permitted by the government and applied to water consumers. It turned the NPVC profitable in 2002, but the net profit was comparatively small. The new unit production cost in 2002 was 529 kip/m^3. In the same year, the average unit price was calculated as 547 kip/m^3. The unit price after tax was 521 kip/m^3, so this still resulted in the NPVC running at an effective loss.
- The NPVC received financial aid of 3.8 trillion Kip from the government in 2002. As a result, the deficit accumulated over the previous three years was settled by means of this assistance.
- The present tariff made the NPVC a small net profit in 2002. The NPVC is planning to again revise the water tariff. In order to revise the tariff, the NPVC has to get permissions from WASA, the DCTPC, the Governor of Vientiane Capital City and, at the final stage, the Lao President. This procedure for revision of the tariff requires a long time.

The result of a customer survey conducted in the early stage of this study indicates that 49 % of the households supplied by the NPVC paid 10,000 to 30,000 Kip a month for their water bill. The average ratio of water bill to the household income is 1.4 %. Results of the survey for willingness to pay for their water bills shows that 40 % of household bills ranged from 5,000 to 10,000 Kip, followed by 28 %, whose bills ranged from 10,000 to 30,000 Kip. However, 70 % of households connected to NPVC purchase bottled water for drinking and cooking and 59 % of households spend 15,000 to 60,000 Kip a month for bottled water. In general, the range of affordability to pay for the water bill is 3 to 5 % of household income. Therefore, the NPVC is recommended to revise the water rate from a financial point of view, namely, a cost recovery policy subject to supplying safe and sufficient volumes of water, under the appropriate pressure.

Water sales will increase after the commencement of operations of the proposed water supply facilities. In addition, implementation of the project for the reduction of UFW initiated by AFD, will save water and consequently contribute to a cost reduction. Thus, the financial situation of the NPVC will be improved by the implementation of both projects, namely the proposed expansion of treatment works, and the reduction of UFW.

In conclusion, the NPVC will be able to operate and maintain the proposed facilities with their own personnel and financial resources.

4.8 Human Resource Development

4.8.1 Concept and Basic Idea

Water supply is indispensable for the citizen's life, urban activities and industrial development. To achieve this mission in a stable and sure manner, it is necessary for the water supply enterprise to utilize various resources that constitute an effective management of water supply. Resources of management are usually drawn from various sources, such as human resources, financial resources, physical (material) resources, and others. The importance of human resources cannot be over emphasized compared to other management resources.

For example, it is a human resource that pushes a switch on a machine, and any superior and complicated machine cannot move without the pushing of a switch by human means. Among management resources, the role of human resources is regarded as the most important. The definition of Human Resource Development in the context of water management means to develop the vocational ability needed for employees who are thought the most important for the management resources of the water supply enterprises.

Human physical ability is displayed as a form of energy. This energy is unified by the activities of the mind and the body, and enables us to complete physical tasks. The level of activity of the processes that controls our physical abilities is developed by learning and experiences. An important element for the understanding of human labour is the employees' 'self-will', or motivation,, i.e. 'morale'. It is necessary for the employers to raise the morale of staff, giving them the consciousness that they are needed, that they are contributing to the performance of the organisation. and that they feel that they play an important role in the organization.

The purpose of Human Resource Development (HRD) is not only to provide and improve the vocational ability of employees, but also to encourage the process of an awakening of their consciousness to facilitate the self development of the vocational ability and skills.

An employee usually has a lot of potential ability. If the employee's potential ability is discovered and trained through the applied principles of HRD, it is an asset not only for the employee themselves, but also the organization and society in general. With the proper opportunities, employees enjoy the chance to show their abilities in their work place.

Trained staff will assure a water utility's ability to survive and grow. Providing for trained staff is a managerial responsibility, with the utility management having a clear voice in determining what will be done, how it will be done, how the results will be evaluated. Training is a priority requirement for water utilities today. Managers must be aware that their organizations are always growing, always subject to internal and external pressures of change, and are constantly altering pace and direction.

Water works technology has expanded. Consumers demand fiscal accountability, rapid response time, and environmental quality. Newer, more sophisticated testing and monitoring procedures have led to more stringent regulations and controls. All of these affect how well a utility will survive. Workforce efficiency and effectiveness is the key to this survival and growth.

4.8.2. Techniques of Human Resource Development

(1) Basic Technical Methods

Three technical methods are usually applied as concrete methodologies of Human Resource Development in an organization. They consist of the followings, On the Job training (OJT), Off the job training, (Off JT) and Self-enlightenment.

These three technical methods are closely related to each other, and an effective HRD cannot be expected if any one of these elements is missing.

1) On the job training:

Generally, staff learn the basic matter of work through the accomplishment of work (man-to-man) in a daily work environment surrounded by fellow workers and a boss. This is a direct way of practice that develops the mastery of skills and improves abilities. An effective OJT programme will usually begin with two components; proper induction to the workplace and an understanding of expectations in job performance. These issues need to be thoroughly and clearly communicated to staff. When this practical training is directly and concretely related to first hand knowledge and practices, it brings an immediate effect.

2) Off the job training:

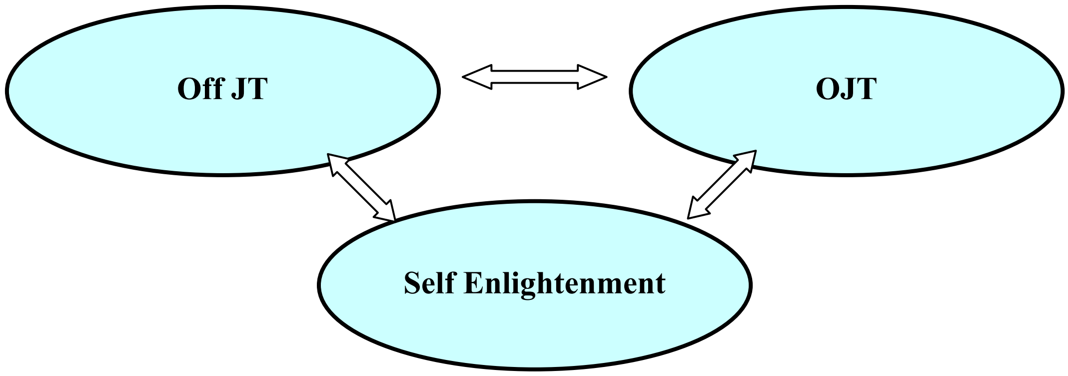
Staff learn specific subjects at places like the training centre. This involves leaving the work place for a while with the other trainees. The training is provided for certain subjects systematically and theoretically, without the restrictions of the daily work environment.

Interactions between trainees who come from various work places are a useful education tool in itself, as employees are learning about work environments outside of their own context. This kind of training is sometimes called 'In-company training' or 'In-service training'.

3) Self-Enlightenment:

In the place outside of work, staff may decide to learn vocational subjects which are undertaken at their own expense and time. This is usually self directed and shows a desire for self enlightenment. It is a starting point of the mental attitude for the worker to have the will to extend their ability of his occupation.

The purpose of Human Resource Development will be realized while these three elements are successfully used as a resource.



(2) Some training techniques

The development of various techniques in Human Resource Development have grown enormously since World War II, and they have been vigorously applied in various industries, depending on the situation.

Some of these techniques are:

1) Knowledge training: Problem discovery and Problem solution.

Structures of problem discovery:

i) Brain storming method：A method to discover (or invent) a new ideas through group discussions.

ii) Gordon method：used to discuss abstract themes.

iii) Case method：Handing an example to the trainees before attending the group discussion, a group of trainees find problems, evaluate information and make solutions.

iv) KT method：Problem analysis, decision making

2) Skill training- training to raise the skills of physical movement.

3) Sensitivity training - to raise ability towards other people by the changing of trainees attitudes and sense of values.

4) Organization Development (OD)

OD is defined as a process revolutionizing the corporate culture by utilizing the theories and techniques of behavioural science.

It includes the following steps:

i) To consider a complete change of the corporate structure if there is a problem or question, by checking the present organization and culture in a frozen state – a recognition of problems, the collection of data, and the diagnosis and restrucuring (defrosting the present situation).

ii) Revolutionization – a change in the behavioral plan and actions

iii) To re-defrost - after the revolutionization of the corporate structure, defrost the organization again. A stabilization and evaluation process follows.

The techniques of OD are as following:

i) Sensitivity Training

ii) Team Building

iii) Grid Seminars

iv) Data Feed-back methods

5) Career Development Programme (CDP)

CDP is defined as a course where the individuals life is expanded and they are able to proceed voluntary and continuously on their chosen path.

It involves

i) The formation of an employment record over one's life.

ii) A course which has expanse and widens one's specialized ability.

iii) It is continuous.

iv) Personal independence and voluntary behaviour plays a key role.

Structures for development are as follows;

i) Career field and Level

ii) Career path

iii) Assess & counselling system

iv) Training & Enlightenment

4.8.3 Long-Term Personnel Training

It does not take a long time to learn the mastery of skills of an occupation in the case of manual workers. However it is a complicated and time consuming process. Complicated training practices are necessary to transfer knowledge and experience about advanced techniques. Water supply enterprises are composed of a lot of various complicated systems supported by advanced technologies such as treatment plants, pumping stations, pipeline networks, etc, In order to operate and maintain these facilities adequately, on the basis of a sound financial foundation, staff are required to be equipped with advanced knowledge, experience and skills.

The required knowledge, experience and skills are not acquired in a short time. Therefore it takes a long time to train an expert for a water service enterprise. An effective HRD plan is necessary to efficiently train and prepare for the future security of the organisation.

4.8.4 Cooperation with Personnel Management

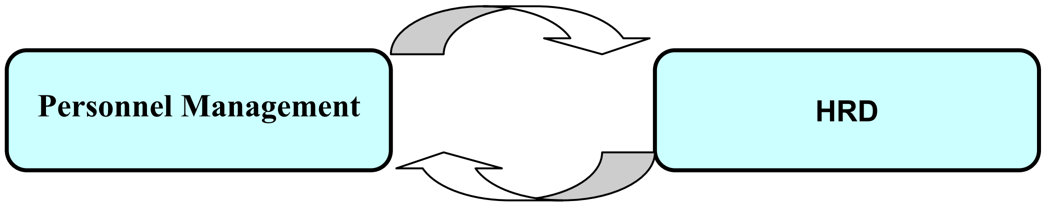
A water utility is an institutional industry and holds a lot of fixed assets, such as raw water reservoirs, intake facilities, water treatment facilitities, distribution pipeline networks and service supplies. They are closely connected to each other and are operated continuously throughout the year. Therefore, a water utility employs a lot of staff in various types of job including shift operators.

The types of job can be divided into the following three categories, clerical workers, technical and engineering workers and labourers. There is a hierarchy of authorities and the various responsibilities of the positions in the work place, and the authority and responsibilities are given for each position. Requirements or qualifications for positions should be defined, and the qualifications must be clearly substantiated by the duties and responsibilities of the job.

A manager is at the top of their assigned group and achieves the objectives of the group by collecting and concentrating the energy of the staff. In other words, the role of the manager is to push forward the staff's individual jobs without stagnation, and to train and evaluate the staff’s vocational ability. The responsibility for properly informing the staff of the requirements of a person’s job is that of the immediate supervisor. The evaluation process is tied to the improvement of the labour conditions. Evaluation of the vocational ability of a staff member is recorded periodically and personal management is carried out based on these evaluations. The evaluation of occupational ability is an important element of personal management, and it tied to Human Resource Development.

Employment, change of assignments, promotion, and retirement of staff are done from within the structure of each section or division. An appropriate personal management system based on an adequate evaluation of each staff member is essential for the development of the organization.

Individual personnel records including training are necessary and should be adequately kept and up-dated.



A promotion within the programme provides staff with the opportunity to progress to more responsible positions within organization. Employees should be fully informed of the qualifications needed for positions, and training should be provided so that staff are prepared for advancement. Adoption of a policy of publicizing positions vacant through posted notices within the organisation is recommended. With this method, staff are provided the opportunity to use their own initiative and self-enlightenment efforts to apply for, and be considered for promotion.

In this sense, it is important for the organization to maintain good levels of cooperation between personnel management and HRD.

4.8.5 Necessity of Training depending on Ability, Will and the Training Needs of Individual Staff

Training is planned in consideration of ability (on the basis of evaluation), self will and the training needs of individual staff members. The trainee is selected by the use of these principles. The company calculates the requirements of the skill levels of their employees, and the employee is required to develop their skills in a similar manner to the requirements of the companies. Self will, or motivation is the desire of the staff to attend training and the desire to extend their own abilities and development. Training needs is a necessity in water supply enterprises and they need take these issues into consideration with the above mentioned elements.

Even if a manager-supervisor of work place feels there is a necessity for staff training, this does not necessarily mean that the staff will accept this need. When the goal is unclear, the staff can be unsure of the reasons for training and the effects of the training are diminished, and so the expected results of the training are not transferred to the workplace. The careful selection criteria used in employing new staff will be wasted if they are not properly trained, and the grievance procedures established by the institution fails if the supervisor does not use them correctly, and the most accurate job classification plan will be useless if it is not followed.

4.8.6 The Planning for Workplace Expertise

A water supply enterprise is an organic entity gathered by various procedures, skills and knowledge,, and it is necessary for each operation to function in total harmony with each other so that they function systematically and effectively. It is necessary for the staff to acquire (or to reinforce) the necessary vocational knowledge and skills systematically according to their classes of position and types of job.

The whole system does not work well, if one section does not work normally (as expected), i.e., the section becomes a bottleneck. At each stage of the operation of the manufacturing process, staff must be trained so that they are expert in their roles and have access to first rate knowledge and technology.

Water has long been used for sanitary purposes, as well as for drinking and other domestic uses. The water utility realizes that safeguarding the quality of water supply means the requirement of trained utility operators. This includes bringing field experience – ways of doing things properly – in water treatment, distribution, quality control, safety, and maintenance into a more formalized setting. It also means an end to operating water systems in an amateurish manner.

4.8.7 Enforcement of the Effective Training, Meeting the Changing Needs of Training

Recently, technology and engineering have been progressing rapidly in accordance with the change of the social and economical situation. Water supply enterprises are also forced to cope with innovation adequately, and remain updated with changing technology. The training needs corresponding to this situation requires a prompt adjustment to training curricula and schedules. The constant and appropriate review of training subjects must not be neglected. It is necessary to make a mechanism examining the expense and effectiveness of the available training. When a training effect is measured from the point of view of a long-term basis, solutions are not always readily apparent, but the mechanism of evaluation of the training system is important.

Today in the NPVC, a simple evaluation system is applied. The trainees are required to submit reports or essays after the training is finished. Furthermore, the trainees are required after one or two years to submit an additional report commenting if the training subjects were effective in the daily routine of their work, or what kind of subjects they want now, etc. The reports are reviewed and the feedback is used reflect in making of the next training programme.

4.8.8 The Roles of Management, and the Training Centre

(1) A management-Supervisor

The necessity of training is derived from the daily routine of staff and the results of the training should be reflected in their daily work. It is the management and supervisors of the staff who are in a position to be able to know the needs of training best, and it is their duty to offer staff an opportunity to accept training.

Management should grasp the absolute vocational ability and training needs of each staff member through the observation of their everyday work, and by taking every opportunity (through OJT or self-enlightenment), they should direct and guide the staff to improve their vocational ability by encouraging effort and motivation in staff by their own example.

A manager–supervisor must be also be aware that staff needs for training must be considered individually and within the scope of the organization’s activities. In many respects staff are acutely aware of their individual requirements for training, and are also sensitive to the water utility’s needs. Their involvement in determining the training needs provides invaluable assistance to management in establishing priority for training needs and in allocating training funds.

(2) A training centre

A training centre plays the role of moderator to tie the three HRD elements, such as OJT, Off JT and Self Enlightenment together, even though the centre’s principal focus is directed towards Off JT. The training centre makes an annual training programme and, according to the programme, carries out the respective training. In addition, the training centre supports OJT and self-enlightenment as a personnel training institution.

4.8.9 Samples of Training Programme for water supply

(1) Training Programme for Various Kind of Job

Water supply systems consist of a lot of various kinds of facility and equipment. Many staff are involved in the planning, design, constructing, operating and maintenance of these facilities and equipment. Good management of the water supply system is commensurate with the cooperation of all staff employed by the organisation. In order to utilise fully the staff members abilities, expertise and knowledge based on basic theories, continuous training and experience as well as a good understanding of other related facilities are needed. An ability development program for staff members is divided according to the different types of job.

(2) Kinds of water supply facilities and the staff

The water supply system consists of the efficient use of a range of equipment, equipment usage and available facilities from the water source to the customer's faucet. The staff engaged in these areas is comprised of both technical staff (engineers, etc.) and non- technical staff (laborers).

1) Water intake (the surface water and the ground water at the source), Storage
2) Transmission, distribution of water supply
3) Water treatment
4) Instrumentation
5) Water quality control
6) Electricity / machinery
7) Service pipe & devices

(3) Importance of operation & maintenance of various facilities

The water supply system, equipped with various facilities, can be divided into the design and construction stage and the operation and maintenance stage. But the central works of water supply is the latter part, the O&M works, which come after the completion of facilities.

(4) Kinds of facilities and equipments

In the field of the operation and maintenance of the water supply service, the completed water supply systems and the associated facilities and equipment can be divided into the following three areas. 1) Mechanical systems, 2) Electrical systems, and, 3) Instrumentation.

1) Mechanical systems :
   a) Control and maintenance of the transmission and distribution systems and the maintenance of the water treatment facilities and equipment.
   b) Management and maintenance of water treatment machines and equipment (Pumps and Chemical feeders, etc.)

c) Management of a drainage processing machines and equipment

* Maintenance of a long length water distribution pipeline networks laid underground and the pumping stations are included in this area.

2) Electrical systems:

a) Control & maintenance of power receiving & distribution equipment

b) Electric equipment for pumping systems

3) Instrumentation equipments:

Handling of venturi meters, electromagnetic, supersonic water flow meters, turbidity meters, PH meters, etc.

(5) Clerical staff

Besides the technical staff, there are some clerical staff as follows. While the number of clerical staff is relatively less than the number of technical staff, the importance of the roles of clerical staff is not ignored.

1) Accounting / Financing / Water tariff setting

2) Tariff collection (meter reading/ tariff collection/ arrears handling)

3) Customer relations, public information

4) Laws and ordinances, document processing, liaison affairs

(6) Hierarchy of management

The expected roles (brief job descriptions) of management are as follows,

1) Management

Top management：Determines the basic policies and corporate strategy, and generalize the water service enterprise and represent the water supply.

Middle management：Sets an organization aim of charged department and commands and supervises the performance achievements of concerned departments. Adjustments and liaison between other departments.
Supervises and trains subordinates.

Lower management：Manages and directs the conduct of the organization, supervises the progress of duties of subordinates to achieve the aims and performances of the organization.
Supervises and trains subordinates.

2) Supervisor:

Plans the accomplishment of the duties utilised to achieve the aims of the organization (performance).

Plans the progress management of the business toward the aim to be achieved.

Discover and resolves the problems in their area of expertise and tries to introduce solutions as needed.

Supervises and trains subordinates.

3) Staff：

Experienced staff--handle their allocated duties which require high levels of knowledge and experience. These tasks should be dealt with effectively.

Discover and improve any problems in their area of expertise.

Assists his/her supervisor and advises new staff of their duties and obligations.

Ordinal staff-- Understands the supervisor's instructions and handles the assigned tasks precisely, correctly, rapidly and faithfully.

(7) Setting of a training subject

1) In the cases of new employees, or staff members who have changed their position within the organisation: Learn the necessary basic knowledge, handling and operation methods of the works (the contents of their allocated duties are written in the relevant job description).

2) In cases of improvement of business abilities or adoption of new facilities, machines, or techniques: Acquire the knowledge and the operational methods relevant to the required task.

3) OJT：A supervisor instructs basic knowledge and operational methods at the workplace according to the individual program.

4) Off JT：Attend training at a nominated training center. The trainee will usually attend the systematically prepared course in conjunction with other trainees.

The program for the group training of engineers in the water treatment section (Table 48-1 and 48-2) (JWWA, 2003) is shown below as examples.

Table 48-1 Specialized Training for Water Supply Technical Staff

No. of Days	Curriculum/Hour		Remark
	am (9:30-12:30)	pm (13:30-16:30)	
1	Orientation	Introduction of Water treatment	
2	Slow sand filtration basin	Chemical feeding facility	
3	Coagulation-sedimentation basin	continue	
4	Rapid filtration basin	continue	
5	Observation at Kanamati Plant	continue	Field work
6	Advanced treatment facility	Membrane process	
7	Introduction of Water quality management	Quality control at raw water	
8	Water quality of transmission,distribution, supply	Mechanical facility	
9	Instrumentation facilities	Drainage facilities	
10	Ground water facilities	Free discussion	

* The trainee candidate should be a technical staff with more than 5-year experience

Table 48-2 Specialized Training for Water Supply Technical Staff (Mechanical, Electrical, Instrumentation Facility)

No. of Day	Curriculum/Hour		Remark
	am (9:30-12:30)	pm (13:30-16:30)	
1	Orientation	Introduction of Water Supply	
2	Control & maintenance of mechanical facilities I -Transmmission distribution treatment facilities		
3	Control & maintenance of mechanical facilities II -Water treatment mechanical facilities		
4	Control & maintenance of mechanical facilities III -Advanced water treatment facilities		
5	Control and maintenance of Electricity facilities		
6	Renewal & Outsoucing of various facilities		
7	Observation of facilities (Training center & Power generation facility)		Field works
8	Control & maintenance of Instrumentation facilities I -Water treatment facility		
9	Control & maintenance of Instrumentation facilities I -Remote facilities		
10	Ground water facilities Free discussion		

* The trainee candidate should be a technical staff with more than 5-year experience

4.9 Preliminary Cost Estimates

4.9.1 Basic Cost Estimations

According to the results of facility planning as mentioned above for the best alternative, preliminarily cost estimates have been conducted. The cost estimates have been carried out based on the costs as of April, 2003 and the results of the cost estimates are quoted in US Dollars. At the time of the cost estimates for this study, the exchange rate of the Japanese Yen to US$ was 119 yen to the US$, and the exchange rate of Lao PDR Kips to US$ was 10,720 Kip to the US$, as of April 30, 2003.

4.9.2 Construction Costs

(1) Costs by Work Components

Table 49-1 Costs by Work Components

(x 1,000 US$)

	Total	Foreign	Local
1. Construction Cost	67,611	45,923	21,688
1.1 Treatment Plants	28,508	17,748	10,760
Expansion of Kaolieo T.P. (1st Stage)	9,624	5,762	3,862
Construction of Thangone T.P.(2nd Stage)	13,427	8,693	4,734
Rehabilitation of Kaolieo T.P. (1st Stage)	3,023	1,951	1,072
Expansion of Reservoir in Chinaimo T.P. (1st Stage)	2,434	1,342	1,092
1.2 Clear Water Transmission Pipelines	8,755	7,182	1,573
For the 1st Stage	1,234	984	250
For the 2nd Stage	7,521	6,198	1,323
1.3 Distribution Center	4,376	2,984	1,392
For the 1st Stage	0	0	0
For the 2nd Stage	4,376	2,984	1,392
1.4 Booster Pump Station	1,103	901	202
For the 1st Stage	737	607	130
For the 2nd Stage	366	294	72
1.5 Distribution Trunk Mains	17,549	11,974	5,575
For the 1st Stage	6,393	4,694	1,699
For the 2nd Stage	11,156	7,280	3,876
1.6 Secondary and Tirtially Distribution Mains	1,808	1,521	287
For the 1st Stage	606	510	96
For the 2nd Stage	1,202	1,011	191
1.7 House Connection Installation	2,626	2,164	462
For the 1st Stage	752	620	132
For the 2nd Stage	1,874	1,544	330
1.8 Unaccounted-for Water Reduction	2,886	1,449	1,437
For the 1st Stage	1,245	652	593
For the 2nd Stage	1,641	797	844
2. Consulting Services	5,327	4,494	833
2.1 D/D and S/V for Stage 1 (2004 - 2007)	1,822	1,540	282
2.2 Feasibility Study for Stage 2 (2008)	595	496	99
2.3 D/D and S/V for Stage 2 (2009 - 2012)	2,910	2,458	452
3. Contingencies	23,668	16,448	7,220
3.1 Physical Contingency = (1.+ 2.)×	7,294	5,041	2,253
3.2 Price Contingency = (1.+ 2. + 3.1)×rate2004～	16,374	11,407	4,967
4. Administration Cost = (1.+ 2. +3.)×	4,831	0	4,831
Total Project Costs = (1.+ 2. +3. +4.)	101,437	66,865	34,572

(2) Costs by Stages

Table 49-2 Costs by Stages

(x 1,000 US$)

	Total	Foreign	Local
FIRST STAGE	**35,372**	**22,549**	**12,823**
1. Construction Cost	26,048	17,122	8,926
1.1 Treatment Plants	15,081	9,055	6,026
Expansion of Kaolieo T.P.	9,624	5,762	3,862
Rehabilitation of Kaolieo T.P.	3,023	1,951	1,072
Expansion of Reservoir in Chinaimo T.P.	2,434	1,342	1,092
1.2 Clear Water Transmission Pipelines	1,234	984	250
1.3 Distribution Center	0	0	0
1.4 Booster Pump Station	737	607	130
1.5 Distribution Trunk Mains	6,393	4,694	1,699
1.6 Secondary and Tirtially Distribution Mains	606	510	96
1.7 House Connection Installation	752	620	132
1.8 Unaccounted-for Water Reduction	1,245	652	593
2. Consulting Services	1,822	1,540	282
2.1 D/D and S/V for Stage 1 (2004 - 2007)	1,822	1,540	282
3. Contingencies	5,817	3,887	1,930
3.1 Physical Contingency	2,787	1,866	921
3.2 Price Contingency	3,030	2,021	1,009
4. Administration Cost	1,685	0	1,685
SECOND STAGE	**66,065**	**44,316**	**21,749**
1. Construction Cost	41,563	28,801	12,762
1.1 Treatment Plants	13,427	8,693	4,734
Construction of Thangone T.P.	13,427	8,693	4,734
1.2 Clear Water Transmission Pipelines	7,521	6,198	1,323
1.3 Distribution Center	4,376	2,984	1,392
1.4 Booster Pump Station	366	294	72
1.5 Distribution Trunk Mains	11,156	7,280	3,876
1.6 Secondary and Tirtially Distribution Mains	1,202	1,011	191
1.7 House Connection Installation	1,874	1,544	330
1.8 Unaccounted-for Water Reduction	1,641	797	844
2. Consulting Services	3,505	2,954	551
2.1 Feasibility Study for Stage 2 (2008)	595	496	99
2.2 D/D and S/V for Stage 2 (2009 - 2012)	2,910	2,458	452
3. Contingencies	17,851	12,561	5,290
3.1 Physical Contingency	4,507	3,175	1,332
3.2 Price Contingency	13,344	9,386	3,958
4. Administration Cost	3,146	0	3,146
Total Project Costs	**101,437**	**66,865**	**34,572**

4.9.3 Operation and Maintenance Costs

Table 49-3 Operation and Maintenance Costs

(x 1,000 US$)

	2004			2005			2006			2007			2008			2009		
	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local
5. Operation and Maintenance Cost	1,471	294	1,177	1,493	294	1,199	1,527	294	1,233	1,891	346	1,545	1,975	362	1,613	2,055	376	1,679
5.1 Electricity	604	0	604	604	0	604	604	0	604	858	0	858	892	0	892	924	0	924
Existing Kaolieo T.P.	174	0	174	174	0	174	174	0	174	146	0	146	153	0	153	159	0	159
Expanded Kaolieo T.P.	0	0	0	0	0	0	0	0	0	215	0	215	225	0	225	234	0	234
Existing Chinaimo T.P.	377	0	377	377	0	377	377	0	377	206	0	206	215	0	215	224	0	224
Improved Chinaimo T.P.	0	0	0	0	0	0	0	0	0	176	0	176	184	0	184	192	0	192
Thangone T.P.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Booster Pump Station	53	0	53	53	0	53	53	0	53	115	0	115	115	0	115	115	0	115
5.2 Chemical Cost	294	294	0	294	294	0	294	294	0	346	346	0	362	362	0	376	376	0
Existing Kaolieo T.P.	59	59	0	59	59	0	59	59	0	49	49	0	52	52	0	53	53	0
Alum	41	41	0	41	41	0	41	41	0	34	34	0	36	36	0	37	37	0
Polymer	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
Chlorine	17	17	0	17	17	0	17	17	0	14	14	0	15	15	0	15	15	0
Expanded Kaolieo T.P.	0	0	0	0	0	0	0	0	0	99	99	0	104	104	0	108	108	0
Alum	0	0	0	0	0	0	0	0	0	69	69	0	72	72	0	75	75	0
Polymer	0	0	0	0	0	0	0	0	0	2	2	0	2	2	0	2	2	0
Chlorine	0	0	0	0	0	0	0	0	0	28	28	0	30	30	0	31	31	0
Existing Chinaimo T.P.	235	235	0	235	235	0	235	235	0	198	198	0	206	206	0	215	215	0
Alum	163	163	0	163	163	0	163	163	0	137	137	0	143	143	0	149	149	0
Polymer	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0
Chlorine	68	68	0	68	68	0	68	68	0	57	57	0	59	59	0	62	62	0
Thangone T.P.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlorine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.3 Salary	261	0	261	271	0	271	285	0	285	303	0	303	317	0	317	332	0	332
Treatment Plant	54	0	54	54	0	54	54	0	54	58	0	58	58	0	58	58	0	58
Existing Kaolieo T.P.	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27
Expanded Kaolieo T.P.	0	0	0	0	0	0	0	0	0	4	0	4	4	0	4	4	0	4
Existing Chinaimo T.P.	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27
Thangone T.P.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meter Reader	35	0	35	37	0	37	39	0	39	42	0	42	44	0	44	47	0	47
Administration/Engineering	172	0	172	180	0	180	192	0	192	203	0	203	215	0	215	227	0	227
5.4 Others	312	0	312	324	0	324	344	0	344	384	0	384	404	0	404	423	0	423
6. Human Resource Development	11	0	11	12	0	12	13	0	13	17	0	17	17	0	17	18	0	18
Total Costs	2,633	1,099	1,534	5,748	3,062	2,686	17,961	10,691	7,270	15,465	8,925	6,540	3,690	1,601	2,089	3,727	1,586	2,141

	2010			2011			2012			2013			2014			2015		
	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local
5. Operation and Maintenance Cost	2,079	373	1,706	2,116	373	1,743	2,454	376	2,078	2,503	393	2,110	2,602	410	2,192	2,702	426	2,276
5.1 Electricity	918	0	918	918	0	918	1,195	0	1,195	1,192	0	1,192	1,239	0	1,239	1,288	0	1,288
Existing Kaolieo T.P.	158	0	158	158	0	158	128	0	128	134	0	134	139	0	139	145	0	145
Expanded Kaolieo T.P.	233	0	233	233	0	233	188	0	188	197	0	197	205	0	205	214	0	214
Existing Chinaimo T.P.	222	0	222	222	0	222	179	0	179	188	0	188	196	0	196	204	0	204
Improved Chinaimo T.P.	190	0	190	190	0	190	154	0	154	161	0	161	168	0	168	175	0	175
Thangone T.P.	0	0	0	0	0	0	241	0	241	252	0	252	263	0	263	274	0	274
Distribution Center	0	0	0	0	0	0	230	0	230	185	0	185	193	0	193	201	0	201
Booster Pump Station	115	0	115	115	0	115	75	0	75	75	0	75	75	0	75	75	0	75
5.2 Chemical Cost	373	373	0	373	373	0	376	376	0	393	393	0	410	410	0	426	426	0
Existing Kaolieo T.P.	53	53	0	53	53	0	43	43	0	45	45	0	48	48	0	49	49	0
Alum	37	37	0	37	37	0	30	30	0	31	31	0	33	33	0	34	34	0
Polymer	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
Chlorine	15	15	0	15	15	0	12	12	0	13	13	0	14	14	0	14	14	0
Expanded Kaolieo T.P.	107	107	0	107	107	0	87	87	0	91	91	0	94	94	0	98	98	0
Alum	74	74	0	74	74	0	60	60	0	63	63	0	65	65	0	68	68	0
Polymer	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0
Chlorine	31	31	0	31	31	0	25	25	0	26	26	0	27	27	0	28	28	0
Existing Chinaimo T.P.	213	213	0	213	213	0	173	173	0	180	180	0	188	188	0	196	196	0
Alum	148	148	0	148	148	0	120	120	0	125	125	0	131	131	0	136	136	0
Polymer	4	4	0	4	4	0	3	3	0	3	3	0	3	3	0	4	4	0
Chlorine	61	61	0	61	61	0	50	50	0	52	52	0	54	54	0	56	56	0
Thangone T.P.	0	0	0	0	0	0	73	73	0	77	77	0	80	80	0	83	83	0
Alum	0	0	0	0	0	0	36	36	0	38	38	0	39	39	0	41	41	0
Chlorine	0	0	0	0	0	0	37	37	0	39	39	0	41	41	0	42	42	0
5.3 Salary	346	0	346	362	0	362	400	0	400	415	0	415	430	0	430	445	0	445
Treatment Plant	58	0	58	58	0	58	82	0	82	82	0	82	82	0	82	82	0	82
Existing Kaolieo T.P.	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27
Expanded Kaolieo T.P.	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4
Existing Chinaimo T.P.	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27
Thangone T.P.	0	0	0	0	0	0	24	0	24	24	0	24	24	0	24	24	0	24
Meter Reader	49	0	49	52	0	52	54	0	54	57	0	57	59	0	59	62	0	62
Administration/Engineering	239	0	239	252	0	252	264	0	264	276	0	276	289	0	289	301	0	301
5.4 Others	442	0	442	463	0	463	483	0	483	503	0	503	523	0	523	543	0	543
6. Human Resource Development	19	0	19	20	0	20	20	0	20	21	0	21	22	0	22	23	0	23
Total Costs	14,670	8,827	5,843	31,278	19,733	11,545	20,834	12,623	8,211	3,393	990	2,403	3,505	1,012	2,493	3,614	1,033	2,581