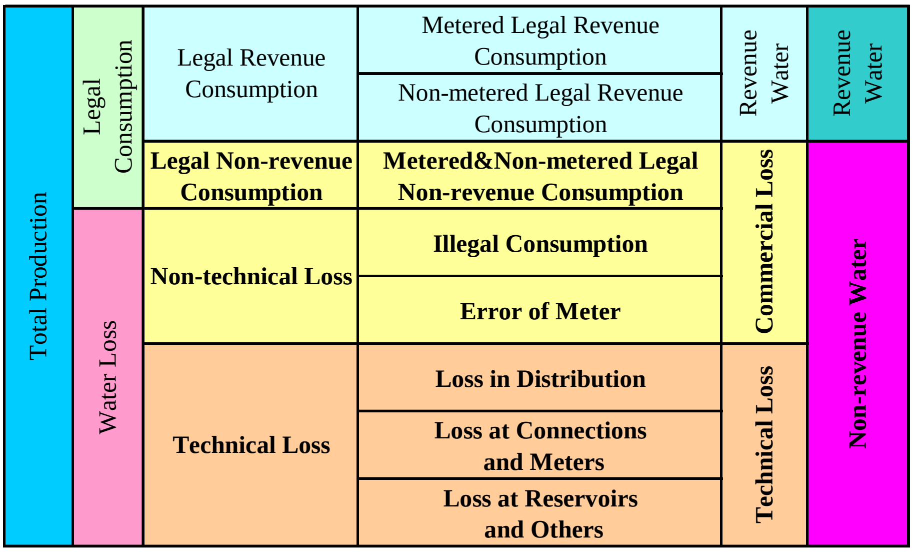
2.5.10 Diagnosis of Existing Condition of Non-revenue Water and Hourly Consumption

(1) Definition of Non-revenue Water (NRW) and Existing SEDAPAL Data

1) Definition of NRW

NRW is the water for which a water supply business does not or cannot charge a tariff to users. It includes commercial loss and technical loss. Commercial loss consists of legal non-revenue water such as water used for watering, fire fighting, and other public uses, as well as illegal consumption and meter error. Technical losses are the water leakage from house connections and meters, water distribution pipes, valves, joints, etc and the water overflow from reservoirs due to poor operation. Leakage from facilities can happen due to material aging, poor material, faulty design, improper construction, inadequate maintenance, natural calamities, and vandalism. Water produced can be categorized as shown in the following figure:



Source: JICA Study Team

Figure 2.5.10-1: Categorization of Produced Water and Definition of NRW

2) Existing SEDAPAL Data

According to a SEDAPAL estimation, non-revenue water (NRW) in the North Lima Area constituted 49.6% of total water produced in 2009, which is very high compared with 35.1% in the Central Lima Area and 27.5% in the South Lima Area. NRW values in the monitored sectors and in the entire North Lima Area are shown in the following table:

Table 2.5.10-1: NRWs in Monitored Sectors and North Lima Area

Sector	Distributed Water	NRW in 2009	
	m^3	m^3	%
83A y 83B	4,460,517	1,912,873	**42.9**
84A y 84B	3,997,461	1,322,575	**33.1**
85A, 85B y 85C	3,383,732	1,696,374	**50.1**
212A y 212B	3,362,695	1,276,643	**38.0**
213	1,602,667	954,988	**59.6**
Total	16,807,072	7,163,453	**42.6**
		Total de Lima Norte	**49.6**

Source: JICA Study Team

(2) Analysis of NRW

1) Necessity of Analysis

In order to prepare a development plan for reducing NRW in the water supply system, it is necessary to identify the causes of the high ratio of NRW and consider corrective measures against each cause of NRW. However, in most of the North Lima Area, even NRW itself is not monitored exactly because of incomplete installation of macrometers and micrometers. Because of the lack of exact data for NRW and for commercial loss, which is considered to account large part of the NRW, it is much more difficult to accurately estimate the technical loss ratio.

In the Study, in order to figure out the actual situation of water distribution and to propose corrective measures against NRW, ratios of commercial loss and technical loss are to be estimated.

2) Methodology of Analysis

An analysis of NRW is carried out by utilizing data of hourly consumption in sectors having meters installed, which are sector 83 (83A and 83B), 84 (84A and 84B), 85 (85A, 85B, and 85C), 212 (212A and 212B) and 213; this data is for June 2009 through May 2010 and is provided by SEDAPAL.

In the analysis, technical loss of each sector is estimated based on the hourly consumption of the sector. Technical loss at each sector is estimated as a difference between the minimum hourly consumption detected and the assumed minimum household consumption.

After technical loss of each sector is estimated, commercial loss can be found by analyzing the relation between NRWs and technical losses of the sectors.

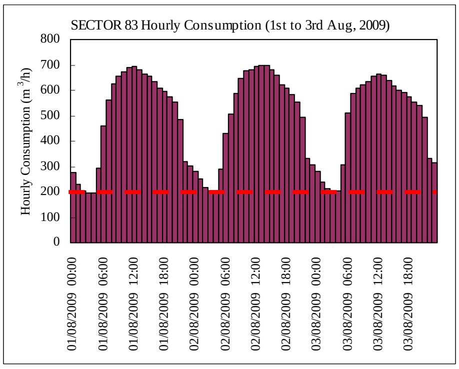
3) Hourly Consumption in Monitored Sectors

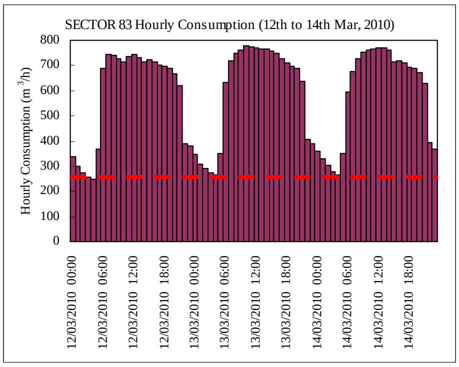
Hourly consumption data for the sectors in summertime (for three days, including a day when annual hourly maximum consumption was recorded) and in wintertime (also for 3 days, 1st to 3rd of August) is presented in Figure 2.5.10-2.

As shown in the figure, a significant consumption has been found consistently during the nighttime in all the sectors, which proves the existence of a significant technical loss. As for sector 213, hourly consumption shows a different curve from other sectors, which is an effect of a pumping station (CR-243).

[Sector 83]

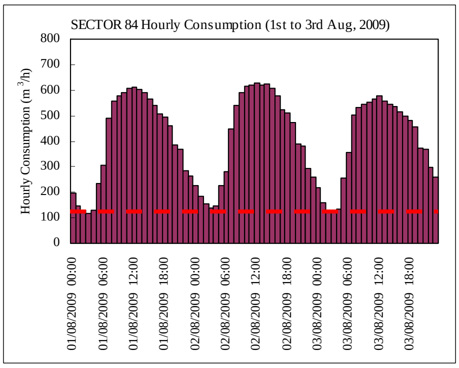
Annual Average: 524m^3/h
Maximum: 893m^3/h
Minimum: 190 – 240m^3/h
Hourly Peak F: 1.70

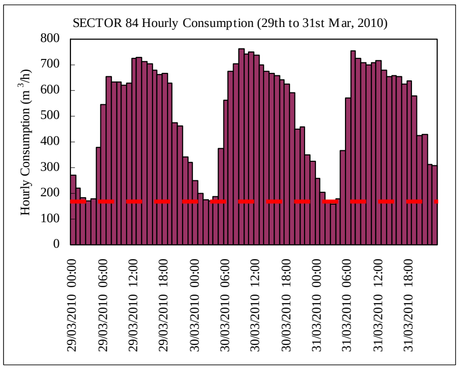




[Sector 84]

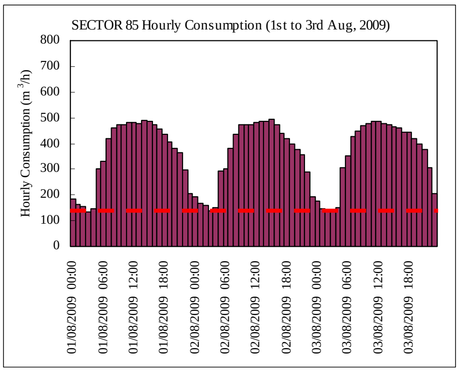
Annual Average: 442m^3/h
Maximum: 788m^3/h
Minimum: 120 – 170m^3/h
Hourly Peak F: 1.78

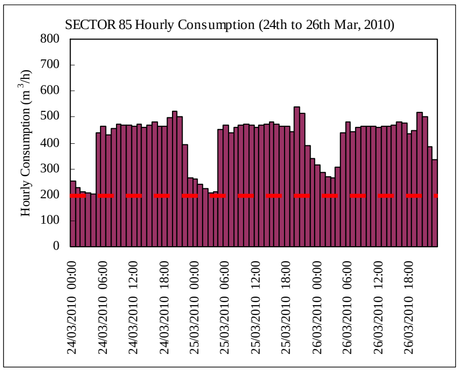




[Sector 85]

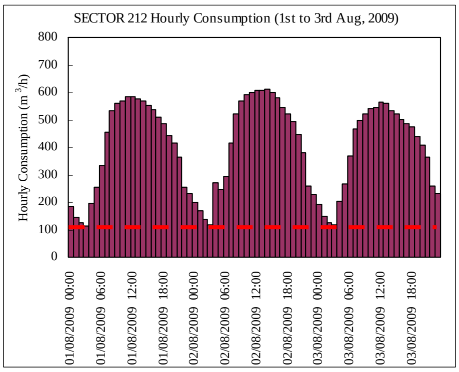
Annual Average: 378m^3/h
Maximum: 569m^3/h
Minimum: 140 – 200m^3/h
Hourly Peak F: 1.50

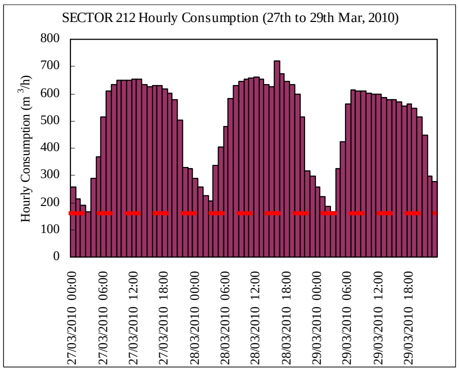




[Sector 212]

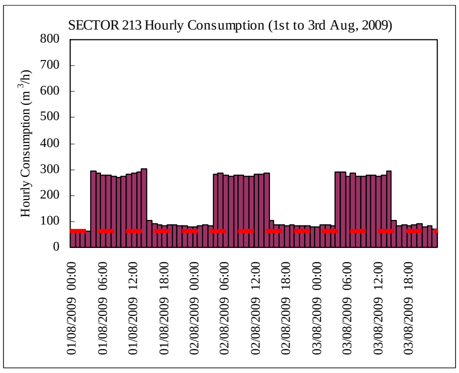
Annual Average: 431m^3/h
Maximum: 722m^3/h
Minimum: 100 – 150m^3/h
Hourly Peak F: 1.68





[Sector 213]

Annual Average: 199m^3/h
Maximum: 362m^3/h
Minimum: 80 – 160m^3/h
Hourly Peak F: 1.82



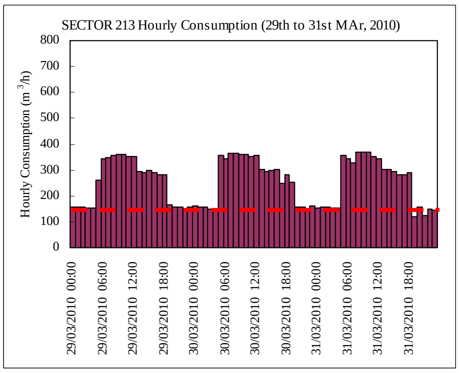


Figure 2.5.10-2: Hourly Consumption of Monitored Sectors
Source: JICA Study Team

4) Estimation of Technical Loss

The amount of water leakage in the pipe lines, including distribution pipes and connections, does not depend on consumption, but rather on water pressure. A damaged pipe causing water leakage can generally be modeled as an orifice on a pipe. Considering that the water pressure of the sector is controlled at the entrance of each sector, water leakage, which accounts for a major part of technical loss, shall be virtually constant.

Therefore, the technical loss of a sector can be estimated from the hourly consumptions presented above, assuming that most of the minimum consumption at nighttime would be the technical loss, by the following formula:

$$\mathbf{Q_{lt} = C_{mm} - C_{tm}}$$
$$\mathbf{C_{tm} = N_v \times 0.3 \times q_f}$$

Where, Q_{lt} : Technical Loss (m^3/h)
C_{mm}: Monitored Minimum Consumption (m^3/h)
C_{em}: Theoretical Minimum Consumption (m^3/h)
N_v : Number of Unit of Use (Domestic and multifamily)
q_f : Consumption by a flush of toilet (=0.012m^3)

[Assumption]
One person in a family goes to the toilet one time in 3 hours between 2AM and 5AM

Technical loss ratio is estimated based on the formula above, as well as on the monitored minimum consumptions that are shown in Figure 2.5-10-2, the number of households from statistical data and the amount of distributed water from the monitored flow at the macrometers.

Regarding sector 213, the consumption curve does not present exact hourly consumption in the sector due to the effect of the pumping station. However, it is considered that the minimum flow at nighttime represents actual minimum consumption in the sector, as it does in the other sectors.

Results of the estimation of technical loss ratio are shown in the following table:

Table 2.5.10-2: Estimated Ratio of Technical Loss

Sector	Number of Unit of Use	Ditributed Water (m^3)	NRW		Technical Loss	
			m^3	%	%	% (against ANF)
83	14,196	4,460,517	1,912,873	**42.9**	**31.2**	72.9
84	15,321	3,997,461	1,322,575	**33.1**	**19.2**	58.1
85	8,014	3,383,732	1,696,374	**50.1**	**37.3**	74.5
212	9,235	3,362,695	1,276,643	**38.0**	**19.4**	51.0
213	2,753	1,602,667	954,988	**59.6**	**55.3**	92.8
Total	49,519	16,807,072	7,163,453	**42.6**	**29.5**	67.2
Total de Lima Norte				**49.6**	-	-

Source: JICA Study Team

5) Technical Loss and Commercial Loss of the Sectors

NRW ratio and estimated technical loss of the sectors are plotted in the following figure:

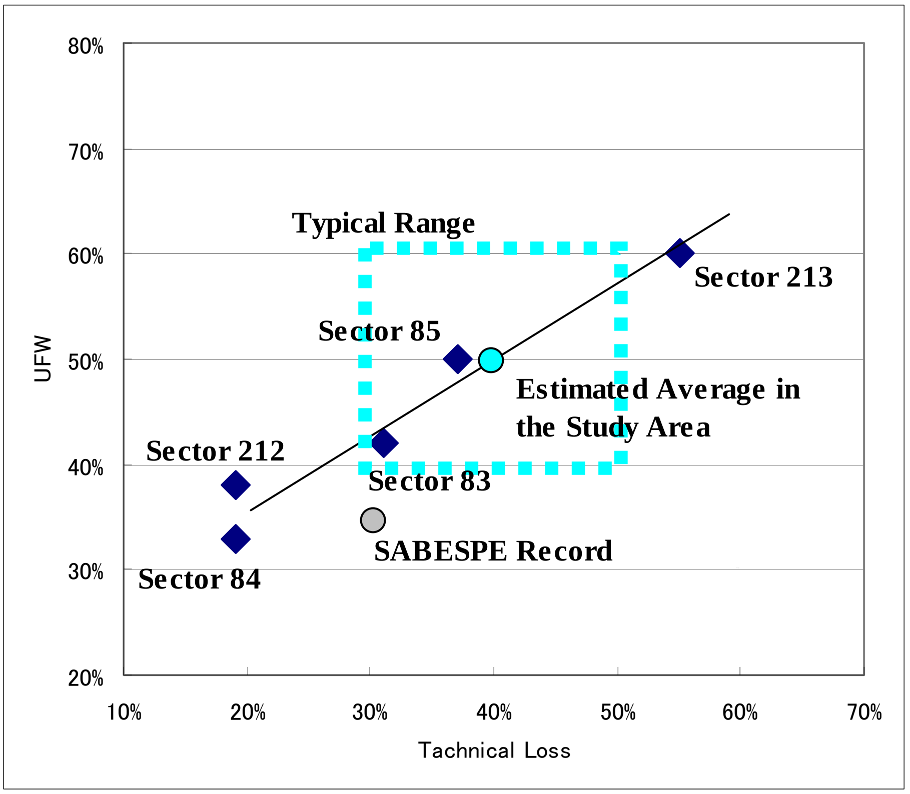


Figure 2.5.10-3: NRW Ratio and Technical Loss Ratio of the Monitored Sector

Just as shown in the graph, NRW index and technical losses in the monitored sectors range between 30 – 70 % and 20 – 60 % respectively. Typical NRW and technical loss indices may be assumed to be around 40 – 60 % and 30 – 50 % respectively. Therefore, it is estimated that the average of NRW and technical loss index in the study area is 50% and 40 %, respectively.

According to SABESP (The São Paulo State Basic Sanitation Company), NRW and technical loss indices are 35.7 % and 29.5 % , respectively, in the 2007 service area. This means that around 80 % of the NRW are technical loses. It is same as the situation in the Study area.

The commercial loss index is the difference between the NRW and the technical losses. The typical commercial loss index might range around 10 - 15 %.

<table>
<tr><th></th><th></th><th></th><th></th><th>Present</th><th>After Project</th><th></th><th></th></tr>
<tr><td rowspan="8">Total Production</td><td rowspan="3">Legal Consumption</td><td rowspan="2">Legal Revenue Consumption</td><td>Metered Legal Revenue Consumption</td><td>35%</td><td>75%</td><td rowspan="2">Revenue Water</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Non-metered Legal Revenue Consumption</td><td>15%</td><td>0%</td></tr>
<tr><td>Legal Non-revenue Consumption</td><td>Metered&Non-metered Legal Non-revenue Consumption</td><td>0-3%</td><td>0-3%</td><td rowspan="3">Commercial Loss</td><td rowspan="6">Non-revenue Water</td></tr>
<tr><td rowspan="5">Water Loss</td><td rowspan="2">Non-technical Loss</td><td>Error of Meter</td><td>0-3%</td><td>0-3%</td></tr>
<tr><td>Illegal Consumption</td><td>5-15%</td><td>0-5%</td></tr>
<tr><td rowspan="3">Technical Loss</td><td>Loss in Distribution</td><td rowspan="3">NRW 50% (45-55%)
35-40%</td><td rowspan="3">NRW 25%
20%</td><td rowspan="3">Technical Loss</td></tr>
<tr><td>Loss at Connections and Meters</td></tr>
<tr><td>Loss at Reservoirs and Others</td></tr>
</table>

Source: JICA Study Team

Figure 2.5.10-4: Result of Analysis on NRW and Target of the Project

6) Conclusion of Analysis of NRW

Through the analysis of NRW above, the following observations and estimations were obtained:

- Significant consumptions are observed in all the sectors even during the nighttime, which proves that there exists a considerable amount of water leakage, which is categorized as technical loss.
- Technical loss ratios estimated in the analysis from monitored minimum flow of the sectors are correlated with amounts of NRW estimated by SEDAPAL.
- It is estimated that the average of NRW ratio is around 50%, of which typical range is between 40 – 60% and the average of technical loss is around 40%, of which the typical range is between 30 – 50 %. The commercial loss is estimated between 10 - 15%.
- Illegal consumption and consumptions at connections without micrometers can be counted as technical loss in the analysis based on minimum flow. Therefore, it should be noted that the actual commercial loss ratio of each sector will vary depending on the status of micrometer installation and on social environment.
- In order to reduce the NRW ratio to 25%, it will be necessary to reduce the technical loss ratio to 20% and the commercial loss ratio to 5%.

(3) Analysis on Hourly Consumption

1) Necessity of Analysis

Hourly consumption is a fundamental parameter in designing a secondary network and analyzing the hydraulic balance of reservoirs. In the National Building Regulation of the Ministry of Housing, Construction and Sanitation (hereinafter National Sanitation Standard), the hourly peak factor is defined to be between 1.8 and 2.5.

Generally, the hourly peak factor depends on the scale of the target area. In addition, water leakage can affect the peak factor if it is relatively large compared with actual consumption by end users.

Here, the hourly peak factor is to be analyzed in order to decide the value to be applied to the sectors in the Study Area for design purpose.

The analysis utilized hourly consumption data for the original sectors 83, 84, 85, and 212. Data for the original sector 213 cannot be used because the monitored consumption is affected by operation of the pumping station (CR243), so the monitored consumption does not present the actual household consumption.

2) Current Condition

As shown in Figure 2.5.10-2, hourly peak factors in the sectors range from 1.50 to 1.78. However, after the Project reduces technical loss to 20%, the peak factor will change.

3) Hourly Consumption in Case of 20% Technical Loss

Based on the hourly consumptions during the day, the hourly maximum of each sector, and the technical loss estimated in analysis of NRW, hourly consumptions in case of 20% technical losses are projected as presented in Figure 2.5.10-5. Hourly peak factors in this case are from 1.67 to 1.85, which are larger than those calculated from the original SEDAPAL data.

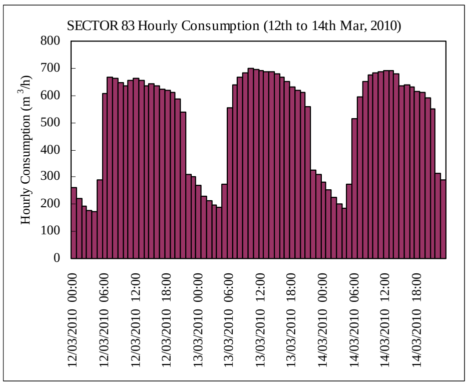
4) Conclusion of Analysis of Hourly Peak Factor

Hourly peak factors projected above and numbers of domestic users (number of unit of use of domestic and multi-family) are plotted in Figure 2.5.10-6. Although areas with many users generally have larger peak factors, there seems to be no significant correlation between number of households and peak factor in the monitored sectors.

As a result of the analysis, an hourly peak factor of 1.8 is recommended to be applied to the design works in the Study, which complies with the National Sanitation Standard.

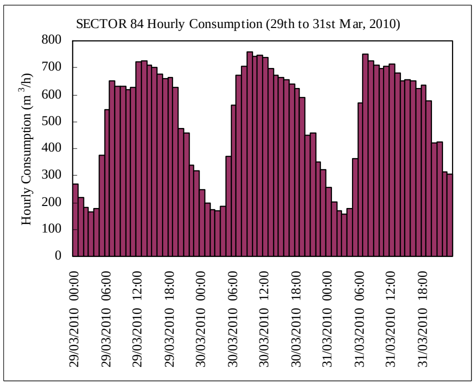
[Sector 83]

Annual Average: 432m^3/h
Maximum: 801m^3/h
Hourly Peak F: 1.85



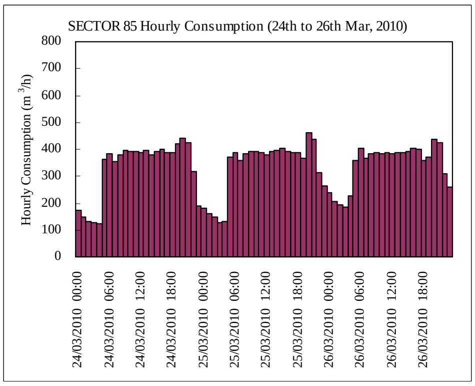
[Sector 84]

Annual Average: 428m^3/h
Maximum: 774m^3/h
Hourly Peak F: 1.81



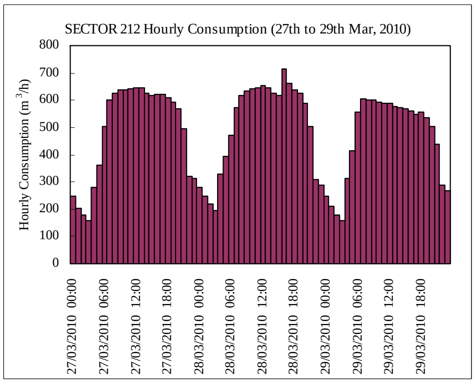
[Sector 85]

Annual Average: 285m^3/h
Maximum: 475m^3/h
Hourly Peak F: 1.67



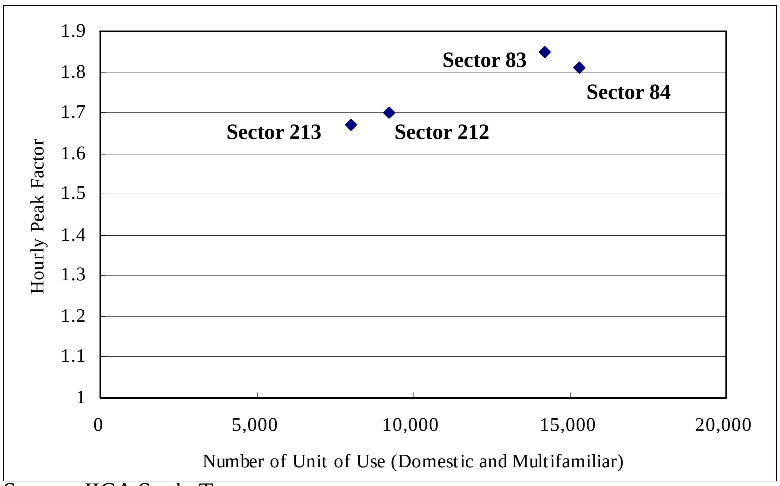
[Sector 212]

Annual Average: 417m^3/h
Maximum: 708m^3/h
Hourly Peak F: 1.70



Source: JICA Study Team

Figure 2.5.10-5: Projected Hourly Consumption in Case of 20% of Technical Loss



Source: JICA Study Team

Figure 2.5.10-6: Projected Hourly Consumption in Case of 20% Technical Loss and Number of Unit of Use (Domestic and Multi-family)

2.5.11 Diagnostic of the Economic-Financial Situation

This section of the report analyzes the following: SEDAPAL´s audited financial statements for the period 2007-2009, the proposals of Optimization Master Plan (*Plan Maestro Optimizado*, or *PMO, 2009*) formulated by SEDAPAL, the price formulas and price structure approved by the SUNASS (*Superintendencia Nacional de Servicios de Saneamiento,* or National Sanitation Services Superintendence), and the SEDAPAL Management Goals approved by the SUNASS for the five-year period from 2010-2015 through the Directive Board´s Resolution N° 018-2010-SUNASS –CD of April 16, 2010.

(1) General Assessment

Table 2.5.11-1 shows that amount of total assets in the year 2009 was S/ 6.047 billion, which is 10% more than 2008, and is also greater than the increase during the period from 2007 to 2008, which was 7%. The increase exists in the Diverse Property, Machinery, and Equipment category as a consequence of the incorporation of the new assets in the water and sanitation infrastructure, machinery and equipment, that have been carried out with the resources transferred by the Ministry of Housing, Construction, and Sanitation as a part of the Water for All Program (*Programa Agua Para Todos*, or *PAPT*).

There is also a significant increase in the current assets in the category of Cash and Cash Equivalent and Trade Accounts Receivable. This increase is due to the larger revenues for the rendering of water and sanitation services.

On the liabilities side, the company´s debt level continues to increase, reaching a total internal and external debt of S/. 2.078 billion in 2009, with the non-current portion or long-term debt being 88% (S/ 1.832 billion).

The company´s equity has managed to remain favorable during the period analyzed, mainly because of the withholding tax before the SUNAT in the year 2008 for an amount of S/ 1.937 billion, and also because of the greater additional capital investments through the MVCS´s transfer of a cumulative sum of S/ 222 million to SEDAPAL in 2009 for the execution of the PAPT and its corresponding 9 water and sanitation projects.

(2) Statement of Results

Table 2.5.11-2 shows the state of the Profits and Losses, and it can be observed that the revenues are shaped by the sale of water and sanitation services as well as the collateral services. The total revenues increased by 16% and 11% during the years 2008 and 2009, respectively. In the same way, the other operational revenues was increased by S/. 15 million in 2009, reaching a total of S/. 59 million; this can be partly attributed to the application of the Legislative Decree 148 (price of underground water)..

The sales costs have also increased by 15% (2008) and 13% (2009) during the period analyzed. Among the categories with the greatest increase in the year 2009 are the personal costs, services rendered by third parties, maintenance and reparation, and electric energy.

As a result of the difference between revenue and sales costs, the company has reported a positive gross income which has a tendency to increase.

Table 2.5.11-1: General Assessment
(Expressed in Thousands of Nuevos Soles)

DESCRIPTION	2007	2008	2009
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	173,756	130,193	191,548
Commercial Receivables (Net)	170,527	202,734	213,731
Other Accounts Receivables (Net)	28,963	44,882	46,831
Stocks (Net)	3,589	4,437	5,539
Prepaid Expenses	984	2,266	468
TOTAL CURRENT ASSETS	**377,820**	**384,512**	**458,117**
FIXED ASSETS			
Commercial Receivables	-	35,243	56,662
Real Estate Investments			
Property, Machinery, Equipment (Net)	4,779,886	5,031,748	5,474,583
Intangible Assets (Net)	5,628	2,247	359
Deferred Tax Assets		61,552	56,403
Other Assets	913	868	541
TOTAL FIXED ASSETS	**4,786,426**	**5,131,658**	**5,588,549**
TOTAL ASSETS	**5,164,246**	**5,516,170**	**6,046,666**
LIABILITIES AND EQUITY			
CURRENT LIABILITIES			
Financial Obligations	107,294	123,964	245,231
Commercial Accounts Payable	85,283	80,208	110,420
Account Payable to Related Parties			
Current income tax liabilities	47,562	18,027	31,408
Other Accounts Payable	194,149	97,504	72,589
Provisions		15,224	2,935
Liabilities kept for sale			
TOTAL CURRENT LIABILITIES	**434,289**	**334,927**	**462,583**
LONG-TERM LIABILITIES			
Financial Obligations	1,135,540	1,763,677	1,832,877
Commercial Accounts Payable			
Account Payable to Related Parties			
Current income tax liabilities	43,876	38,438	58,416
Other Accounts Payable			
Provisions			
Deferred Income (Net)	8	43	84
TOTAL LONG-TERM LIABILITIES	**1,179,424**	**1,802,158**	**1,891,376**
TOTAL LIABILITIES	**1,613,712**	**2,137,085**	**2,353,960**
NET EQUITY			
Capital	3,176,017	5,309,298	5,309,298
Additional Capital	213,577	294,280	383,650
Legal Reserves	30,375	42,956	42,956
Other Reserves			
Retained Earnings	130,565	- 2,267,448	- 2,043,198
Conversion Difference			
TOTAL NET EQUITY	**3,550,534**	**3,379,086**	**3,692,706**
TOTAL LIABILITIES AND EQUITY	**5,164,246**	**5,516,170**	**6,046,666**

Source: SEDAPAL´s Audited Financial Statements, 2007, 2008 and 2009

(Estados Financieros Auditados de SEDAPAL, 2007, 2008 y 2009)

The components of administration expenses have also increased except for the litigation loss category, and this increase corresponded especially to the third party services rendered and to auxiliary materials and supplies.

The sales costs have shown a tendency to increase, observing increases of 9% and 3% during the years 2008 and 2009, respectively. The components with greatest increase are the diverse charges for management, personnel, and services rendered by third parties. The one that has decreased is that of provisions for the fiscal year due the application of a lower amortization amount.

Table 2.5.11-2: Statement of Profits and Losses
(Expressed in Thousands of Nuevos Soles)

DESCRIPTION	2007	2008	2009
TOTAL REVENUE	**866,823**	**1,003,083**	**1,108,674**
Water, sewage, and collateral services	827,374	959,087	1,049,449
Other Operational Revenue	39,448	43,996	59,225
COST OF SALES	**-509,492**	**-584,494**	**-660,541**
Sales Costs	-509,492	-584,494	-660,541
GROSS PROFIT	**357,330**	**418,589**	**448,133**
Administration Costs	-81,034	-89,685	-84,180
Sales Costs	-101,435	-110,741	-114,311
	-182,470	-200,426	-198,490
OPERATING PROFIT	**174,861**	**218,162**	**230,102**
Financial Revenue	122,462	147,655	267,383
Financial Expenditures	-114,611	-356,865	-190,249
Outstanding Revenue	19,161	10,419	16,407
Other Expenditures	-16,346	-24,033	-19,540
	10,666	-222,824	
RESULT BEFORE INCOME TAX AND SHAREHOLDING	**185,527**	**-4,661**	**323,643**
Workers´ Shareholding	-8,913	1,307	-14,744
Income Tax	-50,807	7,448	-84,042
INCOME (LOSS) FOR THE FISCAL YEAR	**125,807**	**4,094**	**224,857**

Source: SEDAPAL´s Audited Financial Statements, 2007, 2008 and 2009
(Estados Financieros Auditados de SEDAPAL, 2007, 2008 y 2009)

As the result of the difference between the gross profit and the administrative and sales costs, the company has reported a positive operating profit in the last three fiscal years, and a growth tendency as well, as shown in Table 2.5.11-2.

On another topic, the financial income has maintained a growth tendency, mainly due to the positive margin of the exchange rate for currencies originating from external loans. The financial expenses were reduced by 47% in 2009 due to minor losses caused by the difference of the exchange rate for the repayment of the external loans. The other expenses were reduced by 19% in 2009 due to the substantial reduction of the legal contingencies from S/. 14.6 million in 2008 to S/. 5.6 million in 2009.

The net profits of the last three fiscal years have been positive, suffering a substantial reduction in 2008 due to the losses originating from the exchange rates of currencies for external loans.

(3) Cash Flow

In the last three years, the operating profit has shown a growth tendency, mainly due to the revenues from customers, which increased by 6% (2008) and 14 % (2009). The revenue of tax resources – for the consumption of groundwater increased by 28% in 2009 with respect to the value reported in 2008 due to the introduction of Legislative Decree Nº 148.

The operating expenses in 2008 for the payment of suppliers, wages and social benefits increased by 12% and 27%, respectively.

As a consequence of the increase of the income during the last year, the operating cash flow amounted to S/ 378 million, which is above the value for 2008, as shown in Table 2.5.11-3.

As regards to the capital expenses, there is a strong growth tendency, increasing 20% and 40% in 2008 and 2009, respectively. Most of these investments, as indicated in the item "Financing Cash Flow" of Table 2.5.11-3, have been enabled by the resources obtained by the international loans; as well as by the contributions of capital and additional capital that correspond to the capitalization of the tributary debt before SUNAT in 2008, and also the contributions for the execution of water and sewerage works under PAPT.

Finally, as can be observed in Table 2.5.11-3, there was a negative cash balance in 2008. In 2009, however, the greatest growth in revenue, partially explained by the greater number of users and the inflation readjustments included in the tariff structure, allowed SEDAPAL to have a positive net cash balance of S/. 191.5 million, or 47% with respect to the balance reported at the end of 2008.

Table 2.5.11-3: Cash Flow
(Expressed in Thousands of Nuevos Soles)

DESCRIPTION	2007	2008	2009
OPERATING ACTIVITIES			
Cash receipts from customers	1,007,187	1,071,318	1,218,625
Revenue of tax resources	35,788	35,294	45,235
Revenue of interests and others	12,393	21,644	19,832
Other cash revenues relative to the activity	19,298	6,882	17,535
Minus			
Cash paid to suppliers	-414,275	-511,942	-573,582
Cash paid to employees and social benefits	-157,041	-173,897	-220,367
Taxes paid	-97,701	-128,366	-100,734
Interests Paid	-13,171	-19	-271
Other payments relative to the activity	-23,830	-28,385	-28,147
CASH FLOWS FROM OPERATING ACTIVITIES	**368,646**	**292,528**	**378,127**
INVESTING ACTIVITIES			
Purchase of property, machinery and equipment	-378,020	-452,933	-259,080
Retirement of fixed assets	-551	-	-376,510
CASH FLOWS FROM INVESTING ACTIVITIES	**-378,570**	**-452,933**	**-635,590**
FINANCING ACTIVITIES			
Loans (amortization net value)	32,610	86,870	286,934
Income due to contribution of capital or additional capital	90,301	264,527	67,485
Loan Interests	-47,415	-38,364	-35,601
Dividends Paid	-1,500	-196,191	-
CASH FLOWS FROM FINANCING ACTIVITIES	**73,996**	**116,842**	**318,818**
NET CASH FLOW	64,072	-43,563	61,355
INITIAL CASH	**109,683**	**173,756**	**130,193**
CASH BALANCE AT THE END OF YEAR	**173,756**	**130,193**	**191,548**

Source: SEDAPAL´s Audited Financial Statements, 2007, 2008 and 2009

(4) Financial and Management Indicators

The financial management of SEDAPAL in the period from 2007-2009 is measured through financial indicators: liquidity, solvency and profitability; and, in a complementary fashion, through some indicators of entrepreneurial management: labor, delinquency and sales by total assets. Table 2.5.11-4 shows the respective indicators.

1) Liquidity

This measures the company´s capacity to fulfill its short-term commitments according to its available resources. The current liquidity index has been increasing for the period between 2007 and 2009 and is slightly below the unit. This indicates that the liquid assets of the company are sufficient to cover its short-term debt. Regarding the quick ratio or acid-test ratio, the result was 0.99 in 2009, which translate 0.99 *soles* available to cover each *sol* of debt.

2) Solvency

The ratio of loan of SEDAPAL presents a growth tendency and has reached a value of 0.64; in other words, the ratio of loan of the company is 64% of its equity. The large indebtedness of the company is not necessarily a threat to its performance, due to the fact that most of these debts, which amount to S/. 1,833 million, as of 2009, are long-term liabilities. This has allowed SEDAPAL to make significant operational improvements, as well as to increase the coverage of the services.

The leverage ratio presents an increase as well, showing that the liabilities are a growing part of the SEDAPAL's total assets.

The interest coverage ratio (financial expenses) was over the unity in 2007 and 2009, but not in 2008. This indicator shows the capacity of internal resource generation (operating profit) to cover the financial expenses. However, the company is exposed to the exchange rates of the loans obtained in foreign currency, which may entail considerable losses, as occurred in 2008.

3) Profitability

The profitability indicators of SEDAPAL, for the 2007 – 2009 period, present a favorable tendency. The operating margin which expresses the percentage of operating profit and net income has remained consistent due to the strong net sales, except for 2008, when SEDAPAL faced great financial losses due to the difference in exchange rates. This behavior assures the company of the sustainability of the services within its jurisdiction.

The net margin, as well as the ROA and the ROE, also registered a decrease in 2008, mainly due to the factors described in the previous paragraph.

4) Labor Ratio

SEDAPAL has reduced its labor ratio in the 2007-2009 period from 52.4% to 42.2%, respectively. This allows a larger margin for the payment of debts, as well as the financing of works with self-generated resources and a better sustainability of the services.

5) Delinquency

This indicator measures the level of net commercial receivable accounts, measured by the number of equivalent billing months that the users owe SEDAPAL, on average.

In the period during 2007 – 2009, the company maintained a delinquency ratio of 2.5 months, improving with respect to the year 2008.

Table 2.5.11-4: Financial and Management Indicators

Indicator	Unit	2007	2008	2009
Financial				
Liquidity				
Current liquidity Ratio	N° of Times	0.87	0.98	0.99
Acid-test Ratio	N° of Times	0.86	0.97	0.98
Solvency				
Indebtedness (Total liabilities/Equity)	N° of Times	0.45	0.63	0.64
Leverage	%	0.31	0.39	0.39
Interests Coverage	N° of Times	1.53	0.61	1.21
Profitability				
Operating margin	%	20%	22%	21%
Net Margin	%	15%	0.4%	20%
ROA	%	2%	0.1%	4%
ROE	%	4%	0.1%	6%
Management				
Delinquency	days	74	76	72
Labor Ratio	%	52.4	44.2	42.2
Sales /Total Assets	N°	0.17	0.18	0.18

Source: Elaboration based on SEDAPAL´s Audited Financial Statements, 2007, 2008, and 2009
(*Estados Financieros Auditados de SEDAPAL, 2007, 2008 y 2009*)

(5) Investments 2005 - 2009

The levels of investment of SEDAPAL have been increasing during the last five (5) years, mainly due to the execution of investment projects for the improvement of the water supply and sewerage services, and to the projects under the Water for All Program (*Programa Agua para Todos*, or PAPT), a program aimed at the expansion of the coverage of the water supply and sewerage services to areas that do not have such services and that, therefore, are exposed to diseases related to the lack of basic sanitation services.

The investment amounts in the period from 2005 to 2009 practically tripled, from S/. 260.7 million in 2005 to S/. 767.9 million in 2009. A third of the investments executed (29% on average) were financed through external loans provided by multilateral organizations (IBRD and IADB), and bilateral organizations (like JICA, KfW), except in 2008. The remaining two thirds were financed, mainly, with self-generated resources in 2005 and 2006, and through transfers (capital contributions) from the Ministry of Housing, Construction and Sanitation for the execution of the PAPT in 2007, 2008 and 2009. The MVCS's percentage of participation has been 30% of the total investment amount during the last three years. It can be observed in Table 2.5.11-5 that the MVCS transfers between 2007 and 2009 were a subsidy to the investments with resources from the Public Treasury.

Table 2.5.11-5: Investment and Financing
(Expressed in Thousands of Nuevos Soles)

Category	2005	2006	2007	2008	2009
Total Investment	260,740	221,547	353,820	419,082	767,892
Financial Source					
External Indebtedness	88,419	57,364	172,449	119,175	206,997
Internal Indebtedness					
Self-generated Resource 1/	172,321	164,183	181,371	299,907	560,896

1/ Incluyes transfer from MVCS (PAPT)

Source: SEDAPAL Annual Statistics -2009

(6) SEDAPAL´s Optimization Master Plan

In 2009, SEDAPAL formulated the Optimization Master Plan (*Plan Maestro Optimizado*, or *PMO*) for the five-year period from 2009 to 2013, following the methodology established by the General Regulations of Tariff Regulation approved by the Directive Council Resolution N° 009-2007-SUNASS-CD.

The objective of the Optimization Master Plan is to provide an overview of the quality level of the services rendered by SEDAPAL, which the company seeks to achieve in the medium and long term in the 49 districts of Metropolitan Lima and Callao under its jurisdiction. This vision must be adjusted to a group of conditioning factors, which have been identified in the referenced PMO.

Regarding the scope of the Optimization Master Plan, the document includes the diagnosis of entrepreneurial macro systems, the program of investments and its financing, aimed at the maintenance of the existing infrastructure as well as at the expansion of the water supply, sewerage and wastewater treatment systems. All of these will allow the sustainability of the services and the achievement of the service quality levels and management objectives that SEDAPAL seeks to attain.

In order to execute the program of investments and accomplish the foreseen management objectives, SEDAPAL proposed a medium-term tariff plan to assure its financial and economic stability. This tariff plan is to be approved by SUNASS. A summary of the PMO proposal to SUNAT is presented as follows.

1) Investment Program

The PMO has established an investment program for the five-year period from 2009-2013, for an amount of S/. 4.084 billion, as shown in Table 2.5.11-6. In the said five-year period, the investments will be executed under the modality of public investment projects, of which: (i) 35% corresponds to the Project of Sanitary Improvement of the Marginal Areas of Lima, (ii) 41% to the *Agua para Todos* Program, (iii) 7% to the Project of Optimization and Improvement of the Primary Water Supply and Sewerage System (iv) 12% to projects of Rehabilitation of the Systems and (V) the remaining 5% to institutional projects, procurement of equipments and machinery, among others.

The investment activities that SEDAPAL has been conducting with charges to the current expenses account were also considered, such as: installation of micro meters, for S/. 137.5 million, and activities related to the operation and maintenance of the networks and commercial management, for an amount of S/. 131 million. Considering the previously described items, the total investment of the referenced five-year period, will be approximately S/. 4.353 billion**.**

The summary of the investment program for the referenced five-year period is presented below, expressed in millions of soles:

Table 2.5.11-6: Investments Program for the Five-Year Period 2009-2013
(Expressed in Millions of Nuevos Soles)

Projects	2009	2010	2011	2012	2013	Total
1. Project of Sanitary Improvement of the Marginal Areas of Lima	**373**	**389**	**433**	**170**	**64**	**1,429**
– Lots 1, 2andy 3 – Intake Facility, Huachipa Treatment Plant and North Branch	256	295	130			681
– Optimization of the Infrastructure of the Water Supply and Sewerage Networks, Sectorization, Rehabilitation, GDN Cadastre – Huachipa Treatment Plant-Drainage Area-Chillón.	2	32	235	170	64	503
– Complementary Works- North Branch	23	31	62			116
– General and Secondary Works	92	31	6			129
2. *Agua para Todos* Program, Phases I, II y III	**238**	**266**	**429**	**418**	**328**	**1,679**
3. Optimization and Improvement of the Primary Water Supply and Sewerage Systems	**15**	**5**	**28**	**94**	**138**	**280**
4. Rehabilitation of the Systems	**27**	**114**	**61**	**118**	**161**	**481**
5. Institutional Projects, Procurement of Equipments and Machinery, and others Projects	**75**	**50**	**41**	**35**	**15**	**216**
Total Budget	**728**	**824**	**992**	**835**	**706**	**4,084**

Source: PMO of SEDAPAL, July 2009

2) Investments Executed under the Modality of Private Concession

The PMO also considered the execution of sanitation projects within the Plan of Private Investment Promotion, mainly focused on the expansion of water supply sources and the treatment of wastewater.

The investment projects that will be executed under this modality are: (i) Huascacocha Derivation- Rímac River, (ii) Taboada Wastewater Treatment Plant (WWTP) and deep sea diffuser outfall. These two projects have already been awarded to the private sector. Also, the projects of (iii) La Chira Wastewater Treatment Plant (WWTP) and deep sea diffuser outfall and, (iv) *Aguas del Sur* Project (Desalination Plant) are expected to be executed with private financing.

These projects will be executed though BOT contracts (Build, Operate and Transfer). The design, construction, operation and maintenance of the projects will be entrusted to the concessionaire for the concession period (25 years). The concessionaire will provide services to SEDAPAL, who will assume the obligation of paying them the investment retribution (RPI) and the operation and maintenance services (RPMO).

The amount of private finance is presented by project in Table 2.5.11-7, according to the information available.

Table 2.5.11-7: Retributions for Private Participation Projects
(Expressed in Millions of Nuevos Soles)

Projects	Total (millions of soles)
Derivation Huascacocha-Rímac	37.9
Taboada WWTP and Emitter	101.6
La ChiraWWTP and Emitter	63.9
Aguas del Sur (Desalination Plant)	131.2

Source: SEDAPAL´s PMO, July 2009

3) Financial Structure

The Investment Program for the five-year period 2009-2013 amounts to S/. 4.084 billion, and will be financed as follows: 48.6% (S/. 1.984 billion) through external loans arranged and to be arranged; 27.3% (S/. 1.114 billion) through transfers from the Public Treasury; and the remaining 24.1% (S/. 985 million) with self-generated resources.

The financing considered for each year is summarized in Table 2.5.11-8:

Table 2.5.11-8: Financial Sources
(Expressed in Millions of Nuevos Soles)

Year	External Loan		Public Treasury	Self-generated Resources	TOTAL
	Arranged	To be Arranged			
2009	275	167	145	147	728
2010	187	274	150	177	825
2011	120	365	339	179	991
2012		300	329	293	834
2013		277	240	189	706
TOTAL	384	1, 600	1, 115	985	4, 084

Source: SEDAPAL´s PMO, July 2009

4) Estimation of Operating Expenses

To determine the operating expenses, which include the permanent expenses for the operation and maintenance of the water supply and sewerage services, SEDAPAL has considered the regulatory accounting norms indicated by SUNASS; in that sense, the operating expenses structure shall exclude some activities that from the regulatory viewpoint are considered investments, and it shall also exclude provisions. Table 2.5.11-9 shows a summary of the operating expenses for the referenced five-year period.

Table 2.5.11-9: Projection of Operating Expense [1/]
(Expressed in Millions of Nuevos Soles)

Concept	Year 1	Year 2	Year 3	Year 4	Year 5
Operating Expenses	589.8	629.6	881.0	966.9	947.7
Provisions	270.0	309.4	330.3	335.9	344.9
Investments	57.8	55.0	54.5	51.3	50.2
Total	**917.6**	**994.0**	**1,265.8**	**1,354.1**	**1,342.8**

1/ Includes RPI and PMO of the projects: Taboada WWTP and Huascacocha – Rímac Derivation
Source: SEDAPAL´s PMO, July 2009

5) Estimation of Revenues

SEDAPAL has estimated the revenues for the water supply and sewerage services, as well as for the collateral services produced by the sale of connections in the analyzed period and for other revenue sources.

The total operating revenue will increase from S/. 1.267 billion in 2009 to S/. 1.527 billion in 2013, resulting from the sale of water supply and sewerage connections due to the incorporation of new users. This can be observed in Table 2.5.11-10.

The expected increase of revenues is the result of the growth of the physical billing levels resulting from the larger number of connections and the improvement of the commercial efficiency, as well as from the predicted tariff increase that considers a readjustment of 10.26% per year in the first three years of the five-year regulatory period, which is explained below.

Table 2.5.11-10: Projection of Revenues
(Expressed in Millions of Nuevos Soles)

Concept	Year 1	Year 2	Year 3	Year 4	Year 5
Water and Sanitation Services [1]	1,290.8	1,290.8	1,441.6	1,460.1	1,479.8
Collateral Services	90.1	104.2	115.7	62.7	37.8
Other Revenues	2.3	6.6	8.1	10.0	8.9
Total	**1,383.2**	**1,401.6**	**1,565.4**	**1,532.8**	**1,526.5**

1/ The water supply and sewerage services represent 94% of the total revenue.
Source: SEDAPAL´s PMO, July 2009

6) Determination of the Tariff Raise

Following the methodology established by the 'Organized Unique Text of the General Law of Water and Sanitation Services', Act 26883[1] and the General Tariff Regulations[2], SEDAPAL has determined the Average Medium-Term Cost, equivalent to the average tariff with which the company will accomplish an economic-financial balance.

In such sense SEDAPAL requires tariff increases of 10.26% per year of the first three years of the next five-year period as below:

[1] *Texto Único Ordenado de la Ley General de Servicios de Saneamiento, Ley 26883*
[2] *Reglamento General de Tarifas*

Años	Incrementos Tarifario %
1	10,26%
2	10,26%
3	10,26%
4	0,00%
5	0,00%

7) Management Objectives

The management objectives forecasted for the analyzed five-year period are proposed based on the results of the investment activities and projects that SEDAPAL will execute with the purpose of expanding coverage and improving the quality of the services. The objectives forecasted by SEDAPAL for the next five-year period are as follows:

- Increase of 337,600 water supply connections.
- Increase of 311,000 sewerage connections.
- Increase of the level of micro metering to 87.43% by the end of the period.
- Reduction of the Non-revenue Water to 33.2% by the end of the fifth year.
- Accomplish a level of service continuity of 21.9 hours/day on average by the end of the fifth regulatory year.
- Accomplish a water pressure of 21.4 m.w.c. by the end of the fifth year.
- Increase the wastewater treatment volume to 17.86 m^3/s by the end of the fifth year.
- Accomplish a staff ratio of 62.1% by the end of the fifth regulatory year.
- Maintain the Water Supply and Sewerage Commercial Cadastre 100% up-to-date during the regulatory period.
- Increase the percentage of active water supply connections to 96.1% by the end of the fifth regulatory year.

(7) SUNASS Tariff Study[3]

The tariff study of SEDAPAL for the regulatory period April 2010 – April 2015, which establishes the tariff formula, structure and management objectives to be applied in its coverage area, starts with the diagnosis of the operational, financial and commercial baseline information provided by SEDAPAL, and assessed by SUNASS.

With this diagnosis, it has been possible to identify the actions and programs to be implemented by SEDAPAL with the purpose of expanding the coverage and improving the quality of the water supply and sanitation services, accomplishing, at the same time, a sustainable economic-financial situation, and assuring that the company does not affect the rights of third-parties regarding its contract obligations assumed in the framework of the promotion of private investments in sanitation.

1) Investment Program

[3] *Estudio Tarifario SEDAPAL – SUNASS*, April 2010

The Tariff Study, based on the information of the Optimization Master Plan developed by SEDAPAL, proposes an Investment Program of S/. 3.383 billion, of which: (i) 28% corresponds to the Project of Water and Sanitary Improvement of the Marginal Areas of Lima, (ii) 52% to the Agua para Todos Program, (iii) 9% to the Project of Optimization and Improvement of the Primary Water Supply and Sewerage System, (iv) 5% to projects of Rehabilitation of the Systems and (V) the remaining 6% to institutional projects, procurement of equipments and machinery, among others. The amount of the Investment Program calculated by SUNASS is smaller by S/. 701 million. (See Table 2.5.11-11).

Table 2.5.11-11: Program of Investments for the Five-year Period 2010-2014
(Expressed in Millions of Nuevos Soles)

Projects	2010	2011	2012	2013	2014	Total
1. Project of Water and Sanitary Improvement of the Marginal Areas of Lima	370	225	243	109		**947**
2. *Agua para Todos* Program, Phases I, II y III	311	391	363	360	348	**1,773**
3. Optimization and Improvement of the Primary Water Supply and Sewerage Systems	0.43	9	35	80	175	**299**
4. Rehabilitation of the Systems	0.51	9	49	66	45	**170**
5. Institutional Projects, Procurement of Equipments and Machinery, and others Projects 1/	45	33	54	26	30	**189**
6. Other Projects 2/		1	4			**5**
Total Budget	**727**	**667**	**744**	**642**	**598**	**3,383**

1/ Includes Supervision of Projects, Machinery, Equipment and Operation.
2/ Includes Liquidation of Works of year 2009

Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), Abril 2010.

2) Financial Structure

The Investment Program proposed by SUNASS for the 2010-2014 five-year period amounts to S/. 3.383 billion, and will be financed as follows: 47% (S/. 1.581 billion) through external loans arranged and to be arranged, 31% (S/. 1.051 billion) with self-generated resources, 12% through transfers from the Public Treasury (S/. 403 million) and the remaining 10% (S/. 347 million) through the sale of new connections.

Table 2.5.11-12 summarizes the financing considered for each year:

Table 2.5.11-12: Financial Sources
(Expressed in Millions of Nuevos Soles)

Source	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Contribution from the Government (Public Treasury)	132	189	82			**403**
External Loan	398	241	351	337	255	**1,581**
Self-generated Resources	172	218	190	225	246	**1,051**
Sale of new connections	26	20	125	80	96	**347**
Total	**727**	**668**	**748**	**642**	**598**	**3,383**

Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), Abril 2010.

3) Estimation of Operating Expenses

The tariff regulation model of SUNASS determines the efficient economic costs of the service rendering and determines the average medium-term cost that allows the coverage of the investments, operating expenses, taxes, variation of the working capital and the profitability of the invested capital.

Table 2.5.11-13: Projection of Operating Expense
(Expressed in Millions of Nuevos Soles)

Concept	Year 1	Year 2	Year 3	Year 4	Year 5
Operating Expenses [1/]	586	648	692	703	716
Diverse Management Expenses	13	13	13	13	13
Total	**599**	**661**	**705**	**716**	**729**

1/ The Operating Expenses do not include devaluation, bad debts provisions, or the contribution for regulation.
Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), Abril 2010.

4) Estimation of Revenues

SUNASS has estimated the revenues of the water supply and sewerage services, as well as other financial incomes resulting from new connection fees and deferred payment charged to clients that did not paid their debt on time.

The total operating revenue will increase from S/. 1.201 billion in 2010 to S/. 1.525 billion in 2014, resulting from the incorporation of new users, the sale of water supply and sewerage connections and commercial efficiency. The amounts estimated by SUNASS are similar to the ones projected by SEDAPAL.

Table 2.5.11-14: Projection of Revenues
(Expressed in Millions of Nuevos Soles)

Concept	Year 1	Year 2	Year 3	Year 4	Year 5
Sanitation Services [1]	1,111.6	1,163	1,252	1,333	1,425
Collateral Services	75	66	85	100	81
Other Revenues	15	21	21	21	19
Total	**1,201**	**1,250**	**1,358**	**1,453**	**1,525**

1/ The water supply and sewerage services represent 93% of the total revenue.
Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), Abril 2010.

The expected increase of revenues is the result of the projected tariff increase (2.0%, 2.0% and 2.3% in the years 1, 2 and 3, respectively), and of the increase of the billed volume due to the increase of the coverage and the commercial efficiency.

5) Determination of the Tariff Increase

Following the methodology established by the Organized Unique Text of the General Law of Sanitation Services', Act 26883[4] and the General Tariff Regulations[5] SEDAPAL has determined the Average Medium-Term Cost, equivalent to the average tariff with which the company will accomplish an economic-financial balance. For the updating of the free cash flow, SUNASS has used a Weighted Average Cost of Capital (WACC) of 3.92 %.

In that sense, according to the financial-economic evaluation conducted by SUNASS, the tariff increases for the water supply and the sewerage services shall be 2.0%, 2.0% and 2.3% in the first, second and third years, respectively, as shown in Table 2.5.11-15.

Table 2.5.11-15: Tariff Increase

Year	Water Supply	Sewerage
1	2.0%	2.0%
2	2.0%	2.0%
3	2.3%	2.3%
4	0.0%	0.0%
5	0.0%	0.0%

Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), Abril 2010.

The tariff formula approved by SUNASS includes the tariff increases corresponding to the projects: "Huascacocha – Rímac Derivation" and "Taboada Waste Water Treatment Plant", in accordance with the respective concession contracts. Moreover, this formula will allow the compliance of the obligations resulting from the "Huachipa Water Treatment Plant and North Branch."

The Tariff Formula was approved by SUNASS on April 16th of 2010 through the Directive Council Resolution Nº 018-2010-SUNASS-CD[6] and is applicable from May of 2010.

The tariff formula that will be applied by SEDAPAL has been divided into the water supply service and the sewerage services. The increase in the average tariffs by volume (S/.m^3) for the first five years will be as follows:

[4] *Texto Único Ordenado de la Ley General de Servicios de Saneamiento, Ley 26883*
[5] *Reglamento General de Tarifas*
[6] Resolución del Concejo Directivo Nº 018-2010-SUNASS-CD

$$T1 = To\ (1+0{,}020)(1+\Phi)$$
$$T2 = T1\ (1+0{,}020)(1+\Phi)$$
$$T3 = T2\ (1+0{,}023)(1+\Phi)$$
$$T4 = T3\ (1+0{,}000)(1+\Phi)$$
$$T5 = T4\ (1+0{,}000)(1+\Phi)$$

Where:

To : Average Tariff of the current structure
T1 : Average Tariff for year 1
T2 : Average Tariff for year 2
T3 : Average Tariff for year 3
T4 : Average Tariff for year 4
T5 : Average Tariff for year 5
Φ : Growth Rate of the Wholesale Price Index (WPI)

6) Management Objectives

The management objectives that are to be achieved by SEDAPAL in the following five-year period determine a route towards efficiency for the benefit of its users. The improvement in efficiency shall be reflected in the fundamental aspects of the services as follows:

- Increase of 249,425 new Water Supply Connections during the five-year period.
- Increase of 275,893 new Sewerage Connections during the five-year period.
- Increase of 239,390 new meters during the five-year period.
- Reduction of the level of non-revenue water from the 38.1% in the base year to 30% in the fifth year.
- Increase the average continuity from 21.6 hours/day in the base year to 22.1 hours/day in the fifth year.
- Accomplish a water pressure of 23.1 m.w.c. by the end of the fifth year
- Increase the labor ratio from 49% in the base year to 61% in the fifth year, due to the increase of the operating expenses.
- Increase the percentage of Active Water Supply Connections from 93% to 95% in the fifth year.
- Maintain the Water Supply and Sewerage Commercial Cadastre 100% up to date during the regulatory period.

7) Tariff Reorganization

The General Guidelines for the Reorganization of the Tariff Structure[7], approved by the Directive Council Resolution Nº 009-2007–SUNASS-CD [8], have the objective of developing tariff structures that promote the economic efficiency and the financial

[7] *Lineamientos Generales para el Reordenamiento de Estructuras Tarifarias*
[8] *Resolución de Consejo Directivo Nº 009-2007–SUNASS-CD*

sufficiency of the EPS[9] and that, at the same time, contribute to the fulfillment of the principles of equity, transparency and simplicity. In that sense, complying with such guidelines, a tariff structure with the following characteristics is proposed for SEDAPAL:

- Ensure the cross subsidies.
- Establish a binominal tariff.
- Simplify the allocation of consumption, allocating one single volume to each category.
- Define two types: Residential and Non-residential.
- Include the social and domestic types in the Residential Type.
- The Non-residential Type shall include the categories: commercial, public and industrial.

(9) Differences between SEDAPAL´s PMO and SUNASS´s Tariff Study

SEDAPAL has expressed its discrepancy regarding the Tariff Study for the Determination of the Tariff Formula and Structure and the management objectives applicable to SEDAPAL for the five-year period 2010-2014 approved by the Directive Council Resolution N° 018-2010-SUNASS-CD. Therefore, SEDAPAL has issued a Motion for Reconsideration of said resolution before the Directive Council of SUNASS. The aspects included in such report, refer mainly to the following topics:

- The five-year evaluation period of the PMO was the 2009-2013 period, and the Tariff Study by SUNASS was done for the 2010-2014 period, thereby, the calculations and projections of operating expenses and profits may have been modified due to the use of different base years for the calculations.
- The PMO by SEDAPAL considered an Investment Program for a total amount of S/. 4.084 billion for the 2009-2013 period. According to SEDAPAL, if these projects are updated to the 2010-2014 period, the amount would increase to S/ 4,525 billion.
- The Tariff Study by SUNASS reduced the investment amount proposed by SEDAPAL for the 2010–2014 period to S/. 3.383 billion, 30% less than the amount calculated by SEDAPAL for the program. In this sense, according to SEDAPAL's report, besides reducing the investment program, SUNASS has reduced the total cost of some projects and the general financial programming of the five-year period.
- Also, according to the calculations done by SEDAPAL, an amount of S/. 450 million corresponds to projects that are currently in the investment stage, for which contract commitments have already been made. The fulfillment of such commitments may be jeopardized if the tariff increase approved by SUNASS is maintained. Other costs

[9] *Empresa Prestadora de Servicios* (Service Rendering Company)

excluded are those related to the operational and commercial maintenance, amounting to S/. 442 million, whose activities are in execution through contracts with third parties.

- SUNASS' Tariff Study considered a total amount of S/. 965 million soles in arranged loans and an amount of S/. 689 million in loans to be arranged for the financing of the investments of the five-year period (See Table 7.2 – Cash Flow of the Tariff Study). According to SEDAPAL, this last amount (loans to be agreed) is larger, because the company has only predicted a disbursement of S/. 368 million for external loans, of which S/. 343 million correspond to disbursements for projects considered by SUNASS in the tariff calculation and S/. 25 million correspond to projects not considered in the calculation.
- The difference of S/. 346 million considered by SUNASS, overestimates the disbursements of external loans that SEDAPAL plans to obtain in the medium term for the projects considered in the tariff calculation. It is pertinent to address that the levels of disbursement are previously approved by the Ministry of Economy and Finances in the annual laws of public indebtedness, and this shall be approved by FONAFE in the annual budget.
- Regarding the management objectives, there is a difference in the increase of water supply and sewerage connections. SUNASS proposes a smaller number of connections, as indicated in the approved management objectives.
- SUNASS' Tariff Study modified the Weighted Average Cost of Capital (WACC), proposing a value of 3.92 %. This ratio requires a smaller increase of tariffs, as shown in Table 2.5.11-16.

Table 2.5.11-16: Weighted Average Cost of Capital

Parameter	SEDAPAL [1]	SUNASS [2]
	Value	Value
Cost of Capital	**11.17%**	**10.96%**
Risk-free Rate	3.35%	3.41%
Beta	0.82	0.82
Market Risk Premium	6.57%	6.57%
Country Risk	2.43%	2.16%
Actual Debt Cost	**1.68%**	**1.87%**
Debt Rate	2.52%	2.81%
Income Tax	30%	30%
Share of Profits	5%	5%
Cost of Nominal Capital	**8.02%**	**7.42%**
Devaluation	0.60%	-1.23%
Inflation	2.40%	2.10%
Effective Cost de Capital S/.	**6.12%**	**3.92%**

1/ PMO de SEDAPAL, September 2009

2/ SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), April 2010.

Source: SEDAPAL Tariff Study (*Estudio Tarifario SEDAPAL – SUNASS*), April 2010.

In March 2010, before the approval of the Tariff Formula, Tariff Structure and Management Objectives of SEDAPAL, SEDAPAL communicated to SUNASS about the Discount Rate to be used (through the Letter N° 528-2010-GG of 03.29.2010), which is sustained in the N° 001-2010-*Grupo de Trabajo* Report of the ESAN University Study. This rate amounts to 9.22% in national currency, significantly greater than the value calculated by SUNASS.

Based on the above description, SEDAPAL considers that the study conducted by ESAN University regarding the Discount Rate is consistent and reflects a detailed and thorough analysis, which demonstrates the need to revise the procedure and sources of information detailed in Appendix Nº 5 (Parameters for the Weighted Average Cost of Capital) of the General Regulation of Tariffs.

In conclusion, according to SEDAPAL, a smaller increase of the tariffs may entail the breaking of the economic-financial balance of the five-year period in the next three (3) years.

(10) SUNASS´s Final Resolution of Tariff Formula, Tariff Structure and Management Objectives

Through the Directive Board´s Resolution N° 026-2010-SUNASS-CD from June 16, 2010, SUNASS has declared that the reconsideration notice given by SEDAPAL was in part well-founded, and it has modified the Tariff Formula, Tariff Structure and Management Objectives for the five-year period 2010-2014.

1) Determination of Tariff Increase

The increase in the average tariffs by volume (S/./m^3) for the first five (5) years is as follows:

$$T1 = To\ (1+0{,}032)(1+\Phi)$$
$$T2 = T1\ (1+0{,}020)(1+\Phi)$$
$$T3 = T2\ (1+0{,}020)(1+\Phi)$$
$$T4 = T3\ (1+0{,}000)(1+\Phi)$$
$$T5 = T4\ (1+0{,}000)(1+\Phi)$$

Where:

To	: Average Tariff of the current structure
T1	: Average Tariff for year 1
T2	: Average Tariff for year 2
T3	: Average Tariff for year 3
T4	: Average Tariff for year 4
T5	: Average Tariff for year 5
Φ	: Growth Rate of the Wholesale Price Index (WPI)

A conditional increase of 4.1% has been incorporated for the Terms and Conditions Portfolio of the Projects of Water and Sewerage Expansion and Network Rehabilitation, whose goals are: i) 38,451 water connections, ii) 38,451 sewerage connections, and iii) 47,372 micrometers.

2) Management Goals

The management goals that SEDAPAL should reach in the next five-year period determine a path towards efficiency that it shall seek to accomplish for the benefit of its users. The improvement in efficiency shall be reflected in the fundamental aspects of the services as follows:

- Increase of 278.614 new Water Supply Connections during the five-year period.
- Increase of 310.639 new Sewerage Connections during the five-year period.
- Increase of 489.652 new meters during the five-year period.
- Increase of 270,600 meters replaced due to expiration of service life during the five-year period.
- Replacement of 599,082 meters due to malfunctioning during the five-year period.
- Reduction of the level of non-revenue water from 38.1% in the base year to 28.5% in the fifth year.
- Increase the labor ratio from 49% in the base year to 58% in the fifth year, due to the increase of the operating expenses.
- Increase the percentage of Active Water Supply Connections from 93% to 93.1% in the fifth year.

The rest of the management goals will remain unchanged, according to what was established in the Tariff Study and approved by the Directive Board´s Resolution N° 018-2010-SUNASS –CD from April 16, 2010.

2.5.12 Institutional Aspects and Legal Framework

SEDAPAL´s general aspects, scope of responsibility, and legal framework are presented in this section; as well as the organization and functional structure, management instruments, and commitment to the environment and human resources available for the rendering of water and sanitation services.

(1) General Aspects

The Water and Sanitation Service company of Lima (*Servicio de Agua Potable y Alcantarillado de Lima SA*, or SEDAPAL) is a state-owned company set up as a corporation. It was created by the Decree No. 150 of June 12, 1981, written in Record No. 02005409 of Lima´s Public Records. Since November 25, 1998, it has been a public company subject to the law of the National Funding Corporation for Financing of State Business Activity (*Corporación Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado,* FONAFE).

It is governed by the provisions of its Statutes and the General Corporation Law - Law N° 26887, its amendments, and its extensions. Likewise, it is found in the scope of Law N° 26887 – Law of State Business Activity, and modified by N° 27170 – Law of National Funding for Financing of State Business Activity of September 1999. These laws define the economic, financial, and labor regimen of the company, as well as the diverse levels of governance and administrative systems.

SEDAPAL´s scope of responsibility was modified through Law N° 28696 of March 2006, specifying that this includes the Province of Lima, the Constitutional Province of Callao, and those other provinces, districts, or zones in the Department (now renamed as Region) of Lima that are included through the ministerial resolution of the Ministry of Construction, Housing and Sanitation (Vivienda), when land continuity and service coverage may be directly affected. Currently, the scope of SEDAPAL´s services rendered covers 49 districts of metropolitan Lima, of which 46 are covered totally and 3 partially.

The bylaws in its article 2 establish that SEDAPAL´s objective is the rendering of water and sanitation services, which are made of up the following services, systems, and activities:

1) Water Supply Service

   A production system, which is made up of: intake, storage and conveyance of raw water, treatment and conveyance of raw water, treatment and conveyance of treated water; a distribution system, which is made up of: storage, distribution networks, and mechanisms of delivery to the user; house connections, including the metering, public tap, and others.

2) Sewerage Service

   Collection system, which consists of: house connections, sinks, drains, and transmitters.

3) System of Sewage Treatment and Disposal

4) System of Sanitary Disposal of Excreta, Systems of Latrines and Septic Tanks

5) Actions of Environmental Protection, linked to the projects executed for the fulfillment of its main activity

Said services are regulated by Law Nº 26338, General Law of Sanitation Services, and by the Consolidated Text of the General Sanitation Services Law (*Texto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento*), approved by Supreme Decree Nº 023-2005-VIVIENDA.

(2) Organization and Functional Structure

The organization of SEDAPAL is composed of a Board of Directors (made up of a president and 4 directors), the General Management Department, the Offices of Consultancy and Support, and the Line Management Department, in addition to the Internal Audit Management Department.

The current organization chart has been modified in the Board of Directors´ Session N° 007-2010 on March 24, 2010.

1) Main Headquarters (La Atarjea)

SEDAPAL´s headquarters is located in the La Atarjea water treatment plant. There are around 200 people working in the General Management Department, which includes the Management Departments of Logistics, Services, Human Resources, and Finances.

The planning, design, and supervision of expansion, rehabilitation, and improvement projects are mainly controlled in the Research and Development Management Department and the Projects and Works Management Department. There are approximately 240 people employed to carry out these activities.

In addition to the control activities previously mentioned, the Production and Primary Distribution Management Department and the Management Department of Collection, Treatment, and Final Disposal carry out operation and maintenance works of the primary and secondary distribution pipes, for water as well as for sewerage, the operation and maintenance of the water and waste water treatment plants, the operation and maintenance of groundwater equipment and its pumping, and the evaluation of the quality of water and residual. The center of operations is located at the Main Headquarters. There are approximately 450 workers dispatched in these departments.

2) Management of Services (North Services Management)

The Managements of the local services carry out the work of operation and maintenance for the water and sewerage systems. The SEDAPAL service area has been divided into three (3) Management areas and seven (7) Network Operation and Maintenance Teams for the daily operation and maintenance of the water and sewerage systems. The total number of workers in the Management of Services is around 600 people, between managers and operators. The North Services Management Department (GSN) is the relevant to this Study and is made up of two Network Teams for operation and maintenance: Callao and Comas.

There are around 600 workers in business administration, under the control of the Business Management Department. The business activities of metering, invoicing, and collection are divided between the main office and the seven (7) local Service Teams.

The Study area is mostly located in the area of influence of the Comas Service Team, with the exception of the Márquez zone (Secotr 259), which belongs to the Callao Service Team.

The operator of the Comas Service Team resolves the daily complaints from users about the water and sanitation service, such as leakages and clogs. SEDAPAL´s strategy has been to entrust a third-party company with the installation work for new connections, as well as works of replacement and repair of the existing connections, for the purpose of minimizing the cost and achieving greater efficiency. Following this strategy, the office of local services only obtains the minimum number of facilities for operation.

Section 2.5.12-(7) gives a brief outline of the activities of each of the Teams related to the project.

The current organization chart (since July 2010) shows the organization of the Support Management Department and the Line Management Department and their respective Work Teams.

(3) Legal Aspects

The following laws, decrees and their amendments form the basis of SEDAPAL's organization, scope and activities.

- Statute and General Policy for Water and Sewerage Service in Lima – SEDAPAL (Estatuto y Política General del Servicio de Agua Potable y Alcantarillado de Lima – SEDAPAL)
- General Corporations Law (Ley General de Sociedades), Law N° 26887 (19/11/1997)
- Law N° 27170 – Law of the National Funding Corporation for Financing of State Business Activity (Ley del Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado)
- Law 26338, Sanitation Services General Law, (Ley General de Servicios de Saneamiento). (24/July/1994)
- Supreme Decree N° 023-2005-Vivienda, Single Revised Text of the Rules of the General Sanitation Services Law (Texto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento), Ley N° 26338 (1/December/2005).
- Law Decree Nº 25965; Law of the Creation of the National Superintendency of Sanitation Services (Ley de Creación de la Superintendencia Nacional de Servicios de Saneamiento).
- General Regulation of National Superintendency of Sanitation Services (Reglamento General de Superintendencia Nacional de Servicios de Saneamiento), Supreme Decree Nº 017-2001-PCM.
- Multi-Annual Strategic Sectoral Plan 2008-2015, RM Nº 920-2008-Vivienda, of the Ministry of Housing Construction, and Sanitation (31/12/2008)

- SEDAPAL´s Institutional Strategic Plan 2009 -2013
- SEDAPAL Master Plan 2009-2013
- SEDAPAL´s Institutional Operative Plan and Budget Plan for 2010

(4) Instruments of Management

SEDAPAL has the a number of main instruments for planning and control of management, such as: Regulations of Organization and Functions (ROF), Manual of Organization and Functions (MOF), Table for Assignment of Personnel (Cuadro de Asignación de Personal , or CAP), Analytical Budget for Personnel (Presupuesto Analítico de Personal, or PAP), Classification of Offices, Internal Work Regulation (Reglamento Interno de Trabajo, or RIT), Personnel Compensation Policy and Map of SEDAPAL processes, among other documents.

Likewise, they have an Optimized Master Plan (OMP) 2009-2030, Operative and Budget Plan 2010, and Institutional Plan framed within the sector´s regulations and the Multi-Annual Strategic Sectoral Plan for 2008-2015 of the Ministry of Housing, Construction, and Sanitation (RM 920-2008 –VIVIENDA del 31/12/2008).

In the same way, in April 2010, the SUNASS approved the Tariff Formula, Tariff Structure, and Management Goals on the basis of the SEDAPAL Tariff Study; these will be applied to SEDAPAL for the five-year period between 2010 and 2015.

It is necessary to point out that according to Law Nº 27806 regarding transparency and access to public information (7/08/2003), all of the company´s management information is published and updated periodically on the company´s web page.

(5) Commitment to the Environment

SEDAPAL has related Integrated Management System policy (Sistema de Gestión Integrado, or SGI) (ISO 9001: 2008 – Calidad-, ISO 14001: 2004 –Medio Ambiente y OHSAS 18001: 2007- Occupational Health and Safety). The Integrated Management System certification – Quality, Environment, and Occupational Health and Safety – guarantees international standards of quality, preservation of the environment, and the maintaining on the job safety and health. The obtaining of the certificate by SEDAPAL has a series of competitive advantages for the company: cost reduction, greater profitability, improvements in production, motivation, commitment on the part of the personnel, better market positioning, and optimization of the use of resources, among others.

The Integrated Management Systems, based on regulations recognized and accepted internationally, provide a true option for orchestrating excellent control of all of those activities and includes the possibility of implementing the necessary corrections, in order to mainstream any possible deviations.

As a public service company, SEDAPAL has a main objective of achieving quality service; incorporating effective management would allow them to complete their Mission.

In that sense, in order to assure the quality of their products and services, to achieve a better environmental performance, and to watch out for workers´ safety, it carries out activities under the strict framework of the Integrated Management System, which is the collection of coordinated activities to direct and control the processes, based on the ISO Regulations for quality and the environment, as well as OHSAS regulations.

(6) Human Resources

In December 2009, the company´s labor force was made up of 2,159 permanent staffs distributed in the different sections of the company, of which 1,394 are employees and 667 are workers, having the additional support of twelve (12) workers contracted for a fixed-term according to Legislative Decree N° 728.

In the scope of the North Services Management Department, there are 217 staffs (10.1% of the total), of which 75 are employees, 141 are workers and 1 is contracted, as shown in Table 2.5.12-1.

Table 2.5.12-1: Distribution of Active Workers by Occupational Group

Type Personnel	Total of SEDAPAL		North Service Management
	2005	2009	2009
Senior Civil Servant	11	9	1
Civil Servant	68	77	4
Employees	1,282	1,394	70
Workers	655	667	141
Contracting	160	12	1
Total	2,176	2,159	217

Source: SEDAPAL´s 2009 Statistical Almanac, March 2010.

According to the productivity indicator "Workers per Thousand Connections," work productivity has improved notably in the last few years, decreasing from 1.92 in 2005 to 1.67 in 2009, results that are lower than the international standards of 5 people per 1,000 connections. This improvement is a product of the investments carried out by SEDAPAL in expansion of water and sanitation services coverage in the framework of the Water for All Program (Programa Agua Para Todos), without increasing the number of employees in the company (see Table 2.5.12-2).

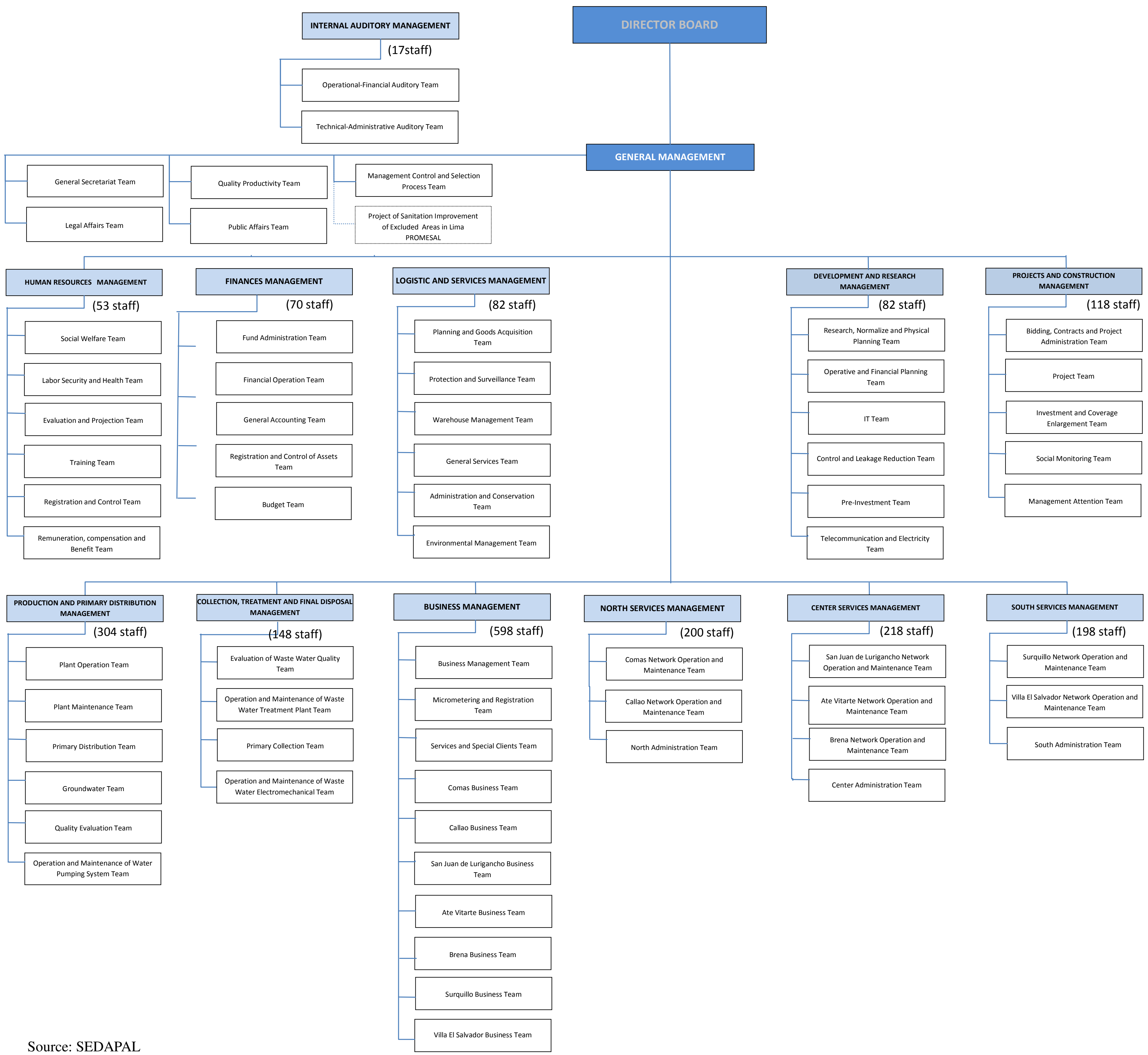
Table 2.5.12-2: Work Productivity Index

Year	Connections	Workers	Workers per 1000 Connections
2005	1,135,184	2,176	1.92
2006	1,144,181	2,224	1.94
2007	1,194,879	2,217	1.86
2008	1,230,638	2,176	1.77
2009	1,293,348	2,159	1.67

Source: SEDAPAL´s 2009 Statistical Almanac, March 2010.

(7) Teams Involved with Project Formulation, Execution and Operation

Several teams are involved in the project during the feasibility study and the execution period. The present number of employees, work scope, and equipment for O&M for each team are shown in Figure 2.5.12-1.



Source: SEDAPAL

Figure 2.5.12-1: SEDAPAL's S.A Overall Organization Chart (December 2009)

Table 2.5.12-3: Summary of Teams Involved in Project Formulation, Execution and Operation

Management Department	Team	Main Objective
- Central Headquarters – la Atarjea		
General Management Department	(1) Sanitation Improvement Project in Marginalized Lima Areas, PROMESAL (*Proyecto Mejoramiento Sanitario de las Areas Marginales de Lima*)	Supervise and approve the project during the execution stage.
Research and Development Management Department	(2) Pre-investment Team	Plan and supervise the feasibility study
	(3) Team for Control and Reduction of Leaks	Detect invisible leaks and repair them. Update the Technical Cadastre of the installations and take control of incidents.
Projects and Works Management Department	(4) Social Project Management Team	Plan and supervise the social monitoring of project beneficiaries, such as the explanation of pre-construction work and hygiene education.
Production and Primary Distribution Management Department	(5) Primary Distribution Team	O&M of the pipes and valves for water distribution.
Management Department for Collection, Treatment and Final Disposal	(6) Primary Collection Team	O&M of the primary sewerage collection pipes, manholes, and transmitters.
Business Management Department	(7) Special Services and Clients Team (Aquafono)	Receive client complaints by phone and internet and transmit them to relevant team of O&M personnel.
	(8) Comas and Callao Service Teams	Operate and control the invoicing and collecting in Service Teams.
- North Services Management Department -		
North Services Management Department	(9) Operation and Maintenance Team for Networks – Comas	Operate and maintain water and sanitation services, including the secondary pipes and house connections.
	(10) Operation and Maintenance Team for Networks – Callao	
	(11) Administration Team – North	Operate administrative matters in the local office.

Source: JICA Study Team

1) PROMESAL Team (Proyecto Mejoramiento Sanitario de las Areas Marginaled de Lima)

(a) Number of people, 5

(b) Functional and Organizational Framework

- Formulate the Annual Purchase and Contracting Plan for the Project, and evaluate it periodically.
- Formulate the Annual Project Investments Budget and evaluate its execution monthly.

- Administrate the Loan Agreements with development partners like the World Bank and the JICA, which implies carrying out the following actions:
- Represent SEDAPAL before the financial entities.
- Formulation and management of Annual Investments and Programs Budget.
- Development of Terms of Reference and Specifications (Technical Files) following international regulations.
- Management of Selection Processes for the acquisition of goods and the contracting of consultants and works with external financing, safeguarding the fulfillment of the current legal rules and regulations.
- Management of expenditures of the international loans.
- Procedures for Project Compensation Payment.
- Administration of Contracts through selection processes.
- Coordination with the Managerial Care Team with respect to the approval of the technical aspects of the studies and the works in progress.
- Development of actions of monitoring and control of the progress of the projects under its care.
- Control of Funds and Finances.
- Revision, approval, and payment procedure for appreciation of Goods, Works, and consultancies.
- Execution of the Project´s Financial Statements.
- Formulation of periodic reports about the progress of the project.
- Coordination and promotion of projects with the Public and Private Entities, Municipalities, and benefitting population.
- Propose the approval of projects of secondary networks and house connections for water and sewerage to the Project and Works Management Department, upon approval of such projects by the Managerial Care Team.

2) Pre-investment Team

(a) Number of people, 8

(b) Functional and Organizational Framework

- Evaluation of Pre-investment Studies in the SNIP framework, through the technical, economic, institutional, social, and environmental verification of the Public Investment Projects.
- Issue technical reports for approval, observation, or rejection of pre-investment studies and recommend the declaration of viability of Public Investment Projects, as appropriate.
- Issue reports or documents about technical matters and SNIP regulations at the requirement of the Executive Management, Research and Development Management Department, Formulating Units, Evaluating Units or other entities.
- Provide technical assistance and consultancy to the distinct SEDAPAL Formulating Units in formulation and evaluation of Investment Projects, technical and administrative procedures in the SNIP framework, and the development of

terms of reference for pre-investment studies.

- Promote and carry out capacity-building activities in formulation and evaluation of Investment Projects for the SEDAPAL Formulating Units, as well as in technical and administrative procedures in the SNIP framework.
- Develop technical proposals for the adequacy of the SNIP regulations, in cases that deserve individual treatment according to the established criteria.
- Coordinate with OPI-Vivienda the DGPI-MEF and other Programming and Budget Offices (*Oficinas de Programación e Inversión*, OPI) in the formulation and evaluation of the SEDAPAL Investment Projects within its competence.
- Coordinate, at the request of the OPI of Local Governments in Metropolitan Lima, the processes of formulation and evaluation of Investment Projects in water and sanitation within their respective jurisdictions.

3) Team for Control and Reduction of Leakages, Research and Development Management Department

(a) Number of people, 20

(b) Functional and Organizational Framework

- Program, implement and execute the macro-metering of the Distribution System.
- Program, execute and evaluate the processes of loss control in the Distribution System, proposing programs and pertinent corrective measures.
- Coordinate, advise, and support the development of the Distribution Sectors, evaluating and validating their operability, by proposing and executing the necessary corrective measures.
- Develop actions of loss control.
- Develop cadastre for keeping documentation current and organized.

(c) Available Equipment

Table 2.5.12-4: Available Equipment of Control and Reduction of Leakage Team – Development and Research Management

Equipment	Quantity
・ Panel van	4
・ Correlater with accessories (red and blue radio)	4
・ Comptometer wheel	4
・ Acoustic water leak detector	4
・ Metal detector	4
・ Geophones (2)	8
・ Generation group	4
・ Drill	4
・ Diverse tools	4 sets

Source: JICA Study Team

4) Social Management Team for Projects, under the Projects and Works Management Department

(a) Number of people, 14

(b) Functional and Organizational Framework

- Monitor, support, and evaluate the social intervention activities in the pre-investment, investment, and post-investment activities for the projects and works of the Projects and Works Management Department.
- Coordinate with the Municipalities, Ministries, and Public and Private Service Companies for the requirements formulated by the Community Organizations.
- Management support, prior to execution of works, for the obtaining of licenses, permission, and authorizations for road use, land acquisition and easement of the Management Teams.
- Facilitate and/or propose Cooperation Agreements, in study, works, and similar things, within the competence of the Projects and Works Management Department.

5) Primary Distribution Team, belonging to the Production and Primary Distribution Management Department

(a) Number of people, 85

(b) Functional and Organizational Framework

- Formulate, propose, organize, control and evaluate the primary distribution network maintenance programs (pipes, valves, pressure-reducers, cathodic protection).
- Formulate, propose, organize, control, evaluate and optimize the operation and maintenance programs for the primary network´s supervision and automated control system (*sistema de supervisión y control automatizado*, SCADA).
- Evaluate the hydraulic behavior of the primary distribution system for diverse operation scenarios through mathematic simulation models.
- Analyze, evaluate, and program the water distribution plans under different situations of loss of production (high tide, ebb tide, drought, and others), in coordination with the Operation and Maintenance Teams involved.
- Supervise, evaluate, analyze, and solve situations of pipe breakages in order to reestablish service.

- Verify and approve quantity and quality of water delivered by the dealer.

6) Primary Collection Team, of the Management Department for Collection, Treatment, and Final Disposal

(a) Number of people, 33

(b) Functional and Organizational Framework

- Plan, organize, manage, supervise, and evaluate the operation and maintenance of the Primary Sewer Network and Transmitters.
- Coordinate and execute works of servicing clogs and collapses in Primary Sewers and Transmitters.
- Coordinate the execution of works in public streets, such as solving interference in the streets within the scope of its competence.
- Authorize, supervise, and/or execute works related to junctions at the Primary Sewers.

7) Special Services and Clients Team, Business Management Department

(a) Number of people, 61

(b) Functional and Organizational Framework

- Formulation, execution, control, and evaluation of plans, budget, and programs linked to the business management of major users.
- Administrate, evaluate, and control the Preferential Clients connected to the Public Water Network and Self-Sourced with use of underground water and/or sewerage.
- Program and carry out management audits and operatives for the services and major users.
- Exert the Original Administrative Instance in the resolution of complaints of major users of the business system connected to the Water and/or Sewerage Network.
- Formulate and promote constant improvements in the service provided to principal users of SEDAPAL.

8) Comas Service Team, and Callao Service Team, Business Management Department

(a) Number of people, 84 and 48

(b) Functional and Organizational Framework

- Carry out actions towards the development of the business process, including the following:
- Execute the operative processes of meter reading, invoicing, and tariff collecting, as well as customer support and proposing necessary improvements or adaptations.
- Coordinate the legal studies contracted and the actions of pre-judicial and judicial collection.
- Program, execute, control, and supervise the works of closing and restoring services.

- Develop, control, and supervise the process of house connections.
- Execute and report the daily control of sales, collateral services, and collection.
- Formulate and execute preventive operative business actions in order to avoid the proliferation of clandestine water connections and fraudulent use of service, identifying sectors with greater incidence.

9) Networks Operation and Maintenance Team – Comas, under North Services Management Department

(a) Number of people, 121 (June 2010)

(Leadership 4, Operational Control 11, Distribution 36, Collection 42, House Connections 28)

(b) Functional and Organizational Framework

- Program, execute, control and evaluate the operation and maintenance works in the secondary water and sewer networks, as well as solve the emergencies that arise in the scope of competence.
- Program, execute, control and evaluate the works of installation, repair, and maintenance of house connections of water and sewerage.
- Program, execute, control and evaluate the works of installation, reposition of meters, changing of filters and meter security.
- Program, supervise, control and evaluate the cleaning and disinfection of the reservoirs, wells, and their hydraulic control elements, in the scope of competence.
- Direct, channel, and approve the applications for technical feasibility of new house connections of water and sewerage in existing and functioning secondary pipes, as well as the technical feasibilities for the implementation of communal or *quinta*[1] connectionms for water and sewerage.
- Monitor the water quality in secondary networks and house connections in the scope of competence.
- Formulate and execute preventive and corrective maintenance actions on the machinery, equipment, and vehicles assigned to the Team.
- Attend to requirements and operative complaints from clients according to the current legislation.
- Coordinate and support the actions related to maintaining the cadastre of networks and house connections of water and sewerage.
- Supervise the service contracted with third parties and verify the strict fulfillment of the contract signed, making note of failures to comply.
- Coordinate with the rest of the operative areas, Municipalities, and individuals and legal entities for the execution of works in public streets, solving the interference in the streets within the scope of its competence.
- Operate the control valves in the secondary networks in diversions after the entry

[1] A “quinta” is a narrow, dead-end street or alley containing residences with common walls. Usually it has single water connection that is used by all members of the community.

point into sectors and in the outflow from reservoirs, in coordination with the Primary Distribution Team and the Electromechanical Operation and Maintenance Team, respectively.

- Secure the supply schedule, in the scope of competence, depending on the availability of water.
- Determine and eliminate the clandestine connections and/or grant technical feasibility, in the case of its regularization, in the scope of competence.

(c) Available Equipment

Table 2.5.12-5: Available Equipment of Networks O&M Team - Comas

Equipment	**Quantity** (procured year)
• Hidro Jet equipment	4 (1997 x 2, 1998, 2006)
• Mini Hidro Jets	2
• Tank truck	2 (1994, 1997)
• Backhoe	1 (1985)
• Dump truck	1 (1984)
• Television unit	0

Source: JICA Study Team

10) Operation and Maintenance of Networks Team – Callao

(a) Number of people, 68 (August 2010)

(Leadership 3, Operational Control 17, Distribution 19, Collection 19, House Connections 10)

(b) Functional and Organizational Framework

(The same as mentioned above)

(c) Available Equipment

Table 2.5.12-6: Available Equipment of Networks O&M Team - Callao

Equipment	**Quantity** (procured year)
• Hidro Jet equipment	3 (1997 x 2, 2006)
• Mini Hidro Jets	1
• Tank trucks	4
• Television unit	1

Source: JICA Study Team

11) Administration Team – North

(a) Number of people, 14

(b) Functional and Organizational Framework

- Consolidate and control the Operative Budget Execution of the Services Management Department, as well as inform about its progress and results, proposing and/or managing budget transfers.
- Coordinate, develop, control and evaluate the Service Centers under their administration, the decentralization of personnel, warehouses, fuel resources, and maintenance infrastructure and equipment; proposing the pertinent corrective

measures.

- Coordinate with the Operative Teams and manage the following in a timely manner: the authorizations and permissions for the water supply trucks, tank trucks, dump trucks, tow trucks, and Hidrojet equipment or similar things belonging to the Services Management Department.
- Control, manage, and evaluate actions developed for the sanitation in the land occupied by businesses and operative structures in the jurisdiction of the Services Management Department.

2.5.13 Diagnosis of Operation and Maintenance Aspect

(1) Present SEDAPAL Maintenance Procedure

The operation and maintenance of each water and sewerage service facility is executed by the teams in charge. In relation to the Study, the primary pipes of both water and sewerage network is managed by the headquarters at La Atarjea, and the secondary network and house connections are controlled by local offices, such as the Comas and Callao service offices.

The operation and maintenance procedures for service are summarized in Table 2.5.13-1, and each of the factors is explained in the following sections;

Table 2.5.13-1: Summary of Operation and Maintenance Procedure

		Water Supply	Sewerage
Maintenance	Corrective	(1) Visibly Detectable Water Leakages	(1) Road Subsidence (2) Pipe Clogs, Manhole Cleaning
	Preventative	(2) Periodical Replacement of Distribution Pipe	(3) Periodical Sewer Pipe Cleaning (4) Periodical Replacement of Sewer Pipe
Operation		(3) Valve Control (4) Cleaning of Reservoirs, Replacement of Fire Hydrants (5) Study of Visibly Non-detectable Leakage (6) Meter installation, Education about Meter Installation	(5) Education Regarding Dumping of Trash
Planning and Control		(1) Maintenance of Inventory and GIS (2) Long Term Planning of Existing Facilities	

Source: JICA Study Team

(2) O&M of Water Supply Service

The operation and maintenance of the water supply service is managed by the O&M teams in the local service offices of Comas and Callao. Both offices are composed of four functional groups: “operational control group,” “distribution group,” “sewage collection group,” and “house connection group”. The “distribution group” and the “house connection group” mainly attend to the repair of water supply pipes.

In addition to the above teams, the underground water leakage detection is managed by “the control and reduction of underground leakage team” working in SEDAPAL´s headquarters. Also, the social activities, such as meter installation seminar for users, are controlled by the “project social management team.”

See Section 2.5.12: “Institutional Aspects and Legal Framework” for more details.

1) Visibly Detectable Water Leakages (Corrective Maintenance)

The claims of water leakage are collected by phone at the “client service team” located in SEDAPAL´s headquarters, and the information is delivered to the appropriate team. The primary distribution department manages the leakages of primary pipes, and the local service offices manage the rest of leakages at secondary pipes and house connections.

Normally, these teams inspect the incidence point and order a third-party company to repair the leakages with their own construction machines. The latest contract for 2 years of the repair works was made in July 2009 with one private company called "CONCYSA Company" which was selected through the tendering process.

The activities for pipe facilities conducted by Comas and Callao service teams are indicated as follow;

Table 2.5.13-2: Leakages in Water Networks (2009)

Unit: Number of leakage

	All of SEDAPAL	Comas	Callao
Leakages in Primary networks	11	0	0
Leakages in Secondary networks	2,449	491	265

Source: Statistical Almanac 2009

Table 2.5.13-3: Pipe Maintenance Activities (2009)

	All of SEDAPAL	Comas	Callao
Installation of water networks	23,785m	2,104m	1,986m
Change or reposition of water networks	29,088m	6,089m	6,503m
Junction of secondary piping	752 units	102 units	46 units
Reparation of water networks	3,582 units	915 units	470 units

Source: Statistical Almanac 2009

Table 2.5.13-4: Activities Involving House Connections (2009)

	All of SEDAPAL	Comas	Callao
Installation of house connections by the EOMR	11,880 units	3,749 units	651 units
Reparation of house water connections	95,591 units	3,175 units	28,647 units

Source: Statistical Almanac 2009

2) Periodic Replacement of Distribution Pipes (Preventative Maintenance)

The total length of water supply pipes and the lengths of pipes repaired annually are indicated in Table 2.5.13-5.

Regarding to the executed work in 2009, the replacement rate is calculated to be 0.29% and 0.65% in the Comas and Callao districts, respectively. Generally, the ideal percentage of replacement for each year is considered to be 2%, assuming the life span of distribution pipes to be 50 years. Hence, it is evident that there is no sufficient preventive replacement activity in order to achieve sustainable maintenance.

According to employee interviews, SEDAPAL does not have any long term plans for pipe replacement, and this is conducted when the budget is obtained from external agencies or the government treasury.

Table 2.5.13-5: Pipe Installation and Replacement (2009)

	All of SEDAPAL	Comas	Callao
Length of existing primary networks	665 km	101 km	130 km
Length of existing secondary networks	11,098 km	2,856 km	1,300 km
Installation of water networks	23,785m	2,104m	1,986m
Change or repositioning of water networks	29,088m	6,089m	6,503m
Total length of pipe installation	**52,873m**	**8,193m**	**8,489m**
Annual pipe replacement rate	0.48%	0.29%	0.65%

Source: Statistical Almanac 2009

3) Valve control (Operation)

Daily operation of water supply valves is conducted by the distribution teams in local service offices for the restriction of water supply and the temporary interruption of water service. The number of activities related to the installations and changes of water supply valves is summarized as follows:

Table 2.5.13-6: Activities Relating to Valves (2009)

	All of SEDAPAL	Comas	Callao
Installation of valves in the network	264 units	51 units	121 units
Replacement of valves in the networks	1,232 units	207 units	82 units
Maintenance of valves in the network	3,116 units	550 units	174 units

Source: Statistical Almanac 2009

4) Cleaning of Reservoirs, Replacement of Fire Hydrants (Operation)

Cleaning of reservoirs is conducted approximately every six month. This frequency is sufficient for maintaining the water supply service in good condition.

Table 2.5.13-7: Activities Relating to Water Supply Accessories (2009)

Unit: Number of Activities

	All of SEDAPAL	Comas	Callao
Cleaning and disinfection of reservoirs	1,139	346	105
Cleaning and disinfection of cisterns	247	80	6
Installation of fire hydrant	70	9	8
Replacement of fire hydrant	488	141	70
Maintenance of fire hydrant	1,722	115	0

Source: Statistical Almanac 2009

5) Study of Visibly Non-detectable Water Leakage (Operation)

The study of visibly non-detectable leakages is conducted by "the control and reduction of leakage team," located in SEDAPAL´s headquarters.

SEDAPAL provides the full leakage detection equipment to the private company, and the team members supervise the study execution. The leakage found will be repaired by private construction companies chosen through tendering, as supervised by "the control and reduction of leakage team".

The average length studied annually for visibly non-detectable leakage is around 2,243km over the last 13 years. This covers approximately 20% of all pipes in the secondary distribution network in the SEDAPAL service area. The study plan for leakage detection should be made based on the prediction of the area with highest leakage rate.

Table 2.5.13-8: Underground Leakage Survey (1997-2009)

	All of SEDAPAL	Comas	Callao
Length of existing secondary network	11,098 km	2,856 km	1,300 km
Cumulative Km reviewed	29,153km	7,255 km	1,837 km
Number of leaks	77,722	20,146	6,040
Annual average km reviewed	2,243 km	558 km	141 km
Annual average rate	20.2%	19.5%	10.8%

Source: Statistical Almanac 2009

6) Meter Installation, Education about Meter Installation (Operation)

The “commercial team” in the local service office plans and manages meter replacement and installation. The actual installation work is conducted by the third-party company following the contract.

Table 2.5.13-9: Meter Replacement (2009)

	Total	Comas	Callao
Replacement of meters by the EOMR	13,030 units	1,194 units	0 units

Source: Statistical Almanac 2009

In order to increase the meter installation rate, social education is conducted during the service expansion project in the new service area. The “Social project management team” coordinates these activities depending on the budget prepared for project execution. The team is composed of 13 social workers, and they only have the capacity to supervise the contract work of third-party companies.

The budget for these social activities is included in the new expansion project; almost no activities are executed in the existing service area.

(3) O&M of Sewerage Service

The operation and maintenance of sewerage service is managed by the O&M teams in the local service offices of Comas and Callao. Both offices are composed of four functional groups: “operational control group,” “distribution group,” “sewage collection group,” and “house connection group”. The “sewage collection group,” mainly attend to the repair of pipes.

In addition to the above teams, the “project social management team” controls the social activities, such as hygiene education of users.

See Section 2.5.12: “Institutional Aspects and Legal Framework” for more details.

The operation and maintenance procedures for service are summarized in Table 2.5.13-1, and each of the factors is explained in the following sections;

1) Road Subsidence (Corrective Maintenance)

The claims of road subsidence are collected by phone at the “client service team” in SEDAPAL´s headquarters, and the information is delivered to the appropriate team in charge. The “primary sewer maintenance department” manages the road subsidence caused by collapses in primary pipes, and the local service office manages the subsidence caused by the secondary pipes.

Normally, these teams inspect the incidence point and order a third-party company called “Concysa” which has the contract with SEDAPAL to repair the subsidence using their company’s construction machines.

The following numbers were obtained as JICA study team evaluated the incident data provided by SEDAPAL. Only the number within the Study Area is included, which composes approximately 30% of the whole north service area.

Table 2.5.13-10: Road Subsidence by Sewer Collapse in the Study Area

	2007	**2008**	**2009**	**Total**
Incidents of collapses in secondary networks	66 units	48 units	62 units	176 units

Source: JICA Study Team

2) Pipe Clogs, Manhole Cleaning (Corrective Maintenance)

As with road subsidence claims, the claims of clogs are collected by the “client service team,” and then the information is delivered to the appropriate team. The “primary sewer maintenance department” manages the clogs of primary pipes, and the local service office manages those of secondary pipes and house connections.

The total number of clogs adds up to approximately 9,750 and 4,900, respectively, in Comas and Callao. The Hydro jet machine is used for cleaning the clogged pipes in normal condition. If the material of the sewer pipe is simple concrete, there is a possibility that the high water pressure of the Hydro jet machine would cause the pipe to collapse, the operators use a bucket machine instead.

Together, the two local services offices have seven Hydro jet machines (four in Comas and three in Callao); however, five of them were bought more than 10 years ago, and they need to be repaired frequently in the workshop. Both offices expect the procurement of new Hydro jet machines for more efficient work progress.

Table 2.5.13-11: Cleaning of Sewer Clog

	Total	**Comas**	**Callao**
Clogs cleaned in secondary sewerage networks	38,975	8,861	4,875
Clogs cleaned in house sewage connections	28,162	6,036	3,277

Source: Statistical Almanac 2009

Table 2.5.13-12: Sewer Pipe Repair and Installation

	Total	Comas	Callao
Length of existing secondary sewerage networks	9,731 km	2,444 km	1,269 km
Installation of secondary sewage networks	5,092m	77m	387m
Replacement and/or repositioning of secondary sewage networks	53,832m	16,773m	5,290m
Sewer cleaning with Hydro Jet	821,652m	175,337m	153,365m
Sewer cleaning – bucket machine	615,164 m	79,176m	31,735m

Source: Statistical Almanac 2009

Table 2.5.13-13: Activities Relating to House Connections

	Total	Comas	Callao
Installation of house sewerage connections	26,471 units	8,007 units	4,978 units
Maintenance of house sewerage connections	10,196 units	3,019 units	1,158 units
Replacement and/or repositioning of house sewerage connections	3,436 units	1,420 units	398 units

Source: Statistical Almanac 2009

Cleaning of manholes is executed in order to remove clogs in the pipes. One of the main reasons for the occurrence of clogs is that inhabitants dump trash into the manhole, as the garbage collection service managed by the local municipality is not adequate. The education of avoiding such a habit is important, as is regular cleaning of the manholes.

Also, theft of the manhole lid is a problem in the Study Area as the metal lid can be sold in the black market; and replacement of manhole lids is included in the daily operation work.

Table 2.5.13-14: Manhole Cleaning

	Total	Comas	Callao
Total number of existing manholes	188,773 units	48,021 units	17,462 units
Maintenance of manhole/retention chamber	6,102 units	722 units	4,978 units
Cleaning of manhole/retention chamber	26,471 units	8,007 units	4,978 units
Total number of manholes with maintenance	32,573 units	8,729 units	9,956 units
Percentage of total number	17.3%	18.2%	57.0%
Replacement of manhole lid (theft)	2,600 units	670 units	376 units

Source: Statistical Almanac 2009

3) Periodical Sewer Pipe Cleaning (Preventative Maintenance)

As explained above in the section regarding clog resolution, the bucket machine is chosen to do the cleaning only when the pipe material is simple concrete, and there is a risk of the pipe collapsing. Regarding the report of operational activity, the annual lengths of pipe cleaning were 255 km and 185 km in 2009 for Comas and Callao, which composes 10.4% and 11.8% of the total secondary sewer pipes in respective areas. The workers in the local service offices expect to do cleaning of all pipes once a year. However, it is not easy to decide the ideal frequency of pipe cleaning for preventative maintenance, as the occurrence of clogs depends on the condition of the facility.

Table 2.5.13-15: Activities of Pipe Cleaning

	Total	Comas	Callao
Length of existing secondary sewerage networks	9,731 km	2,444 km	1,269 km
Sewer cleaning with Hydro Jet	821,652m	175,337m	153,365m
Sewer cleaning – bucket machine	615,164 m	79,176m	31,735m
Total length of pipe cleaned	1,437 km	255 km	185 km
Percentage of annual cleaning	14.8 %	10.4 %	11.8 %

Source: Statistical Almanac 2009

4) Periodic Replacement of Sewer Pipe (Preventative Maintenance)

The total length of sewer pipes and length of pipes repaired annually are indicated in Table 2.5.13-16. The total annual replacement rates for all pipes are calculated to be 0.69% and 0.48%, respectively, in the Comas and Callao districts. Generally, the ideal percentage of replacement each year is considered to be from 2.0% to 3.0%, assuming the life span of sewer pipes to be between 30 and 50 years. The total length replaced by the annual budget achieves only one third of this criterion. If this same rate of pipe replacement continues, it is thought that clogs and pipe collapses will increase over time.

According to interviews in local service centers, there is no long-term plan and budget for the replacement of sewer pipes. The replacement is conducted when the clog is found at one point, and the pipe condition is considered quite severe. In this case, workers decide to change the current pipe for the span between adjacent manholes, which corresponds to an average of around 50meters. An overall pipe rehabilitation plan is required for the area, and a fixed amount of budget should be prepared for sustainable operation.

Table 2.5.13-16: Sewer Pipe Installation

	Total	Comas	Callao
Km of secondary sewerage networks	9,731 km	2,444 km	1,269 km
Installation of secondary sewage networks	5,092m	77m	387m
Replacement and/or reposition of secondary sewage networks	53,832m	16,773m	5,290m
Total length of pipe installation	**58,924m**	**16,850m**	**5,677m**
Annual pipe replacement rate	0.61%	0.69%	0.48%

Source: Statistical Almanac 2009

5) Education Regarding the Dumping of Trash in Manholes (Operation)

The activities regarding manholes are indicated in the Table 2.5.13-14. As previously mentioned, the avoidance of illegal trash damping to the manholes is necessary to prevent the pipe clogs. The “project social management team” coordinates these activities depending on the budget prepared. However, the budget for these social activities is included in the new expansion project; almost no activities are executed in the existing service area.

(4) Planning Activities for Both Water Supply and Sewerage Service

1) Maintenance of Inventory and GIS Data

The inventory and GIS (Geographical Information System) map can be managed in the local service office. The new inventories are prepared by the local office workers and are reported to the headquarters periodically. These inventories include the claim resolution information and construction/repair design changes.

The commercial, accidental, and facility information is managed in GIS system so that the daily operation, maintenance and planning work are controlled efficiently. However, the workers do not have sufficient capacities to operate the GIS or evaluate its information in local service offices.

Additionally, workers in the local service office mention the existence of errors in GIS and cadastre information about installation year, material, location; etc. Some facilities were owned and operated by the municipality in the past, and transferred to SEDAPAL afterward. The information error is mainly derived from the low reliability of the original cadastre made by municipalities.

2) Long Term Planning for Existing Facilities

Planning work is primarily carried out by the Development and Investigation Management that is located at the La Atarjea headquarters. This management's function is to plan the development of the sanitation services, including the infrastructure's extension, enhancement, improvement, and rehabilitation.

This local office's objective is to operate and maintain the existing infrastructure; rehabilitation work planning is not a part of its job description. Therefore, there are no specific teams or departments in charge of carrying out planning and execution of rehabilitation works to the existing infrastructure.

An ongoing rehabilitation to the existing infrastructure is recommended, in compliance with each year's budget; international levels of rehabilitation to the water supply system and sewerage pipes recommend between 2 and 3 % of pipeline replacements each year. Also, with regard to the existing infrastructure's quality analysis, incidents and other data must be efficiently provided to the local office's planning team.

2.5.14 Identification of Problems – Needs and Constraints

Through the diagnoses above, problems of water supply and sewerage systems in the Study Area have been identified.

(1) Problems and its causes in the Water Supply System

Problem-1: High Non Revenue Water Ratio

- According to the actual monitored data in the original sectors 83, 84, 85, 212 and 213, the non-revenue water ratio is 42.6%, and the estimated ratio in the entire Lima North Area is 49.6%. These ratios are much higher than 25%, which is SEDAPAL´s target ratio. Moreover, they are also much higher than the other areas of Lima, which are 35.1% in the Central Lima Area and 27.5 % in the South Lima Area.
- Within the non-revenue water ratio (50%), 35% is estimated to be the technical loss and the remaining 15% the commercial loss ratio. However, the actual commercial loss ratio of each sector varies depending on the status of micrometer installation and on the social environment.
- In order to reduce the NRW ratio to 25%, it will be necessary to reduce the technical loss ratio to 20% and the commercial loss ratio to 5%.

Problem-2: Many Incidents

- Many incidents in distribution networks and connections, such as water leakage on the ground and settlement of pavement, are deteriorating living conditions of inhabitants.

Problem-3: Non Continuous Water Supply Service

- There are some areas where 24-hour ongoing water supply service has not been realized such as sector 259, where the service continuity is for 12 hours, and sectors 348 and 249, where the service varies between 3 and 8 hours.

Problem-4: Large Fluctuation of Water Pressure

- Water pressure at end users tends to be unstable, and in addition, it sometimes becomes too high or too low in some areas.

Major causes of above four problems are identified as below:

1) Fluctuation of water pressure (Causes of Problem-1, 2 and 4)
    - Water pressures in primary networks tend to be continuously very high in Los Olivos, which can cause damage on pipe and water leakage.
    - In some areas, water pressures in secondary networks are also too high, even in the sectors with pressure control valves; this is caused by the high pressure of primary networks.
2) Water Source and Water Production (Causes of Problem-3)
    - Existing water treatment plants (WTPs) cannot always satisfy the demand because the production of the WTPs is reduced significantly in the dry season.
    - The Huachipa WTP, which just started operation, may have to supply water to the area outside of its influence area in the dry season in order to compensate for the lowered production of other WTPs. This means that the supply capacity of the Huachipa WTP to its influence area can be lowered in the dry season.
3) Reservoirs and Pumping Stations (Causes of Problem-3 and 4)

- There are no serious problems in structures of reservoirs and pumping stations, but some rehabilitation works are necessary for them to operate and maintain properly.
- Electromechanical equipment in non-operating reservoirs needs to be renewed in order for the reservoirs to begin operation.
- Some of the electromechanical equipment of operating reservoirs and pumping stations needs to be replaced or rehabilitated to maintain their function.
- In order to improve the existing reservoirs and pumping stations for reliable and suitable operation, additional equipment is required, such as by-pass line and inflow control.

4) Wells and Groundwater (Causes of Problem-3)

- Many of the 23 wells to be used for emergency purposes do not have pumping equipment or are not equipped with the equipment required for suitable operation. New installation of pumping equipment and rehabilitation and improvement of existing equipment is necessary.

5) Valve Pits (Causes of Problem-1, 3 and 4)

- Only 11 original sectors have valve pits for control of inflow to the sectors. In addition, only five of them can be controlled or monitored automatically, which is not sufficient for proper operation of the water supply system.

6) Secondary Networks (Causes of Problem-1 and 2)

- There are some pipes with unsuitable pipe materials such as steel pipe, galvanized iron pipe and a type of PVC pipe (referred as "ITINTEC").
- Some pipes are not satisfying the technical requirements of minimum earth cover, supporting bed, compaction and backfilling.
- Some pipes are installed in private properties.
- Some pipes in Collique are seriously clogged by sediments derived from groundwater.
- AC pipes, which account for 47% of the total pipe length, may start to cause many incidents in the future, as 50% of them were installed more than 20 years ago.

7) House Connections and Micrometers (Causes of Problem-1 and 2)

- Many incidents resulting water leakage occur in house connections, especially at the corporation with the distribution pipes.
- Micrometers are not installed completely, and moreover, many of the installed micrometers are not functioning correctly.
- It is assumed that a significant percentage of distributed water is consumed by illegal consumption.

8) Automation and SCADA System (Causes of Problem-1, 2 and 4)

- None of the reservoirs, excluding some reservoirs to be upgraded by other projects, have any equipment required for SCADA operation. Currently, all valves are manually operated and must be upgraded to and/or replaced with automated valves.
- None of the wells have any equipment required for SCADA operation. Power panel boards are in very poor conditions: they lack electronic starters with speed variations. Some of the Wells have incomplete panel boards with a 12-year old technology that lacks Ethernet communications. All valves are manually operated.
- Among the eleven valve pits, only five valve pits have instrumentation and automated systems.

9) Non-Technical Loss (Causes of Problem-1)

- There are faulty meters that need to be replaced.
- There might be users without authorized connections.

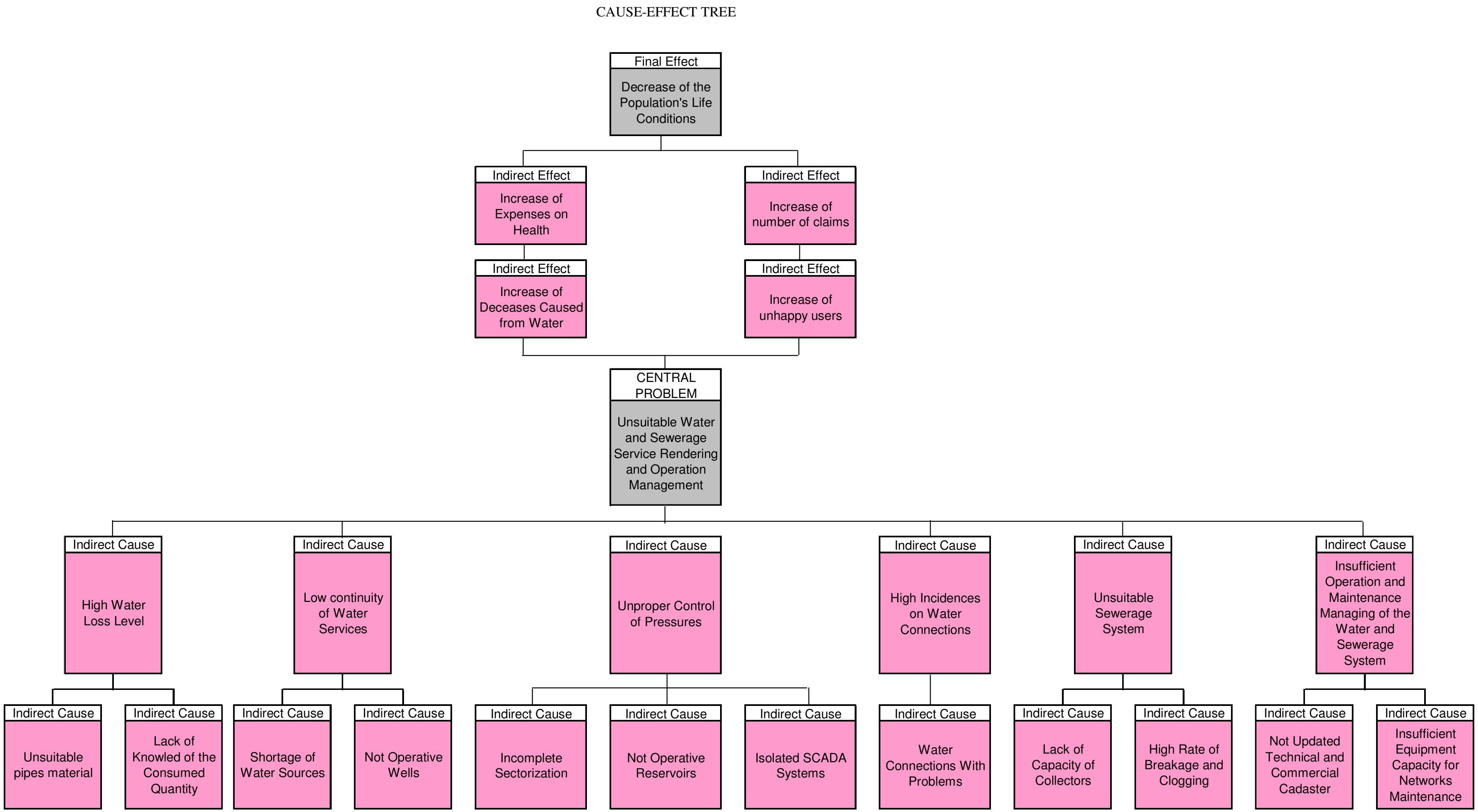
(2) Problems in the Sewerage System

In this Study, problems regarding primary sewers and sewerage treatment have not been investigated, which are to be studied by other Projects. The major problems identified for the secondary sewers are:

- Large numbers of incidents like clogs and collapses have been recorded in recent years.
- Hydro Jet cleaning equipment could not be used for maintenance in some areas, because corroded pipes are easy to be broken by high pressure water flow.

The causes of above problems are identified as below:

- Some of the simple concrete pipes are very old, and thus have completed their useful life.
- Existence of severe corrosion was found in the lower parts of the Study area.
- Visual inspection of pipes shows medium to severe deterioration of the pipes in many areas.
- H2S gas was detected in most of the test manholes; this gas is directly related to the pipe material degradation.
- Covers of manhole lids are missing in some case.
- Low pipe gradient slows down flow, increases retention of sewerage, and thereby causes corrosive gas production that leads to pipe degradation.
- Due to the lack of preventive maintenance (currently only corrective maintenance is performed), in addition to the deterioration due to ageing, the pipes have suffered much more deterioration than expected.
- Equipment for pipes maintenance is old; they were acquired more than 10 years ago.



Source: JICA Study Team

Figure 2.5.14-1: Cause – Effect Tree

2.6 Objective and Purpose of the Project

As explained in Section 2.5.1, the main objective of this Project is to ensure suitable rendering of water supply and sewerage services and operating management. The current situation is analyzed for water supply in Section 2.5.8, for sewerage in 2.5.9, for non-revenue water in 2.5.10, for financial and economic aspects in 2.5.11, for institutional aspects in 2.5.12 and for O&M aspects in 2.5.13. Section 2.5.14 summarizes current problems and future needs.

Thus, the main purpose of this Project is to address those issues. In a broader sense, the purpose of the Project is given below:

(1) Realize Continuous Water Supply for Current and Future Demand in the Study Area

- To provide the measures to convey water from the Huachipa WTP, which has just started its operation, to the Study area through primary pipes.
- To provide the measures to convey water from the existing wells, for emergency purpose in draught season, to the Study area through primary pipes.

(2) Improve Operation and Control of Water Supply System

- To sectorize the water supply system in the Study Area with macrometers and pressure control values for better operation.
- To bring the water supply facilities of the Study area under SCADA system for efficient operation and exact control.
- To rehabilitate reservoirs in order to bring them into proper working condition for better control of water pressure.
- To replace the water supply pipes those having not enough capacity to meet future water demand.

(3) Realize the Target of 25 % for NRW Ratio

- To replace inappropriate water supply pipes that are causing water leakage in order to reduce technical water loss.
- To replace house connections in order to reduce technical water loss which is mainly caused by water leakage and commercial water loss which is mainly caused by illegal consumption.
- To install micrometers for exact counting of water consumption for exact and fair tariff collection and monitoring of NRW.

(4) Improve Service Level of Sewerage

- To identify and replace sewers in bad condition in order to reduce clogs and collapses.
- To replace the sewer pipes those not having enough capacity to meet future demand enhancing the effect of construction of Taboada Wastewater Treatment Plant.

(5) Improve the Operation and Maintenance Management of SEDAPAL

- To provide necessary equipment for operation and maintenance of water supply and sewerage for improve facilities´ maintenance of SEDAPAL.
- To improve cadastre system of SEDAPAL for more efficient and preventive maintenance work.
- To establish a new team for planning of preventive maintenance. This will benefit the long-term vision and policy of SEDAPAL's facility maintenance. The Team will utilize the improved cadastre system, which can be a kind of asset management tool; and has the power to request sufficient budget for the implementation of maintenance works, in order to maintain the proper function of the existing facilities.

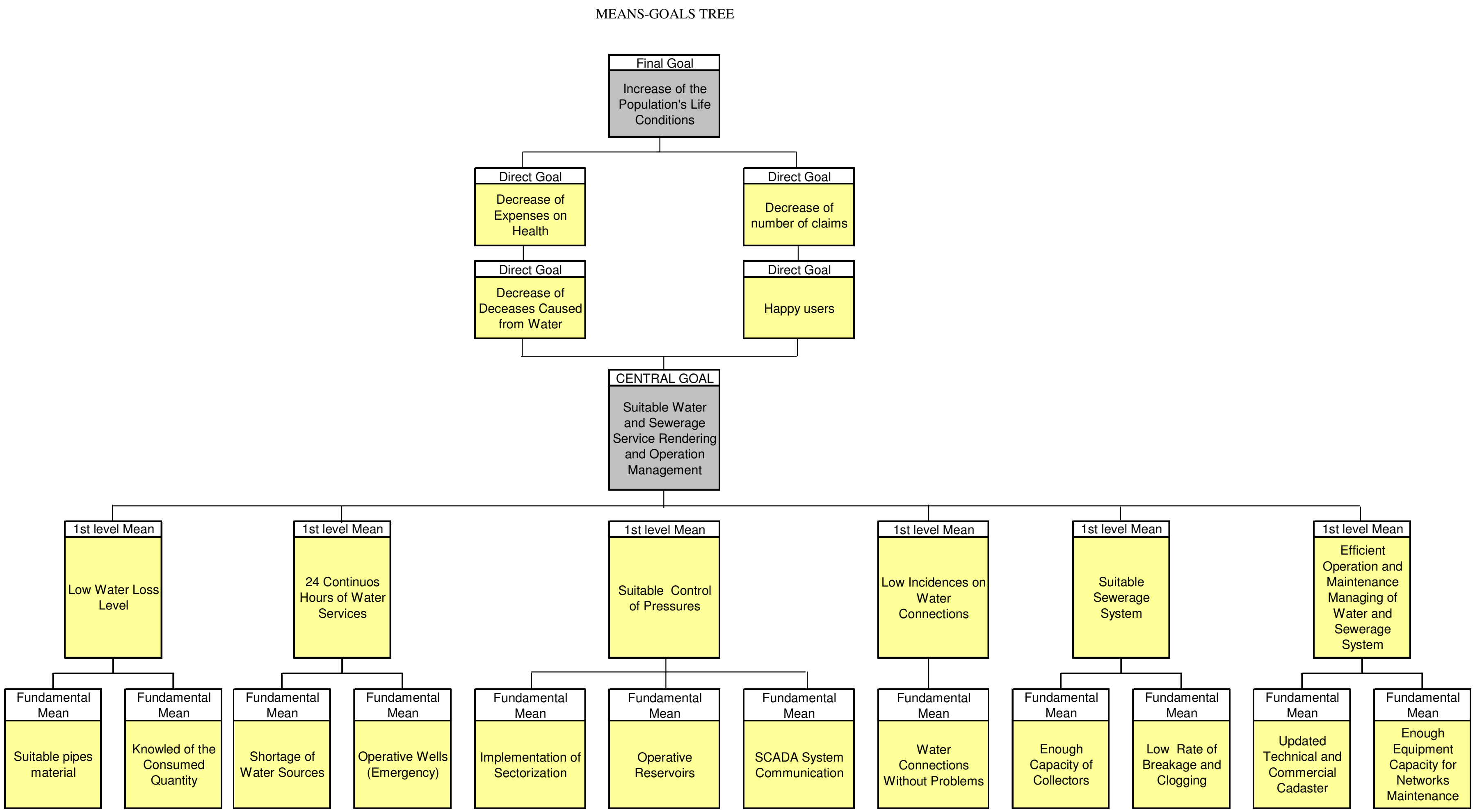


Figure 2.6-1: Means and Goals Tree

Source: JICA Study Team

FUNDAMENTAL MEANS

Fundamental Mean	Action
Suitable pipes material	Replacement of pipes older than 25 years old and/or pipes installed unproperly
Knowled of the Consumed Quantity	Installation of Micrometers
Shortage of Water Sources	Development of North Main Pipe and Supporting Pipes
Operative Wells (Emergency)	Rehabilitation of Wells for Emergency
Implementation of Sectorization	Implementation of Micro-Circuits, Sub-Sectors and Sectors
Operative Reservoirs	Rehabilitation of Reservoirs and Valve Pits Adaptation
SCADA System Communication	Automation in Reservoirs, Pumping Chambers and Wells
Water Connections Without Problems	Replacement of 100% of House Connections
Enough Capacity of Collectors	Replacement of Sewerage Pipes Diameters
Low Rate of Breakage and Clogging	Rehabilitation of Corroded and Damaged Pipes
Updated Technical and Commercial Cadaster	Software Implementation for Management of Information on Planned Infrastructure
Enough Equipment Capacity for Networks Maintenance	Acquisition of Equipment for Suitable Operation and Preventive Maintenance of Water and Sewerage Networks

Figure 2.6-2: Fundamental Means Tree

Source: JICA Study Team

CHAPTER 3 FORMULATION AND EVALUATION

3.1 Demand Analysis

3.1.1 Target Design Period

The period of demand analysis is equal to the target period of the Project. The Project's initial operational year is set as 2015, when the construction will be completed and the operation will start. Since 20-year-period is usually considered in Peru as operational life span for similar projects, the period of analysis shall be from 2015 to 2035. The base year is 2009 because the basic data used for the Study is that of 2009.

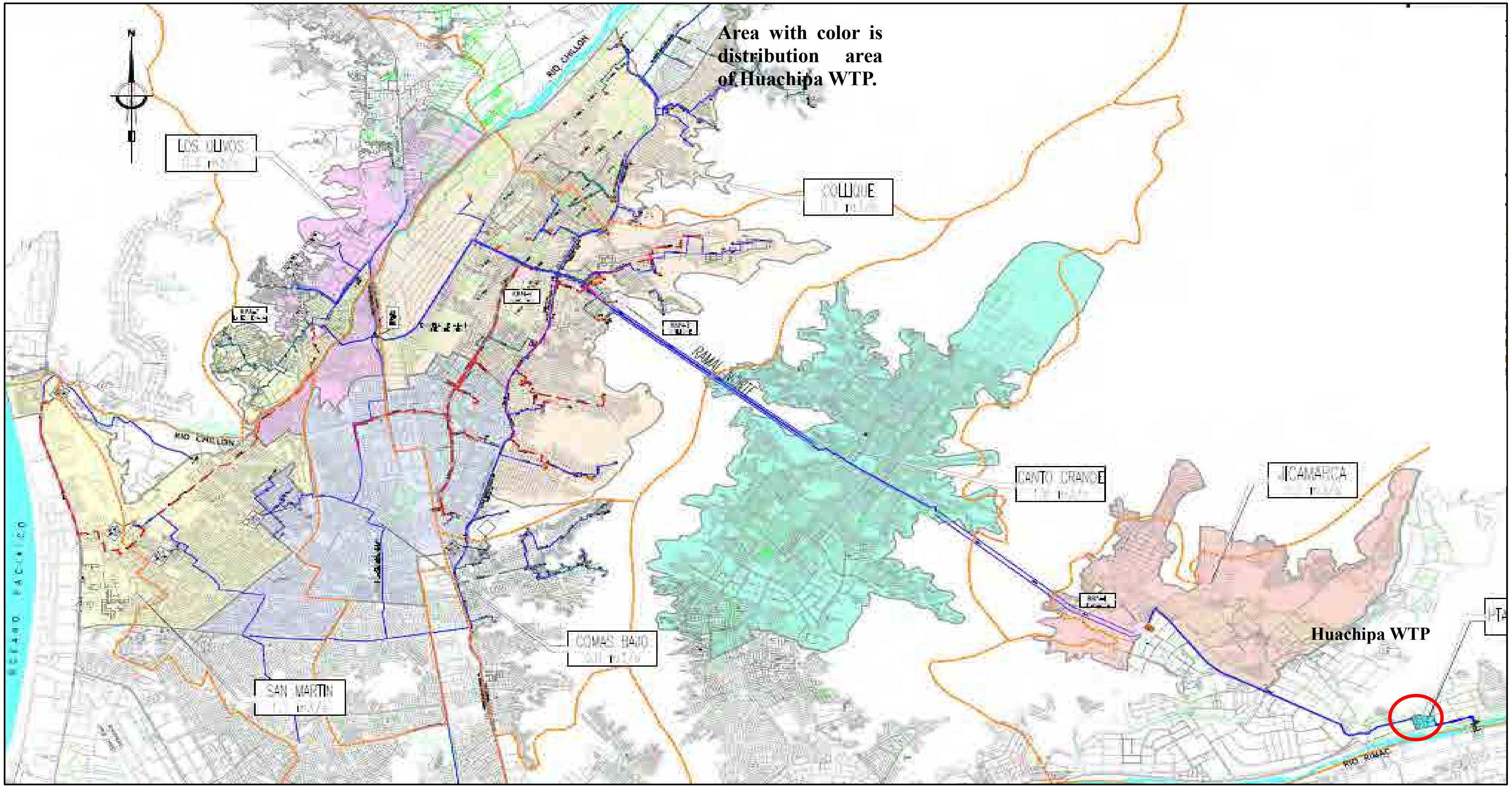
3.1.2 Water Supply

(1) Basic Methodology of the Analysis

1) Target Area and Unit of Analysis

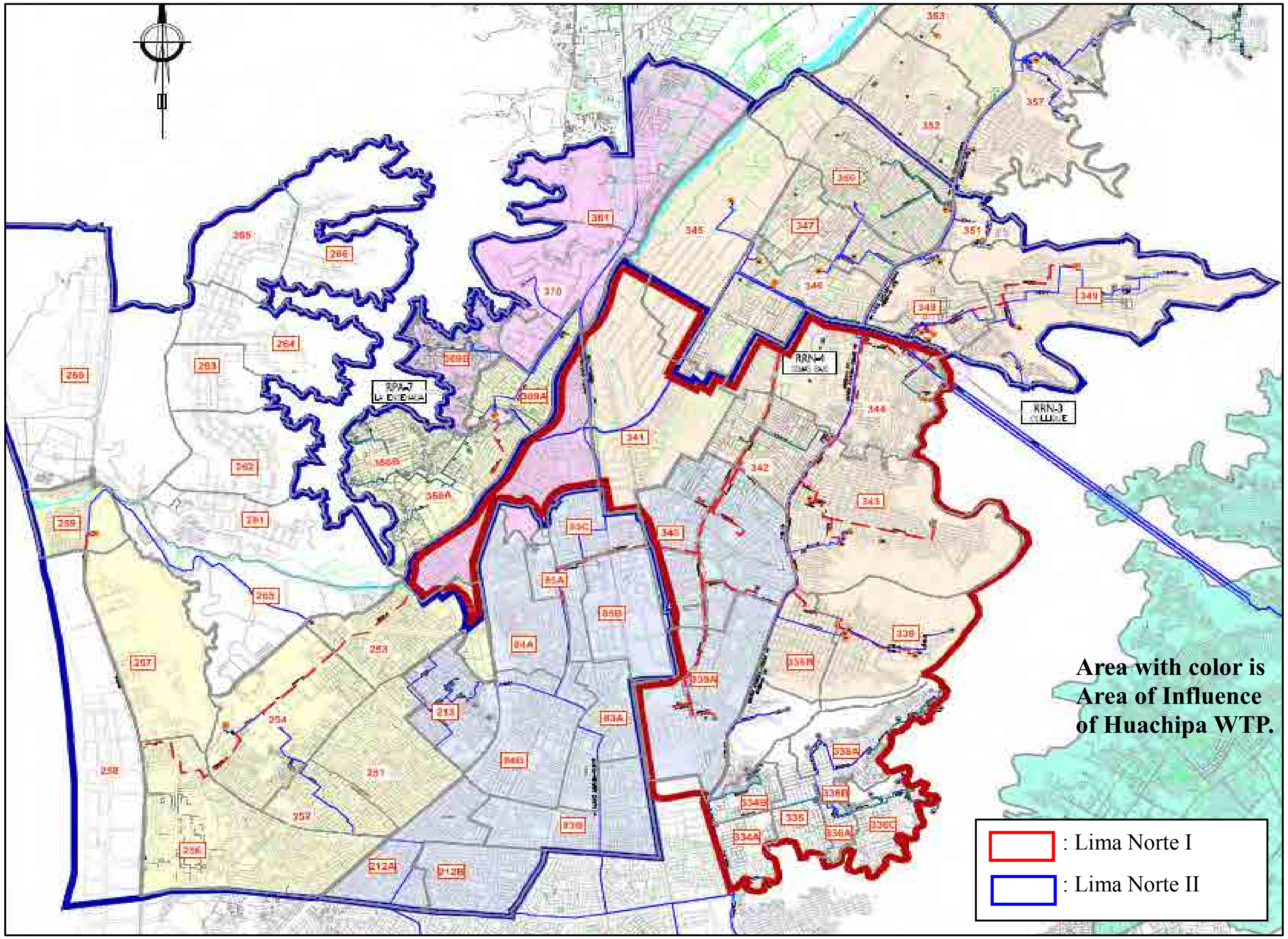
The water demand is summarized in two ways: i) water demand of the total Study Area, and ii) water demand in the water distribution area of the Huachipa Water Treatment Plant (hereinafter "Area of Influence").

Figure 3.1.2-1 shows the planned water distribution area for the Huachipa Water Treatment Plant (WTP) as prepared in the Huachipa Water Treatment Plant Project-Lima North Main. Figure 3.1.2-2 and Table 3.1.2-1 show Huachipa's influence area within the Study Area of the Lima Norte II Project.



Source: Huachipa Water Treatment Plant Project-Lima North Main and JICA Study Team

Figure 3.1.2-1: Distribution Area of Huachipa WTP



Source: Huachipa Water Treatment Plant Project-Lima North Main and JICA Study Team

Figure 3.1.2-2: Influence Area of Huachipa WTP in the Study

Table 3.1.2-1: Target Sectors of the Analysis

District	Sectors included in the Influence Area*1	Sectors not included in the Influence Area*1
Callao	259	256, (258)*2
Ventanilla	-	(260, 261, 262, 263, 264, 265, 266)*2
Carabayllo	350, 351	-
Comas	345, 346, 347, 348A, 348B, 349A, 349B	-
Los Olivos	83A, 83B, 84A, 84B, 85A, 85B, 85C	-
Puente Piedra	368A, 368B, 369A, 369B, 370	361, 368B, 369B, 370
S.M. de Porres	212A, 212B, 213	(251, 252)*2, 253, (254, 257)*2, (255)*2
Total Number	22	19

*1: Some original sectors are proposed to be divided into new sectors in the Study.
*2: Sectors without existing networks
Source: JICA Study Team

The Area of Influence covers all sectors which already have water supply networks; it also includes some sectors in the San Martín de Porres District, such as sectors 251, 252, 254 and 257, in which distribution networks are not yet established. The sectors in the Influence Area without networks are the sectors in which distribution networks will soon be installed by SEDAPAL.

2) Urban development of the Study Area

As explained earlier, the Study Area is comprised of areas that are parts of 7 districts, but entire districts are not included in the Study Area. The Study area is located on the alluvial plains of the Chillón and Rímac Rivers' valleys. These valleys become wider as they get closer to their outlet to the ocean and on the coastline strip. These areas were initially devoted to agriculture. However, demographic growth in the city has brought about a dramatic reduction of farmland, especially in the Rimac River valley, and also, at a lesser extent, in the Chillón and Lurín Rivers' valleys. In the last few years, there has been strong pressure to urbanize the farmlands. At present, 6 of the 7 districts that make up the Study area have over 75 % of their habitable areas already populated. Carabayllo and Ventanilla are the districts with the lower percentages of habitable populated areas (13 % and 63 %, respectively), whereas Los Olivos and Callao have the highest percentages of habitable populated areas (100 % and 94 %, respectively).

Most parts of the habitable area is of medium density, however, there are possibilities of growth until these areas reach to high density (zoning map of the Province Municipality of Lima, see drawing APT-12). The residential districts of medium and medium-high density have tendency to be consolidated as high density district in the future, and their commercial zones have been located along large avenues. District of Comas, as exception to others, is characterized as having more commercial tendency. Industrial facilities have been located in all inhabited area as they are mostly light industry.The Study area has no

Government residential complexes planned for the next few years; there are only private developments in the area.

The annexes show drawings of urban development plans for each district related to the Study area. Drawing APT-12 shows urban development by district and drawing APT-13 shows consolidation of lands based on the existing dwellings.

The next paragraphs describe the characteristics of the districts within the Study area.

Callao:

Callao is the capital of the Constitutional Province of Callao. Its total area is 45.65 km2 and its habitable area 37.26 km2. At present, 94 % of its habitable surface is populated. Population in 1993 was 369,768, and in the 2007 Census, INEI (The National Institute of Statistical and IT Information) registered a population of 415,888. Callao has still 2.33 km available for expansion. Its urban development has a medium and high density residential tendency. The area included in the Study Area, based on drawing APT-12 is characterized as a zone destined for large and heavy industry.

Table 3.1.2-2: Extension and characteristic of the district areas included in the Study (km^2)

District	Habitable Area			Not Inhabitable Area	Total Area
	Occupied	Expansion Possible	Total		
North Service Management					
C.S. Comas					
Carabayllo	12	82.71	94.71	252.29	347
Comas	24.6	4.76	29.36	19.39	48.75
Los Olivos	18.25	0	18.25	0	18.25
Puente Piedra	24.26	7.23	31.49	18.6	50.09
San Martín de Porras	23.08	6.28	29.36	7.55	36.91
C.S. Callao					
Callao	34.93	2.33	37.26	8.39	45.65
Ventanilla	18.94	11.23	30.17	43.35	73.52

Souce: JICA Study Team

Ventanilla

This district has a total area of 73.52 km. Its total habitable area is 30.17 m2, and only 13% of it is populated. Its registered population in the 1993 Census was 94,497, and in the 2007 Census, INEI registered a population of 277,895. The Pachacutec Housing Project is being developed in this district, but it is out of this Project's scope. Probabilities for this district's growth are potentially large, as Ventanilla has a significant possible expansion area and currently has very low density. Its urban development has a residential tendency.

Area of this district which is conformed by the project has been destined as a production settlement zone of livestock and for the large industry, see drawing APT-12.

Carabayllo:

The Carabayllo district has the largest surface area in the province of Lima with 347 km2. 94 km2 of this area are habitable (27 %). This is one of the districts that has experienced significant growth in the last few years, from an population of 52,800, according to the 1981 Census, to 106,543 in the 1993 Census, and to 213,386 in the last 2007 Census.

It is part of the Chillón River valley, and according to the effective urban zoning plan, a large portion of its area will remain as agricultural land; however, some of the areas are currently being urbanized and divided into lots. A large area used by the Peruvian Nuclear Energy Institute is located in the northern part of Carabayllo.

There are also a significant number of lands devoted to other uses around the district, such as landfills, farms, stables, cemeteries, etc. Strictly commercial areas are generally located along the major avenues, such as Túpac Amaru. Public and industrial areas (usually light industry) are scattered throughout the populated area.

According to the zoning map, this district is characterized as a residential district with medium and high density, see drawing APT-12.

Comas:

Comas has a total area of 48.75 km2, and 60 % of it is habitable area. It is one of the districts that has experienced greatest growth in the last 25 years, with a population of 486,977, as registered in the 2007 Census, as opposed to a population of 404,352, as registered in the 1993 Census. A large portion of its habitable area is already populated; however, Comas still has space to carry on growth, but its growth rate is expected to gradually decrease. This district’s urban development is medium density residential, with a tendency to become a high density residential district and to increase its commercial activity, see drawing APT-12.

San Martín de Porres:

This district has a total surface of 36.91 km2, with a habitable surface of 26.36 km2. Registered population in the 1993 Census was 380,384, and registered population in the 2007 Census was 579,561. San Martin de Porres still has areas for probable extension and densification. It is medium and medium-high residential area with growth tendency to high density, see drawing APT-12.

Puente Piedra:

This district has a surface area of 50.09 km2 and a habitable area of 31.5 km2. It was originally a farming area. Registered population in the 1993 Census was 102,808, and it was 233,602 in the 2007 Census. Puente Piedra shows a slowing down growth rate, even though its current growth rate is quite high. Characteristics of this district include an urban development with a residential tendency and a conservation of farming land.

The area that is part of the study is characterized as medium density residential and neighborhood commercial zone, see drawing APT-12.

Los Olivos:

This district has a surface area of 18.26 km2 that is totally habitable. According to the 1993 Census, its population was 228,143, and in the 2007 Census, it was 318,140. Los Olivos has probabilities for population growth by densification.

According to district zoning, area that is part of the study is considered as medium density residential zone, projected to be high density residential and heavy industry zone, see drawing APT-12.

3) Basic Formula of Water Demand Forecast

Water demand forecast is calculated as a daily average by using the following formula for each sub-sector:

$$Q = \sum_{k=a}^{f} (Np_k \times A_k \times q_{nk}) / (1-B)$$

where, Q : Water demand
Np : Potential number of connections
A : Connection ratio
B : Water loss ratio
qn : Unit consumption per connection
a : domestic (with one family)
b : commercial
c : industrial
d : public
e : social
f : domestic (with multiple families)

As presented in the formula above, the fundamental parameter in the forecast is the number of connections, which consists of six categories (Housing, Commercial, Industrial, Public, Social and Multifamily); water demand is calculated for each category. The number of connections for each category is further divided into those with micrometers and those without micrometers because the unit consumptions depend on whether or not a micrometer is installed. Although “with/without micrometer” is not explained in the formula above in order to keep the formula simple, water demand shall be calculated for the connections with micrometers and those without micrometers, separately.

4) Other Factors for Demand Analysis

In the analysis, peak factors of water demand are considered in the calculation of daily maximum water demand and hourly maximum water demand. Also, the storage ratio is considered in the calculation of the required storage volume of the reservoirs.

(2) Base Data and Key Parameters for the Forecast

1) Potential Number of Connections

The current potential number of connections is the total number of households, commercial and industrial establishments, and public offices, etc., including those that have connections and those that do not have connections but has potential to connect. These calculations are based on the present number of connections and the annual growth rate of connections by category.

The forecast of the potential number of connections (i.e., maximum possible connection) is carried out assuming that potential numbers for domestic, commercial, public, social and multifamily connections will increase by projected population increase ratios, and that the potential industrial connections will increase by industrial GDP growth rate of Lima Region.

2) Current Number of Connections and Unit of Use

The unit of use is the number of the families with domestic connections. Therefore, in the case of a domestic connection with one family, the unit of use in the connection is one; in case of a domestic connection with multiple families, on the other hand, the unit of use in the connection is more than one. In the analysis, the value is used, together with person per family and total population, to calculate the served population and connection ratio. Table 3.1.2-3 presented the number of blocks and lots of the total area of the study (according to INEI) and Table 3.1.2-4 shows the number of lots by connection category of SEDAPAL. Table 3.1.2-5 shows the summary of connections with and without metering.

The current number of lots with connections and units of use are stated in the cadastre of SEDAPAL, which is administrated by the commercial department. The cadastre data was delivered to the Study Team and it was analyzed utilizing GIS, by which the current number in each sub-sector was detected. The current number of houses, connections and units of use are shown in drawing APT-14.

Table 3.1.2-3: Number of blocks and lots in sector of the Study Area (units)

Sector	N° Blocks	N° Lots
83	540	9,204
84	615	14,102
85	409	7,414
212	421	9,510
213	287	4,915
251	339	7,477
252	171	3,765
253	291	5,277
254	413	6,599
255	112	1,023
256	509	9,160
257	118	1,174
258	33	75
259	200	3,371
260	35	175
261	81	735
262	33	154
263	32	127
264	49	271
265	30	253
266	35	403
345	205	3,191
346	312	6,267
347	198	3,453
348	292	3,776
349	795	9,144
350	525	7,700
351	184	1,666
361	240	3,919
368	706	7,991
369	487	7,112
370	199	1,236
Total	**8,896**	**140,639**

Source: INEI Censos Nacionales 2007: XI de Población y VI de Vivienda

Table 3.1.2-4: Number of lots by connection category in the Study area

SECTOR	SUB-SECTOR	Domestic	Comercial	Industrial	Public	Social	Multiple Family Not Independent	Total
83A	83A-1	1,147	25	2	3	5	427	1,609
	83A-2	1,506	66	4	11	3	897	2,487
83B	83B-1	610	18	0	2	3	640	1,273
	83B-2	2,620	73	2	15	11	1,347	4,068
84A	84A-1	3,911	37	0	9	3	517	4,477
	84A-2	2,701	24	0	4	7	373	3,109
84B	84B-1	3,260	44	3	3	4	707	4,021
	84B-2	1,225	38	3	2	3	398	1,669
85A	85A	1,690	38	4	3	4	445	2,184
85B	85B-1	535	59	23	4	2	295	918
	85B-2	457	34	48	7	6	342	894
	85B-3	192	21	20	2	1	51	287
85C	85C	1,131	46	4	5	8	463	1,657
212A	212A-1	2,706	88	4	5	6	535	3,344
	212A-2	1,581	49	7	3	2	442	2,084
212B	212B-1	1,143	40	3	1	0	425	1,612
	212B-2	987	32	7	1	4	327	1,358
213	213-1	2,556	63	1	4	7	372	3,003
	213-2	67	0	0	0	0	1	68
	213-3	128	0	0	0	2	0	130
251	251	2	0	0	0	0	1	3
252	252	2	0	0	0	0	0	2
253	253	20	0	0	0	0	7	27
254	254	2	1	0	0	0	1	4
255	255	1	0	0	1	0	0	2
256	256	6	4	1	0	1	3	15
257	257	1	3	0	0	0	0	4
258	258	1	8	23	0	0	0	32
259	259	2,127	19	0	6	8	122	2,282
260	260	0	1	4	0	0	0	5
261	261	0	5	0	0	0	0	5
262	262	1	0	0	0	0	0	1
263	263	1	0	0	0	0	0	1
264	264	1	0	0	0	0	0	1
265	265	1	0	0	0	0	0	1
266	266	1	0	0	0	0	0	1
345	345	376	16	1	3	3	16	415
346	346-1	684	11	2	9	1	152	859
	346-2	1,371	32	3	4	4	332	1,746
347	347-1	1,435	39	3	8	8	557	2,050
	347-2	1,501	24	6	6	5	253	1,795
348A	348A	649	7	0	10	6	169	841
348B	348B-1	1,610	12	0	3	9	400	2,034
	348B-2	177	0	0	0	1	0	178
349A	349A-1	1,513	7	0	5	10	214	1,749
	349A-2	323	0	0	3	1	13	340
	349A-3	776	3	0	2	3	110	894
349B	349B-1	679	1	0	3	8	93	784
	349B-2	707	1	0	7	5	44	764
	349B-3	699	7	0	5	4	32	747
	349B-4	2	0	0	0	0	0	2
350	350-1	2,369	77	1	36	19	1,337	3,839
	350-2	2,708	47	2	25	12	654	3,448
351	351-1	551	2	0	0	2	43	598
	351-2	361	0	0	0	0	0	361
	351-3	75	0	0	1	0	0	76
361	361	1,288	14	2	7	0	44	1,355
368A	368A-1	1,677	18	0	2	0	64	1,761
	368A-2	294	0	0	0	0	3	297
368B	368B	2,900	4	0	3	3	18	2,928
369A	369A	2,091	16	1	8	2	61	2,179
369B	369B	2,481	5	0	9	130	19	2,644
370	370	137	41	27	2	2	42	251
TOTAL		**61,754**	**1,220**	**211**	**252**	**328**	**13,808**	**77,573**

Source: JICA Study Team

Table 3.1.2-5: Current Number of Connections and Units of Use in the Study area

CM: with Meter, SM: without Meter

Sector	Sub'sector	Connection			Unit of Use
		CM	SM	Total	
83A	83A-1	1,398	211	1,609	2,316
	83A-2	1,958	529	2,487	3,968
83B	83B-1	1,160	113	1,273	2,236
	83B-2	3,220	848	4,068	5,933
84A	84A-1	4,121	356	4,477	4,963
	84A-2	2,784	325	3,109	3,527
84B	84B-1	3,420	601	4,021	4,858
	84B-2	1,469	200	1,669	2,159
85A	85A	1,810	374	2,184	2,746
85B	85B-1	659	259	918	1,650
	85B-2	640	254	894	1,344
	85B-3	65	222	287	339
85C	85C	1,288	369	1,657	2,286
212A	212A-1	2,815	529	3,344	3,936
	212A-2	1,819	265	2,084	2,571
212B	212B-1	1,387	225	1,612	2,179
	212B-2	1,207	151	1,358	1,800
213	213-1	2,416	587	3,003	3,382
	213-2	62	6	68	69
	213-3	124	6	130	130
251	251	2	1	3	4
252	252	0	2	2	2
253	253	18	9	27	40
254	254	2	2	4	4
255	255	1	1	2	2
256	256	8	7	15	163
257	257	2	2	4	4
258	258	26	6	32	33
259	259	1,530	752	2,282	2,404
260	260	4	1	5	5
261	261	5	0	5	10
262	262	1	0	1	1
263	263	1	0	1	1
264	264	1	0	1	1
265	265	1	0	1	1
266	266	1	0	1	1
345	345	337	78	415	462
346	346-1	620	239	859	1,107
	346-2	1,169	577	1,746	2,152
347	347-1	1,123	927	2,050	2,633
	347-2	1,325	470	1,795	2,053
348A	348A	14	827	841	938
348B	348B-1	17	2,017	2,034	2,306
	348B-2	140	38	178	178
349A	349A-1	185	1,564	1,749	1,956
	349A-2	3	337	340	347
	349A-3	2	892	894	964
349B	349B-1	95	689	784	878
	349B-2	125	639	764	794
	349B-3	183	564	747	758
	349B-4	1	1	2	2
350	350-1	2,610	1,229	3,839	5,359
	350-2	2,588	860	3,448	4,285
351	351-1	554	44	598	641
	351-2	358	3	361	362
	351-3	73	3	76	76
361	361	1,274	81	1,355	1,386
368A	368A-1	1,590	171	1,761	1,836
	368A-2	290	7	297	300
368B	368B	2,892	36	2,928	2,946
369A	369A	1,630	549	2,179	2,231
369B	369B	2,456	188	2,644	2,665
370	370	60	191	251	288
TOTAL		**57,139**	**20,434**	**77,573**	**94,971**

Source: SEDAPAL and JICA Study Team

3) Current Population, Number of Families and Number of Inhabitants per Family

The following table shows person per dwelling at district level, for all districts related to the study scope, based on population and housing censuses of 1981, 1993, and 2007.

Number of inhabitants per house was calculated from the estimation of population and number of houses by the Census of Population and Housing, year 1981, 1993 and 2007 at district level, as shown in following table; population density in districts of the study area has decreased in average from 5.92 inhab/house (1981) to 4.85 inhab/house (1993) and 4.26 inhab/house (2007), showing a decrease of 28% between 1981 and 2007 census.

Table 3.1.2.6: Population Density (person/family)

Census Year	Callao	Ventanilla	Carabayllo	Comas	Los Olivos	Puente Piedra	San Martin de Porrres
1981	5.68	5.82	6.10	6.02		6.15	5.78
1993	5.07	3.71	4.98	5.69	4.81	4.62	5.10
2007	4.58	3.45	4.04	4.99	4.15	4.17	4.45

Source: INEI- Census of population and housing years 1981, 1993 y 2007,

Following table shows the present population of each sub sector and the number of inhabitants per house based on official information of INEI at block level according to population and housing census of 2007.

For the demand study, it has been considered that the family size determined in the last census will stay invariable in the planning horizon of the Study.

Table 3.1.2.7 shows the family size at sub-sector level. Table 3.1.2.8 shows the family size determined by population and housing survey of year 2007 and by samples taken in the social economic study of the Study. The two results are quite similar, differences are caused by methodology used; INEI methodology calculates the rate from total population of the sector and number of existing houses; while the study have used the results of the survey samples.

Table 3.1.2-7: Current Population and Number of Inhabitants per Household

Sestor	Sub'sector	Population	Number of Families (2007)	Numberf of Persons per Family		District
				The Study	(Perfil)	
83A	83A-1	10,179	2,498	4.07	4.10	Los Olivos
	83A-2	19,849	5,152	3.85	4.10	
83B	83B-1	11,289	2,985	3.78	4.10	
	83B-2	29,135	7,228	4.03	4.10	
84A	84A-1	24,627	5,622	4.38	4.10	
	84A-2	16,849	3,922	4.30	4.10	
84B	84B-1	23,931	5,583	4.29	4.10	
	84B-2	11,188	2,649	4.22	4.10	
85A	85A	13,072	3,083	4.24	4.10	
85B	85B-1	6,263	1,562	4.01	4.10	
	85B-2	6,172	1,537	4.02	4.10	
	85B-3	1,923	452	4.25	4.10	
85C	85C	11,069	2,644	4.19	4.10	
212A	212A-1	17,951	4,126	4.35	4.40	S.M. de Porres
	212A-2	11,766	2,777	4.24	4.40	
212B	212B-1	9,870	2,321	4.25	4.40	
	212B-2	8,515	2,004	4.25	4.40	
213	213-1	17,480	4,015	4.35	4.40	
	213-2	312	63	4.95	4.40	
	213-3	539	124	4.35	4.40	
251	251	23,528	5,383	4.37	4.40	
252	252	9,316	2,110	4.42	4.40	
253	253	10,809	2,517	4.29	4.40	
254	254	12,782	2,920	4.38	4.40	
255	255	1,340	356	3.76	4.40	
256	256	16,162	3,713	4.35	4.40	Callao
257	257	1,706	423	4.03	4.40	S.M. de Porres
258	258	210	66	3.18	4.40	Callao
259	259	16,397	3,722	4.41	4.40	
260	260	727	184	3.95	3.40	Ventanilla
261	261	3,370	862	3.91	3.40	
262	262	375	105	3.57	3.40	
263	263	309	89	3.47	3.40	
264	264	243	112	2.17	3.40	
265	265	147	65	2.26	3.40	
266	266	201	106	1.90	3.40	
345	345	8,079	1,880	4.30	4.90	Carabayllo
346	346-1	4,576	1,065	4.30	4.90	
	346-2	9,268	2,143	4.32	4.90	
347	347-1	14,516	3,193	4.55	4.90	
	347-2	12,419	2,781	4.47	4.90	
348A	348A	7,360	1,551	4.75	4.90	
348B	348B-1	15,627	3,244	4.82	4.90	
	348B-2	1,101	260	4.23	4.90	
349A	349A-1	14,227	3,087	4.61	4.90	
	349A-2	3,133	773	4.05	4.90	
	349A-3	7,539	1,651	4.57	4.90	
349B	349B-1	6,385	1,401	4.56	4.90	
	349B-2	7,124	1,629	4.37	4.90	
	349B-3	4,862	1,133	4.29	4.90	
	349B-4	2,257	571	3.95	4.90	
350	350-1	23,816	5,545	4.30	3.90	
	350-2	22,781	5,184	4.39	3.90	
351	351-1	4,097	950	4.31	3.90	
	351-2	2,400	596	4.03	3.90	
	351-3	355	94	3.78	3.90	
361	361	12,791	2,972	4.30	4.00	Puente Piedra
368A	368A-1	10,833	2,538	4.27	4.00	
	368A-2	1,847	423	4.37	4.00	
368B	368B	14,778	3,526	4.19	4.00	
369A	369A	11,579	2,607	4.44	4.00	
369B	369B	13,432	3,251	4.13	4.00	
370	370	5,616	1,383	4.06	4.00	
TOTAL		**592,399**	**138,511**	**4.28**	**-**	-

Source: SEDAPAL and JICA Study Team

Table 3.1.2-8: Present population and number of inhabitants per family

DISTRICT	SECTOR	Number of family members according to population and housing survey 2007 INEI	Number of family members according to social economic survey of the Study
CALLAO	256	4.4	
	258	3.2	
	259	4.4	4,4
VENTANILLA	260	4.0	
	261	3.9	
	262	3.6	
	263	3.5	
	264	2.2	
	265	2.3	
	266	1.9	
CARABAYLLO	350	4.3	4,3
	351	4.2	4,7
COMAS	345	4.3	3,6
	346	4.4	4,0
	347	4.5	4,2
	348	4.8	4,6
	349	4.4	4,1
LOS OLIVOS	83	3.9	3,9
	84	4.3	3,9
	85	4.2	4,2
PUENTE PIEDRA	361	4.3	
	368	4.2	4,3
	369	4.3	4,9
	370	4.1	
SAN MARIN DE PORRAS	212	4.3	4,5
	213	4.4	4,2
	251	4.4	
	252	4.4	
	253	4.3	
	254	4.4	
	255	3.8	
	257	4.0	

Source: JICA Study Team

4) Population growth rate

Annual average inter-census population growth rate for Metropolitan Lima city has been 2.7 % between 1981 and 1993, and 2.04 % between 1993 and 2007. This shows a decreasing tendency in the Lima population's annual growth rate

Figure 3.1.2-1 shows annual average inter-census growth rate's behavior for the 1940 – 2007 period. During the 1993 – 2007 inter-census period, Lima region population increased by 2,296,051, that is, 164,004 inhabitants per year, and this means, a 32.7 % increase, with regard to the population of 7,026,037 in 1993.

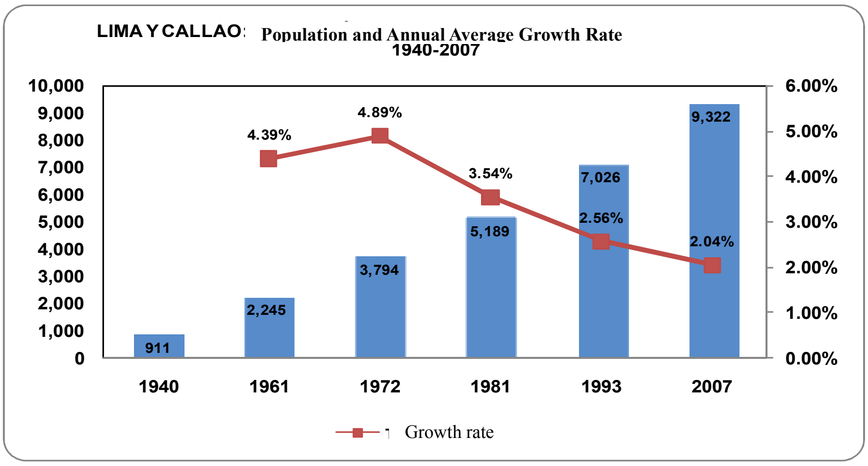


Figure 3.1.2-3 Behavior of the growth rates in Lima and Callao Provinces

Annual average growth during the 1993 – 2007 period was 2.04 %, which is less than growth during the prior inter-censusperiods. This mainly accounts for the reduction of the fertility levels (demographic indicators).

According to censuses carried out in 1993 and 2007 by INEI, districts in the area of influence have a population of 2,525,449 in 2007, with an annual average growth of 2.93 %; this exceeds the annual average growth of 2.04 %. for the department of Lima

With regard to population growth in the urban area, a growth of 2.96 % is noticed, which is 3 percentage points above the growth for the Department of Lima's urban area growth. Carabayllo is the only district having rural areas; and according to the 2007 Census, these rural areas have shown a decrease of -1.62 % during the 1993 – 2007 period.

Inter-census growth rates in study area districts were used to project the population for the study planning period; based on population and housing censuses between 1961 and 2007. These rates were used in SEDAPAL's Optimized Master Plan of July 2009 (from now on "2009 Master Plan") to update the demand study, and revise the supply at the beginning of 2001.

INEI is the institution in charge of evaluating the population's evolution at national level to provide database to the Government development plans, and gathering and managing all relevant information.

Forecasts made by INEI on populations in prior years and gathering of vital statistical information (births, deaths), school enrollments, etc. denominated as "symptomatic variables". These have been included in the Department population projections by calendar year and age groups for the 1995 – 2015 period (published in July 1997), as well as the Department population projections per calendar year, per Department, province, and district for the 1990 – 2005 period – published in January 2002 (Bulletin No. 16). The later publication updates the prior information but only up to 2005.

The demand updating and supply correction study that was carried out at the beginning of 2001, determined the updated population projection that can be adopted until 2030.

The population projections were estimated in SEDAPAL's Optimized Master Plan at district level by taking into account the annual average growth rates for the last inter-census period and adjusting the tendency set out with the rate suggested in the OMP for each district. This allowed for establishing the new growth rates for the next 20 years, and for the remaining projection years, the tendency and the rate suggested in the OMP were taken into account.

The following table shows the growth rates in detail proposed in the Study.. 2007 Census population, at block level, was taken into account, in order to estimate the base population for each sector or sub sector.

The population growth rate, applied to each sub sector corresponds to the growth rate of the district that the sub sector belongs to. If the sub sector goes beyond the district boundary, the rate is calculated from the current connection weighted averages in each sector.

Population growth rate applied to each sector is shown in Table 3.1.2-9.

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It must be pointed out that for those sectors where 2 or more districts coincide (like, for example, 350 and 256), district growth rates have been weighted among the population that corresponds to each area's sector, in order to get the relevant rate. In this way, growth rate has been independently used for each sector and sub sector.

Table 3.1.2-9: Population Growth Ratio of the Study

Year			Callao Province		Lima Province				
			1	2	3	4	5	6	7
			Dist. Callao	Dist. Ventanilla	Dist. Carabayllo	Dist. Comas	Dist. Los Olivos	Dist. Puente Piedra	Dist. San Martin de Porros
-	2007	(2006-2007)							
-	2008	(2007-2008)	0.837%	7.570%	4.840%	1.269%	2.131%	5.738%	3.016%
BASE	2009	(2008-2009)	0.834%	7.155%	4.602%	1.202%	1.891%	5.450%	2.600%
-5	2010	(2009-2010)	0.832%	6.762%	4.376%	1.138%	1.678%	5.177%	2.240%
-4	2011	(2010-2011)	0.829%	6.391%	4.161%	1.077%	1.489%	4.918%	1.931%
-3	2012	(2011-2012)	0.826%	6.041%	3.956%	1.020%	1.320%	4.672%	1.664%
-2	2013	(2012-2013)	0.824%	5.709%	3.762%	0.966%	1.170%	4.438%	1.434%
-1	2014	(2013-2014)	0.821%	5.396%	3.577%	0.915%	1.037%	4.215%	1.236%
0	2015	(2014-2015)	0.818%	5.100%	3.401%	0.866%	0.919%	4.004%	1.065%
1	2016	(2015-2016)	0.816%	4.820%	3.234%	0.820%	0.813%	3.804%	0.918%
2	2017	(2016-2017)	0.813%	4.555%	3.075%	0.777%	0.720%	3.613%	0.791%
3	2018	(2017-2018)	0.810%	4.305%	2.924%	0.736%	0.637%	3.432%	0.682%
4	2019	(2018-2019)	0.807%	4.069%	2.780%	0.697%	0.563%	3.260%	0.588%
5	2020	(2019-2020)	0.805%	3.846%	2.643%	0.660%	0.498%	3.097%	0.506%
6	2021	(2020-2021)	0.802%	3.635%	2.513%	0.625%	0.454%	2.942%	0.436%
7	2022	(2021-2022)	0.800%	3.341%	2.454%	0.621%	0.452%	2.862%	0.434%
8	2023	(2022-2023)	0.797%	3.072%	2.397%	0.617%	0.450%	2.785%	0.433%
9	2024	(2023-2024)	0.794%	2.824%	2.341%	0.613%	0.448%	2.709%	0.431%
10	2025	(2024-2025)	0.792%	2.596%	2.286%	0.609%	0.446%	2.636%	0.429%
11	2026	(2025-2026)	0.789%	2.386%	2.232%	0.606%	0.444%	2.564%	0.427%
12	2027	(2026-2027)	0.787%	2.226%	2.105%	0.601%	0.442%	2.355%	0.425%
13	2028	(2027-2028)	0.784%	2.076%	1.984%	0.597%	0.439%	2.164%	0.423%
14	2029	(2028-2029)	0.781%	1.937%	1.871%	0.592%	0.437%	1.987%	0.421%
15	2030	(2029-2030)	0.779%	1.807%	1.764%	0.588%	0.435%	1.826%	0.419%
16	2031	(2030-2031)	0.776%	1.685%	1.663%	0.584%	0.433%	1.677%	0.417%
17	2032	(2031-2032)	0.774%	1.572%	1.568%	0.579%	0.430%	1.541%	0.415%
18	2033	(2032-2033)	0.771%	1.466%	1.478%	0.575%	0.428%	1.415%	0.413%
19	2034	(2033-2034)	0.769%	1.368%	1.394%	0.571%	0.426%	1.300%	0.411%
20	2035	(2034-2035)	0.766%	1.276%	1.314%	0.566%	0.424%	1.194%	0.409%
21	2036	(2035-2036)	0.763%	1.190%	1.239%	0.562%	0.421%	1.097%	0.407%
22	2037	(2036-2037)	0.761%	1.110%	1.168%	0.558%	0.419%	1.007%	0.404%
23	2038	(2037-2038)	0.758%	1.035%	1.101%	0.554%	0.417%	0.925%	0.402%
24	2039	(2038-2039)	0.755%	0.966%	1.038%	0.550%	0.415%	0.850%	0.400%
25	2040	(2039-2040)	0.753%	0.901%	0.979%	0.546%	0.413%	0.781%	0.398%
Values used in Perfil (Constant)			0.840%	8.010%	5.090%	1.340%	2.040%	6.040%	3.050%

Source: SEDAPAL, INEI and JICA Study Team

5) Industrial Connections

Water consumption by industrial activities is associated with the growth rate of the industrial sector. According to an industrial GDP projection by region and by productive sector for the years 2002-2020, carried out by Maximixe Consult S.A. at MEF's request, the average growth ratio of industry in Lima is 3.74% between the years 2010 and 2020.

In the analysis, the increase of industrial connections is assumed to be 3.74% considering the projected growth of industry.

6) Commercial and public connections

Commercial and public connection growth has been correlated to the population growth in the sub sector, as it is presumed that the commercial and public consumption are correlated to the domestic consumption. Therefore, a guideline to estimate the Water Supply Companies' minimum cost plans demand, as stated by SUNASS, and the methodological considerations for the water supply demand projection to be used in the preparation of the draft investments plan that is considered in the scope of the National Water Supply and Sewerage Program's Institutional and Operative Improvement Project (IOI or MIO, in Spanish) (Attachment N° 6 of the MIO's Terms of Reference.) have been taken into account.

Table 3.1.2-10 shows connections in the influence area of the study (see drawing APT-14) along with the high consumers connected to the network and its average consumptions. From the analysis of the tables, it can be deducted that at the present, there are 77,573 connections, 318 (0.41%) of them are high consumers, 239 are connected to SEDAPAL network and 79 of them have own network or source (wells).

Within the high consumers, 79.8% consumers belongs to public connections, most of them are Schools, Municipalities, etc. Commercial and industrial connections are 13.2% and 12.6% of high consumers respectively; and the house connections are only 0.3% of high consumers.

Table 3.1.2-10: Number of total connections and high consumers - 2009

Type of Connections	Total Connections		High Consumers		Incidences of high consumers of the total connections
	Units	%	Units	%	%
Social	328	0.4%	9	2.8%	2.74%
Domestic	61,754	79.6%	1	0.3%	0.00%
Commercial	1,220	1.6%	42	13.2%	3.44%
industrial	211	0.3%	40	12.6%	18.96%
Estate	252	0.3%	225	70.8%	89.29%
Multifamily	13,808	17.8%	1	0.3%	0.01%
Total	**77,573**	**100.0%**	**318**	**100.0%**	**0.41%**

Source: JICA Study Team

The most percentage of high consumers that are connected to SEDAPAL network are located in districts of Comas, Los Olivos, Carabayllo and Callao, with total percentage of 36%, 25%, 11% and 10 % respectively; districts of San Martin and Ventanilla have smaller percentage with only 5% and 3% respectively. See following table and drawing APT-15.

Table 3.1.2-11: Percentage of High Consumers at District Level - 2009

District	Connections (units)	Percentage Effect
Callao	33	10.38%
Ventanilla	9	2.83%
Carabayllo	36	11.32%
Comas	115	36.16%
Los Olivos	78	24.53%
Puente Piedra	32	10.06%
San Martin de Porres	15	4.72%
TOTAL	318	100.00%

Source: JICA Study Team

Table 3.1.2-12: Number of total connections and used units per sub-sector (2009)

SECTOR	SUB-SECTOR	NUMBER OF CONNECTIONS AND UNITS OF USE																											
		DOMESTIC				COMMERCIAL				INDUSTRIAL				PUBLIC				SOCIAL				MULTI FAMILY				TOTAL			
		CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE	CONNECTION			UNIT OF USE
		CM	SM	Total		CM	SM	Total		CM	SM	Total		CM	SM	Total		CM	SM	Total		CM	SM	Total		CM	SM	Total	
83A	83A-1	1,021	126	1,147	1,151	18	7	25	25	1	1	2	2	3	0	3	3	5	0	5	5	350	77	427	1,130	1,398	211	1,609	2,316
	83A-2	1,200	306	1,506	1,508	49	17	66	67	1	3	4	4	10	1	11	11	3	0	3	3	695	202	897	2,375	1,958	529	2,487	3,968
83B	83B-1	568	42	610	611	16	2	18	18	0	0	0	0	2	0	2	2	2	1	3	3	572	68	640	1,602	1,160	113	1,273	2,236
	83B-2	2,129	491	2,620	2,634	50	23	73	74	2	0	2	2	14	1	15	15	8	3	11	11	1,017	330	1,347	3,197	3,220	848	4,068	5,933
84A	84A-1	3,658	253	3,911	3,917	24	13	37	37	0	0	0	0	9	0	9	9	2	1	3	3	428	89	517	997	4,121	356	4,477	4,963
	84A-2	2,448	253	2,701	2,705	18	6	24	24	0	0	0	0	4	0	4	4	5	2	7	7	309	64	373	787	2,784	325	3,109	3,527
84B	84B-1	2,830	430	3,260	3,268	26	18	44	44	3	0	3	3	3	0	3	3	4	0	4	4	554	153	707	1,536	3,420	601	4,021	4,858
	84B-2	1,100	125	1,225	1,227	28	10	38	40	2	1	3	3	2	0	2	2	1	2	3	3	336	62	398	884	1,469	200	1,669	2,159
85A	85A	1,445	245	1,690	1,695	24	14	38	39	3	1	4	4	3	0	3	3	1	3	4	4	334	111	445	1,001	1,810	374	2,184	2,746
85B	85B-1	403	132	535	535	29	30	59	66	20	3	23	23	4	0	4	4	1	1	2	2	202	93	295	1,020	659	259	918	1,650
	85B-2	346	111	457	457	19	15	34	37	31	17	48	48	7	0	7	7	1	5	6	6	236	106	342	789	640	254	894	1,344
	85B-3	25	167	192	192	14	7	21	21	17	3	20	20	2	0	2	2	1	0	1	1	6	45	51	103	65	222	287	339
85C	85C	877	254	1,131	1,133	31	15	46	47	4	0	4	4	5	0	5	5	4	4	8	8	367	96	463	1,089	1,288	369	1,657	2,286
212A	212A-1	2,316	390	2,706	2,713	50	38	88	94	4	0	4	4	5	0	5	5	3	3	6	6	437	98	535	1,114	2,815	529	3,344	3,936
	212A-2	1,402	179	1,581	1,584	39	10	49	50	5	2	7	7	3	0	3	3	2	0	2	2	368	74	442	925	1,819	265	2,084	2,571
212B	212B-1	994	149	1,143	1,146	29	11	40	40	3	0	3	3	1	0	1	1	0	0	0	0	360	65	425	989	1,387	225	1,612	2,179
	212B-2	888	99	987	989	25	7	32	35	6	1	7	7	1	0	1	1	2	2	4	4	285	42	327	764	1,207	151	1,358	1,800
213	213-1	2,079	477	2,556	2,558	42	21	63	64	1	0	1	1	4	0	4	4	4	3	7	7	286	86	372	748	2,416	587	3,003	3,382
	213-2	61	6	67	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	62	6	68	69
	213-3	122	6	128	128	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	0	0	0	0	124	6	130	130
251	251	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	1	3	4
252	252	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
253	253	16	4	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	7	20	18	9	27	40
254	254	1	1	2	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	2	2	4	4
255	255	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	2	2
256	256	6	0	6	6	0	4	4	4	1	0	1	1	0	0	0	0	0	1	1	69	1	2	3	83	8	7	15	163
257	257	0	1	1	1	2	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4
258	258	0	1	1	1	6	2	8	8	20	3	23	24	0	0	0	0	0	0	0	0	0	0	0	0	26	6	32	33
259	259	1,433	694	2,127	2,130	8	11	19	19	0	0	0	0	6	0	6	6	3	5	8	8	80	42	122	241	1,530	752	2,282	2,404
260	260	0	0	0	0	1	0	1	1	3	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	4	1	5	5
261	261	0	0	0	0	5	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	10
262	262	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
263	263	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
264	264	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
265	265	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
266	266	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
345	345	307	69	376	376	9	7	16	16	1	0	1	1	3	0	3	3	3	0	3	3	14	2	16	63	337	78	415	462
346	346-1	496	188	684	686	6	5	11	11	2	0	2	2	9	0	9	9	0	1	1	1	107	45	152	398	620	239	859	1,107
	346-2	922	449	1,371	1,374	17	15	32	32	2	1	3	3	4	0	4	4	3	1	4	4	221	111	332	735	1,169	577	1,746	2,152
347	347-1	786	649	1,435	1,443	21	18	39	39	2	1	3	3	8	0	8	8	5	3	8	8	301	256	557	1,132	1,123	927	2,050	2,633
	347-2	1,110	391	1,501	1,505	14	10	24	24	4	2	6	7	6	0	6	6	4	1	5	5	187	66	253	506	1,325	470	1,795	2,053
348A	348A	2	647	649	650	0	7	7	7	0	0	0	0	10	0	10	10	1	5	6	6	1	168	169	265	14	827	841	938
348B	348B-1	10	1,600	1,610	1,618	0	12	12	12	0	0	0	0	3	0	3	3	0	9	9	9	4	396	400	664	17	2,017	2,034	2,306
	348B-2	140	37	177	177	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	140	38	178	178
349A	349A-1	177	1,336	1,513	1,516	1	6	7	8	0	0	0	0	5	0	5	5	0	10	10	10	2	212	214	417	185	1,564	1,749	1,956
	349A-2	0	323	323	323	0	0	0	0	0	0	0	0	3	0	3	3	0	1	1	1	0	13	13	20	3	337	340	347
	349A-3	0	776	776	779	0	3	3	3	0	0	0	0	2	0	2	2	0	3	3	3	0	110	110	177	2	892	894	964
349B	349B-1	90	589	679	680	0	1	1	1	0	0	0	0	3	0	3	3	2	6	8	8	0	93	93	186	95	689	784	878
	349B-2	119	588	707	709	0	1	1	1	0	0	0	0	6	1	7	7	0	5	5	5	0	44	44	72	125	639	764	794
	349B-3	175	524	699	700	0	7	7	7	0	0	0	0	5	0	5	5	0	4	4	4	3	29	32	42	183	564	747	758
	349B-4	1	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
350	350-1	1,601	768	2,369	2,379	41	36	77	83	0	1	1	1	36	0	36	36	11	8	19	19	921	416	1,337	2,841	2,610	1,229	3,839	5,359
	350-2	2,054	654	2,708	2,715	27	20	47	49	1	1	2	2	24	1	25	26	5	7	12	12	477	177	654	1,481	2,588	860	3,448	4,285
351	351-1	528	23	551	552	1	1	2	2	0	0	0	0	0	0	0	0	1	1	2	2	24	19	43	85	554	44	598	641
	351-2	358	3	361	362	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	358	3	361	362
	351-3	72	3	75	75	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	73	3	76	76
361	361	1,220	68	1,288	1,288	8	6	14	14	1	1	2	2	4	3	7	7	0	0	0	0	41	3	44	75	1,274	81	1,355	1,386
368A	368A-1	1,519	158	1,677	1,679	13	5	18	18	0	0	0	0	1	1	2	2	0	0	0	0	57	7	64	137	1,590	171	1,761	1,836
	368A-2	288	6	294	294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	6	290	7	297	300
368B	368B	2,867	33	2,900	2,905	3	1	4	4	0	0	0	0	3	0	3	3	2	1	3	3	17	1	18	31	2,892	36	2,928	2,946
369A	369A	1,562	529	2,091	2,096	13	3	16	16	1	0	1	1	6	2	8	8	0	2	2	2	48	13	61	108	1,630	549	2,179	2,231
369B	369B	2,426	55	2,481	2,483	2	3	5	5	0	0	0	0	9	0	9	10	2	128	130	130	17	2	19	37	2,456	188	2,644	2,665
370	370	22	115	137	139	7	34	41	41	14	13	27	28	2	0	2	2	0	2	2	2	15	27	42	76	60	191	251	288
TOTAL		**46,228**	**15,526**	**61,754**	**61,893**	**736**	**484**	**1,220**	**1,261**	**155**	**56**	**211**	**214**	**241**	**11**	**252**	**254**	**93**	**235**	**328**	**396**	**9,686**	**4,122**	**13,808**	**30,953**	**57,139**	**20,434**	**77,573**	**94,971**

Remarks CM: With meter, SM: Without meter

Source: SEDAPAL, INEI and JICA Study Team

Table 3.1.2-13: Number of connections of high consumers per sub-sector (2009)

SUBSECTOR	DISTRICT	SOCIAL				DOMESTIC				COMMERCIAL				INDUSTRIAL				PUBLIC				TOTAL			
		C/M	S/M	CNX	CSMO	C/M	S/M	CNX	CSMO	C/M	S/M	CNX	CSMO	C/M	S/M	CNX	CSMO	C/M	S/M	CNX	CSMO	C/M	S/M	CNX	CSMO
83 A-1	LOS OLIVOS		-				-			1	-	1	32		-			3	-	3	1,054	4	-	4	1,086
83 A-2	LOS OLIVOS		-				-				-				-			9	-	9	2,120	9	-	9	2,120
83 B-1	LOS OLIVOS		-				-				-				-			2	-	2	300	2	-	2	300
83 B-2	LOS OLIVOS	3	-	3	406		-			1	-	1	11		-			14	-	14	4,616	18	-	18	5,033
84 A-1	LOS OLIVOS		-				-				-				-			8	-	8	1,098	8	-	8	1,098
84 A-2	LOS OLIVOS		-				-				-				-			4	-	4	705	4	-	4	705
84 B-1	LOS OLIVOS		-				-				-				-			3	-	3	842	3	-	3	842
84 B-2	LOS OLIVOS		-				-				-				-			2	-	2	347	2	-	2	347
85 A	LOS OLIVOS		-				-				-				-			3	-	3	747	3	-	3	747
85 B-1	LOS OLIVOS		-				-				-			1	-	1	34	4	-	4	1,185	5	-	5	1,219
85 B-2	COMAS		-				-				-			1	-	1	1,163	7	-	7	1,046	8	-	8	2,209
85 B-3	LOS OLIVOS		-				-			5	-	5	4,779	9	-	9	16,418	2	-	2	2,342	16	-	16	23,539
85 C	COMAS		-				-			1	-	1	685	3	-	3	2,421	3	-	3	710	7	-	7	3,816
	LOS OLIVOS		-				-			2	-	2	16		-			2	-	2	714	4	-	4	730
212 A-1	SAN MARTIN DE PORRES		-				-				-				-			4	-	4	809	4	-	4	809
212 A-2	SAN MARTIN DE PORRES		-				-				-				-			3	-	3	541	3	-	3	541
212 B-1	SAN MARTIN DE PORRES		-				-			1	-	1	132		-			1	-	1	117	2	-	2	249
212 B-2	SAN MARTIN DE PORRES		-				-				-				-			1	-	1	91	1	-	1	91
213-1	SAN MARTIN DE PORRES		-				-				-				-			4	-	4	1,349	4	-	4	1,349
254	SAN MARTIN DE PORRES		-			1	-	1	34		-				-				-			1	-	1	34
257	CALLAO		-				-			2	-	2	117		-				-			2	-	2	117
258	CALLAO		-				-			5	-	5	3,704	19	-	19	247,918		-			24	-	24	251,622
259	CALLAO		-				-			2	-	2	499		-			5	-	5	1,431	7	-	7	1,930
260	VENTANILLA		-				-			1	-	1	2,251	3	-	3	102,501		-			4	-	4	104,752
261	VENTANILLA		-				-			5	-	5	291,479		-				-			5	-	5	291,479
345	CARABAYLLO		-				-				-			1	-	1	2,024		-			1	-	1	2,024
	COMAS	1	-	1	668		-			4	-	4	871		-			2	-	2	806	7	-	7	2,345
346-1	COMAS		-				-				-				-			9	-	9	1,721	9	-	9	1,721
346-2	COMAS		-				-				-				-			4	-	4	696	4	-	4	696
347-1	COMAS		-				-				-				-			7	-	7	1,344	7	-	7	1,344
347-2	COMAS		-				-				-			1	-	1	89	6	-	6	811	7	-	7	900
348 A	COMAS		-				-				-				-			8	-	8	1,941	8	-	8	1,941
348 B-1	COMAS		-				-				-				-			3	-	3	588	3	-	3	588
349 A-1	COMAS		-				-				-				-			5	-	5	581	5	-	5	581
349 A-2	COMAS		-				-				-				-			2	-	2	240	2	-	2	240
349 A-3	COMAS		-				-				-				-			2	-	2	345	2	-	2	345
349 B-1	COMAS	2	-	2	251		-				-				-			3	-	3	220	5	-	5	471
349 B-2	COMAS		-				-				-				-			6	-	6	697	6	-	6	697
349 B-3	COMAS		-				-				-				-			5	-	5	616	5	-	5	616
350-1	CARABAYLLO	2	-	2	31		-				-				-			18	-	18	6,871	20	-	20	6,902
	COMAS		-				-				-				-			18	-	18	3,159	18	-	18	3,159
350-2	CARABAYLLO		-				-			2	-	2	68		-			11	-	11	3,228	14	-	14	3,347
	COMAS		-				-				-				-			12	-	12	2,420	12	-	12	2,420
351-3	CARABAYLLO		-				-				-				-			1	-	1	358	1	-	1	358
361	PUENTE PIEDRA		-				-			8	-	8	514		-			3	-	3	418	11	-	11	932
368 B	PUENTE PIEDRA		-				-				-				-			3	-	3	1,128	3	-	3	1,128
369 A	PUENTE PIEDRA		-				-				-				-			3	-	3	436	3	-	3	436
369 B	PUENTE PIEDRA	1	-	1	81		-				-				-			8	-	8	3,552	9	-	9	3,633
370	PUENTE PIEDRA		-				-			2	-	2	131	2	-	2	654	2	-	2	714	6	-	6	1,499
TOTAL		**9**	**-**	**9**	**1,437**	**1**	**-**	**1**	**34**	**42**	**-**	**42**	**305,289**	**40**	**-**	**40**	**373,222**	**225**	**-**	**225**	**55,054**	**318**	**-**	**318**	**735,087**

Source: JICA Study Team

In the following tables, it is shown the list of high consumers, who are supplied by SEDAPAL service and by own sources.

Table 3.1.2-14: Listo f High Consumers with Own Sources

SubSector	District	Tariff Type	Consumer
85 C	COMAS	Industrial	CONSORCIO NACIONAL DE HILADOS S.A.
		Industrial	GRUPO TEXTIL EXPORTADOR S A
		Industrial	INDUSTRIAS ALGOTEC S.A.
256	CALLAO	Comercial	COLAN LEVANO,JOSE ALFREDO
		Comercial	DE LA CRUZ VILLANUEVA,JUAN LEON
		Comercial	NAVARRO RAMOS,JULIO ROBERTO
		Industrial	REACTIVOS NACIONALES S A
259	CALLAO	Comercial	CORPORACION TRANSERFI S.A.C.
		Comercial	GUEVARA CAMPOS,JAVIER
		Comercial	INCA GARMENTS S.A
345	CARABAYLLO	Industrial	GRUPO TORVISCO S.A.
	COMAS	Social	HERMANOS DE LA,CARIDAD
		Domestico	GUEVARA GARCIA,ARTURO
		Domestico	SALAS GALLARDO,MARCELINA
		Comercial	BADAJOS CASAVERDE DE ESPINOZA,CESAREA
		Comercial	BARRENA SANTILLAN,OSCAR AGUSTIN
		Comercial	CESAR CASTRO GIURIA Y HNOS,
		Comercial	CHAVEZ HUATAY,NOEMI MARITZA
		Comercial	COMPLEJO TURISTICO ECOLOGICO EL REMANSO S R L
		Comercial	INSTITUCION EDUCATIVA PARTICULAR,MARISCAL A CACERES
		Comercial	INSTITUCION EDUCATIVA PRIVADA JOHN NASH HIGH SCHOOL S A C
		Comercial	PALOMINO COTRINA,GRIMALDO
		Comercial	ROCA NUÐEZ VDA DE SIANCAS,ESPERANZA
		Comercial	TRUJILLO EGUSQUIZA,FERNANDO ZENON
348 A	COMAS	Estatal	HOSPITAL SERGIO E BERNALES
361	PUENTE PIEDRA	Domestico	TOVAR PACHECO,HECTOR
		Comercial	ADMINISTRADORA BJ S.A.C.
		Comercial	CENTRO RECREACIONAL EL CHICLAYANO
		Comercial	CENTRO RECREACIONAL,EL SOL
		Comercial	CENTRO TURISTICO RECREACION BAÐOS DEL INCA EIRL
		Comercial	CEP DIVINO CORAZON DE JESUS
		Comercial	COMPLEJO TURISTICO BELLAVISTA S. A.
		Comercial	HOST SNACK BAR REST LAS TRES RUEDAS S.A.
		Comercial	INVERSIONES NINOSKA SAC
		Comercial	RESTAURANT LA CAPULLANA,
		Estatal	POLICIA NACIONAL DEL PERU
		Estatal	UGEL 04
370	PUENTE PIEDRA	Comercial	AGRICOLA LAS LLAMOZAS S.A.
		Comercial	COMERCIALIZADORA SALEM SAC
		Comercial	CORPORACION SMILE SAC
		Industrial	PAPELERA ZARATE SAC
		Industrial	SOCIEDAD ANONIMA PAPELSA
	COMAS	Comercial	TELLO VARGAS,MAXIMO
		Industrial	PAPELERA JESICAR S R L
254	SAN MARTIN DE PORRES	Domestico	VELASQUEZ MIGUEL,AUGUSTO
		Domestico	YAMASHIRO PALOMINO,ESTHER MIOKO
		Comercial	REYNA GARCIA DE PEREZ,ALBERTA
257	CALLAO	Domestico	TAKAYOSI TAKAYOSI,VICTOR
		Comercial	BANCO CONTINENTAL
		Comercial	COLAN SANCHEZ,ALBERTO
258	CALLAO	Domestico	HIRAOKA GALVEZ,NARCISA ESTAUROFILA
		Comercial	CARDENAS COLAN,RICHARD HERIBERTO
		Comercial	INVERSIONES MARITIMAS UNIVERSALES DEPOSITO S.A
		Comercial	NEPTUNIA S.A.
		Comercial	TRANSPORTES Y ALMACENAMIENTO DE LIQUIDOS S.A TRALSA
		Industrial	AJINOMOTO DEL PERU S A
		Industrial	FABRICA DE ENVASES S A
		Industrial	INDUSTRIAS VENCEDOR SA IVSA
		Industrial	INKABOR S A C
		Industrial	OLEO ABASTECIMIENTOS S.A.
		Industrial	PAPELERA REYES S.A.C.
		Industrial	PESQUERA SKAVOS SAC
		Industrial	PRODUCTOS DE ACERO CASSADO PRODAC S.A.
		Industrial	QUIMPAC S.A.
		Industrial	SILVATEAM PERU S.A.C.
		Industrial	SUDAMERICANA DE FIBRAS S.A.
		Industrial	TECNOLOGICA DE ALIMENTOS S.A.
		Industrial	ZETA GAS ANDINO S.A.
		Industrial	ZINC INDUSTRIAS NACIONALES SA
260	VENTANILLA	Comercial	REPSOL YPF COMERCIAL DEL PERU S.A.
		Industrial	REFINERIA LA PAMPILLA S.A.A.
261	VENTANILLA	Comercial	EDEGEL S A A
347-2	COMAS	Comercial	VALVERDE CALDAS,ALEJANDRO J
		Industrial	INTEGRACION AVICOLA SAC
362	PUENTE PIEDRA	Comercial	CENTRO TURISTICO RECREACION BAÐOS DEL INCA EIRL
		Comercial	DEL NORTE CENTRO RECREACIONAL,PARAISO
		Comercial	REPSOL COMERCIAL S.A.C.
85 B-2	COMAS	Industrial	CONDUCTORES ELECTRICOS PERUANOS S A
85 B-3	LOS OLIVOS	Industrial	CORPORACION FABRIL DE CONFECCIONES S A

Source: JICA Study Team

Table 3.1.2-15: List of High Consumers Connected to SEDAPAL Network

SubSector	District	Tariff Type	Consumer
85 A	LOS OLIVOS	Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	UGEL 02
85 C	COMAS	Comercial	EDELNOR S.A.A.
		Estatal	UGEL 02
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
	LOS OLIVOS	Comercial	BANCO DE CREDITO DEL PERU
		Comercial	TELEFONICA DEL PERU S.A.A.
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
259	CALLAO	Estatal	CENTRO EDUCATIVO OCUPACIONAL,CEO FUNDO MARQUEZ
		Estatal	DIRECCION DE SALUD I CALLAO
		Estatal	DIRECCION REGIONAL DE EDUCACION DEL CALLAO
		Estatal	MUNICIPALIDAD PROVINCIAL DEL CALLAO
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
345	COMAS	Estatal	MUNICIPALIDAD DE COMAS
348 A	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	UGEL 04
361	PUENTE PIEDRA	Estatal	MUNICIPALIDAD DE PUENTE PIEDRA
		Estatal	UGEL 04
368 B	PUENTE PIEDRA	Estatal	UGEL 04
369 A	PUENTE PIEDRA	Estatal	MUNICIPALIDAD DE PUENTE PIEDRA
		Estatal	UGEL 04
369 B	PUENTE PIEDRA	Social	ASPERSUD
		Estatal	MUNICIPALIDAD DE PUENTE PIEDRA
		Estatal	UGEL 04
370	PUENTE PIEDRA	Comercial	PODER JUDICIAL
		Estatal	HOSPITAL PUENTE PIEDRA Y SERV. BAS. DE SALUD
		Estatal	UGEL 04
	COMAS	Comercial	EDELNOR S.A.A.
		Estatal	FUERZA AEREA DEL PERU
212 A-1	SAN MARTIN DE PORRES	Estatal	UGEL 02
212 A-2	SAN MARTIN DE PORRES	Estatal	UGEL 02
212 B-1	SAN MARTIN DE PORRES	Comercial	REPSOL COMERCIAL S.A.C.
		Estatal	UGEL 02
212 B-2	SAN MARTIN DE PORRES	Estatal	UGEL 02
213-1	SAN MARTIN DE PORRES	Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
		Estatal	UGEL 02
346-1	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	UGEL 04
346-2	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	RED DE SALUD TUPAC AMARU
347-1	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	RED DE SALUD TUPAC AMARU
		Estatal	UGEL 04
347-2	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	UGEL 04
348 B-1	COMAS	Estatal	UGEL 04
349 A-1	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	PRONOEI ,PAQUITO YUNQUE
		Estatal	RED DE SALUD TUPAC AMARU
		Estatal	UGEL 04
349 A-2	COMAS	Estatal	UGEL 04
349 A-3	COMAS	Estatal	UGEL 04
349 B-1	COMAS	Social	PROGRAMA INTEGRAL NACIONAL PARA EL BIENESTAR FAMILIAR INABIF
		Estatal	MUNICIPALIDAD DE COMAS
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
349 B-2	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	RED DE SALUD TUPAC AMARU
		Estatal	UGEL 04
349 B-3	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	UGEL 04
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
350-1	CARABAYLLO	Social	CUERPO GENERAL DE BOMBEROS VOLUNTARIOS DEL PERU
		Estatal	MUNICIPALIDAD DE CARABAYLLO
		Estatal	SISTEMA METROPOLITANO DE LA SOLIDARIDAD . SISOL
		Estatal	UGEL 04
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
	COMAS	Estatal	MUNICIPALIDAD DE COMAS
		Estatal	UGEL 04
350-2	CARABAYLLO	Comercial	EDELNOR S.A.A.
		Comercial	TELEFONICA DEL PERU S.A.A.
		Estatal	MUNICIPALIDAD DE CARABAYLLO
		Estatal	MUNICIPALIDAD METROPOLITANA DE LIMA
		Estatal	UGEL 04
		Multifamiliar no Individualizado	BANCO DE LA NACION
	COMAS	Estatal	MUNICIPALIDAD DE CARABAYLLO
		Estatal	MUNICIPALIDAD DE COMAS
		Estatal	MUNICIPALIDAD METROPOLITANA DE LIMA
		Estatal	RED DE SALUD TUPAC AMARU
		Estatal	UGEL 04
351-3	CARABAYLLO	Estatal	UGEL 04
362	PUENTE PIEDRA	Estatal	UGEL 04
368 A-1	PUENTE PIEDRA	Estatal	MUNICIPALIDAD DE PUENTE PIEDRA
83 A-1	LOS OLIVOS	Comercial	TELEFONICA DEL PERU S.A.A.
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
83 A-2	LOS OLIVOS	Comercial	UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	MUNICIPALIDAD DISTRITAL DE LOS OLIVOS
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
		Estatal	SERVICIO DE PARQUES DE LIMA SERPAR
		Estatal	UGEL 02
83 B-1	LOS OLIVOS	Estatal	MUNICIPALIDAD DE LOS OLIVOS
83 B-2	LOS OLIVOS	Social	PROGRAMA INTEGRAL NACIONAL PARA EL BIENESTAR FAMILIAR INABIF
		Comercial	BANCO DE CREDITO DEL PERU
		Comercial	PERUANA DE ESTACIONES DE SERVICIOS S.A.C.
		Estatal	DIRECCION REGIONAL DE EDUCACION DE LIMA METROPOLITANA
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	PODER JUDICIAL
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
		Estatal	SENCICO
		Estatal	UGEL 04
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
84 A-1	LOS OLIVOS	Estatal	CLAS CENTRO MATERNO INFANTIL CONFRATERNIDAD
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	MUNICIPALIDAD METROPOLITANA DE LIMA
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
		Estatal	UGEL 02
84 A-2	LOS OLIVOS	Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
84 B-1	LOS OLIVOS	Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	VII DIRECCION TERRITORIAL DE POLICIA LIMA DIRTEPOL
84 B-2	LOS OLIVOS	Estatal	INSTITUTO PERUANO DEL DEPORTE
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
85 B-1	LOS OLIVOS	Industrial	TEXTILES CAMONES S.A.
		Estatal	MUNICIPALIDAD DE LOS OLIVOS
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
85 B-2	COMAS	Estatal	ASOCIACION DE PROPIETARIOS DE LA URBANIZACION,SANTA LUISA
		Estatal	MUNICIPALIDAD DE SAN MARTIN DE PORRES
		Estatal	PODER JUDICIAL
		Estatal	RED DE SALUD RIMAC SAN MARTIN LOS OLIVOS
		Estatal	UGEL 02
85 B-3	LOS OLIVOS	Comercial	INSTITUTO DE CIENCIAS Y HUMANIDADES
		Comercial	MOLITALIA S A
		Comercial	TRANSPORTES LAS VEGAS S.A.
		Comercial	UNIVERSIDAD CESAR VALLEJO S.A.C.
		Industrial	CIA INDUSTRIAL TEXTIL CREDISA TRUTEX S A A
		Industrial	CORPORACION FABRIL DE CONFECCIONES S A
		Industrial	FARMAGRO S A
		Industrial	MOLITALIA S A
		Industrial	SAN JORGE INDUSTRIAL S A
		Industrial	UNIQUE S.A.
		Industrial	YOBEL SUPPLY CHAIN MANAGEMENT S.A.
		Estatal	POLICIA NACIONAL DEL PERU

Source: JICA Study Team

7) Water supply service coverage

In the study, coverage rate of house connections (including single and multi family house connections and social connections) has been considered separately from the commercial and industrial connections.

Present coverage of domestic water supply service is the served population value divided by total population, and for the planning horizon of the study it is assumed to be 100% in the tenth year.

As a result of calculation, house connection coverage in the study area is 64.02% and in the influence area is 64.83%. In demand analysis it is projected to increase, and assumed that in 2019 this rate will be 100%, ten years after base year.

8) Unit consumption

Information on unit consumption per connection was obtained from SEDAPAL cadastre of Commercial Department. An average consumption for twenty four (24) months was estimated, from January 2008 to December 2009. For the estimation, those consumption of users are considered, who have 24 hours service, have active connections and effective metering, and have their meters in good conditions. Finally, results consistency was analyzed; taking out those consumptions that was very low and/or very high and the results were compared with the results of other sub sectors of same social economical characteristics, so the average per sector was determined. Average was determined except sector 85B, because it concentrates large industrial consumers, so the unit consumption of sector 85B.2 is calculated separately.

For calculation of unit consumption the total consumption of all users including high consumers has been considered.

In following tables are shown high consumers and its average unitary consumption along 24 months provided by SEDAPAL and own sources.

Table 3.1.2-16: Number of connections of big consumers by sub-sector (2009), (m^3/month)

SUB-SECTORES	DISTRICT	SOCIAL			DOMESTIC			COMMERCIAL			INDUSTRIAL			PUBLIC			MULTI FAMILIAR			TOTALES		
		Connection			Connection			Connection			Connection			Connection			Connection			Connection		
		C/M	S/M	Total	C/M	S/M	Total	C/M	S/M	Total	C/M	S/M	Total	C/M	S/M	Total	C/M	S/M	Total	C/M	S/M	Total
83 A-1	Los Olivos				1		1	1		1				3		3				5		5
83 A-2	Los Olivos								1	1				10		10				10	1	11
83 B-1	Los Olivos				1		1							2		2				3		3
83 B-2	Los Olivos	3		3	2	1	3	1	1	2				14	1	15	3	2	5	23	5	28
84 A-1	Los Olivos													9		9	1		1	10		10
84 A-2	Los Olivos													3		3				3		3
84 B-1	Los Olivos				2	1	3							3		3		1	1	5	2	7
84 B-2	Los Olivos													2		2				2		2
85 A	Los Olivos													3		3				3		3
85 B-1	Los Olivos					1	1				1		1	4		4				5	1	6
85 B-2	Comas													7		7				7		7
85 B-3	Comas					1	1														1	1
	Los Olivos							7		7	12	1	13	2		2				21	1	22
85 C	Comas				1		1	1		1	3		3	3		3				8		8
	Los Olivos							3		3				2		2				5		5
212 A-1	San Martín de Porres													4		4				4		4
212 A-2	San Martín de Porres													3		3				3		3
212 B-1	San Martín de Porres							1		1				1		1				2		2
212 B-2	San Martín de Porres													1		1				1		1
213-1	San Martín de Porres													4		4				4		4
259	Callao													6		6				6		6
345	Comas													3		3				3		3
346-1	Comas				2		2							9		9				11		11
346-2	Comas													4		4				4		4
347-1	Comas													8		8				8		8
347-2	Comas				1		1							6		6				7		7
348 A	Comas		2	2		1	1							10		10				10	3	13
348 B-1	Comas					1	1							3		3				3	1	4
349 A-1	Comas		1	1										5		5				5	1	6
349 A-2	Comas													3		3				3		3
349 A-3	Comas													2		2				2		2
349 B-1	Comas	2		2		1	1							3		3				5	1	6
349 B-2	Comas					1	1							6		6				6	1	7
349 B-3	Comas					1	1							5		5				5	1	6
350-1	Carabayllo	2		2										18		18				20		20
	Comas													18		18		1	1	18	1	19
350-2	Carabayllo				1		1	2		2				11		11	2		2	16		16
	Comas													12	1	13				12	1	13
351-1	Carabayllo							1		1										1		1
351-3	Carabayllo													1		1				1		1
361	Puente Piedra								1	1				4	2	6				4	3	7
368 A-1	Puente Piedra													1	1	2				1	1	2
368 B	Puente Piedra				1		1							3		3				4		4
369 A	Puente Piedra					1	1							5	2	7				5	3	8
369 B	Puente Piedra	1		1										9		9				10		10
370	Puente Piedra							1		1				1		1				2		2
Total general		8	3	11	12	10	22	18	3	21	16	1	17	236	7	243	6	4	10	296	28	324

Source: JICA Study Team

Table 3.1.2-17: Unit Consumption for the Demand Analysis (m^3/month)

Sector	Domestic		Comercial		Industrial		Estatal		Social		Multifamiliar	
	CM	SM	CM	SM	CM	SM	CM	SM	CM	SM	CM	SM
83A	21.3	29.8	34.8	48.7	19.0	26.6	283.8	397.3	66.4	92.9	15.6	21.9
83B	21.3	29.8	34.8	48.7	19.0	26.6	283.8	397.3	66.4	92.9	15.6	21.9
84A	13.6	19.8	16.5	23.1	14.9	20.9	228.3	319.7	19.2	26.9	12.2	17.1
84B	13.6	19.8	16.5	23.1	14.9	20.9	228.3	319.7	19.2	26.9	12.2	17.1
85A	17.4	24.4	243.9	341.4	186.5	261.1	267.5	374.5	81.4	114.0	14.7	20.6
85B*	17.4	24.4	243.9	341.4	186.5	261.1	267.5	374.5	81.4	114.0	14.7	20.6
85B-2	17.4	24.4	243.9	341.4	1,281.5	1,794.1	267.5	374.5	81.4	114.0	14.7	20.6
85C	17.4	24.4	243.9	341.4	186.5	261.1	267.5	374.5	81.4	114.0	14.7	20.6
212A	15.8	22.1	46.4	65.0	17.7	24.7	156.3	218.9	11.8	16.5	14.3	20.0
212B	15.8	22.1	46.4	65.0	17.7	24.7	156.3	218.9	11.8	16.5	14.3	20.0
213	14.4	20.2	14.2	19.9	14.9	20.9	315.9	442.3	59.0	82.6	17.1	24.0
251	14.4	20.2	-	-	-	-	-	-	-	-	-	-
252	14.4	20.2	-	-	-	-	-	-	-	-	-	-
253	14.4	20.2	-	-	-	-	-	-	-	-	16.4	23.0
254	14.4	20.2	-	-	-	-	-	-	-	-	28.6	40.0
255	14.4	20.2	-	-	-	-	-	-	-	-	-	-
256	14.4	20.2	-	-	-	-	-	-	-	-	14.4	20.2
257	14.4	20.2	-	-	-	-	-	-	-	-		-
258	14.4	20.2	909.1	1,272.7	18,890.0	26,446.0	-	-	-	-	-	-
259	14.4	20.2	11.4	16.0	-	-	428.3	599.6	8.7	12.2	14.4	20.2
260	13.4	18.8	3,083.5	4,316.9	45,137.0	63,191.8	-	-	-	-	-	-
261	13.4	18.8	46,017.6	64,424.6	-	-	-	-	-	-	-	-
262	13.4	18.8	-	-	-	-	-	-	-	-	-	-
263	13.4	18.8	-	-	-	-	-	-	-	-	-	-
264	13.4	18.8	-	-	-	-	-	-	-	-	-	-
265	13.4	18.8	-	-	-	-	-	-	-	-		-
266	13.4	18.8	-	-	-	-	-	-	-	-		-
345	16.5	23.1	19.6	27.4	-	-	317.9	445.1	282.0	394.8	17.2	24.1
346	15.8	22.2	15.0	21.1	19.2	26.9	168.4	235.8	13.2	18.5	13.3	18.6
347	15.3	21.4	13.2	18.5	21.8	30.5	129.4	181.2	13.2	18.5	14.5	20.2
348A	15.8	22.2	28.4	39.8	-	-	222.1	310.9	14.4	20.2	13.3	18.6
348B	15.8	22.2	28.4	39.8	-	-	222.1	310.9	14.4	20.2	13.3	18.6
349A	15.4	21.5	-	-	-	-	125.8	176.1	125.8	176.1	13.3	18.6
349B	15.4	21.5	-	-	-	-	125.8	176.1	125.8	176.1	13.3	18.6
350	18.7	26.1	19.1	26.8	1,019.0	1,426.6	197.2	276.0	48.5	67.9	15.0	21.0
351	15.6	21.8	42.5	59.5	-	-	-	-	9.3	13.0	13.8	19.3
361	14.4	20.2	-	-	6.7	9.4	31.6	44.3	-	-	13.3	18.6
368A	14.4	20.2	9.0	12.6	-	-	74.6	104.4	7.6	10.6	14.1	19.8
368B	14.4	20.2	9.0	12.6	-	-	74.6	104.4	7.6	10.6	14.1	19.8
368	14.4	20.2	9.0	12.6	-	-	74.6	104.4	7.6	10.6	14.1	19.8
369A	14.4	20.2	13.3	18.7	41.7	58.4	179.2	250.8	27.0	37.9	12.1	17.0
369B	14.4	20.2	13.3	18.7	41.7	58.4	179.2	250.8	27.0	37.9	12.1	17.0
370	18.8	26.3	121.8	170.5	47.5	66.5	257.3	360.2	-	-	17.3	24.2

*: Except Sub-sector 85B-2

Source: SEDAPAL and JICA Study Team

9) Increase of Metered Connections

According to the SEDAPAL cadastre, the metered connection was 74% in December 2009. The ratios range from 70% to 90% in most of the sectors but in some sub-sectors, especially in the Comas District, the metered ratios are lower than 50%.

In order to operate and manage an equitable and economically sound water supply business, water consumption of each connection shall be properly monitored. This enables accurate charging of tariffs and promotes appropriate water use by the users, and it assures sustainability of the SEDAPAL water supply business.

A SEDAPAL project called “Sistema Integral de Gestion Comercial” began in July 2010. It proposes an aggressive plan of installation of micrometers, upgrading the commercial cadastre and detecting illegal connections. The project is scheduled to be completed in three years. In the Study, assuming successful results from the said project, the metered ratio is expected to increase constantly to 100% by 2013.

10) Water Loss Ratio

(a) Definition of "Water Loss" in Demand Forecast

As explained in section 2.5.10, non revenue water consists of technical loss and non-technical loss, and non-technical loss includes illegal consumption and meter error. "Water loss" in demand analysis shall be defined as technical loss which is not consumed by inhabitants. In other words, the amount of commercial loss which corresponds to current illegal consumption and meter error, which are counted as a part of water loss in general definition, should be calculated as water demand because illegal consumption and meter error are derived from actual water demand.

The Figure 3.1.2-4 shows the current situation of water distribution in typical sectors with 50% of non-revenue water in the Study Area, which was estimated in section 2.5.10. As shown in the figure, water loss in the analysis shall be 40% before Project and 20% after Project in order to achieve target non-revenue water ratio of 25%.

<table>
<tr><th></th><th></th><th></th><th></th><th>Present</th><th>After Project</th><th></th><th></th></tr>
<tr><td rowspan="8">Total Production</td><td rowspan="3">Legal Consumption</td><td rowspan="2">Legal Revenue Consumption</td><td>Metered Legal Revenue Consumption</td><td>35%</td><td>75%</td><td rowspan="2">Revenue Water</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Non-metered Legal Revenue Consumption</td><td>15%</td><td>0%</td></tr>
<tr><td>Legal Non-revenue Consumption</td><td>Metered&Non-metered Legal Non-revenue Consumption</td><td rowspan="3">10-15%
NRW: 50%</td><td rowspan="3">5%
NRW: 25%</td><td rowspan="3">Commercial Loss</td><td rowspan="6">Non-revenue Water</td></tr>
<tr><td rowspan="5">Water Loss</td><td rowspan="2">Non-technical Loss</td><td>Error of Meter</td></tr>
<tr><td>Illegal Consumption</td></tr>
<tr><td rowspan="3">**Technical Loss**</td><td>**Loss in Distribution**</td><td>**35-40%**</td><td>**20%**</td><td rowspan="3">Technical Loss</td></tr>
<tr><td>**Loss at Connections and Meters**</td><td colspan="2" rowspan="2">**[Asssumption of Loss]**
Before Project: 40%
After Project: 20%</td></tr>
<tr><td>**Loss at Reservoirs and Others**</td></tr>
</table>

*: Current ratios and future ratios after the Project in the Study Area
Source: JICA Study Team

Figure 3.1.2-4 Category of Distributed Water and Presumed Ratio of Water Loss in Demand Analysis (in case of sub-sectors with 50% NRW Ratio)

(b) Applied Water Loss Ratios

The NRW ratio in the North Lima Area is estimated by SEDAPAL to be approximately 50% at present. However, it is impossible to estimate the ratio in each sector or sub-sector because there are only five sectors in which inflow is monitored, and even the monitored inflows are only monitored by sectors and not by sub-sectors.

In the demand analysis, the current water loss ratio of each sub-sector is defined based on the following conditions:

- In principle, current water loss is estimated to be 10% less than the NRW ratio, following the results of the current NWR diagnosis in section 2.5.10 and Figure 3.1.2-4.
- NRW and water loss ratio shall be common in sub-sectors within a sector.
- Current NRW ratios for the sub-sectors in sectors 83, 84, 85, 212, and 213 are defined based on the monitored data of the sector to which each sub-sector belongs.
- Current NRW ratios of the sub-sectors in other sectors are estimated considering the actual pipe conditions and social conditions. In the estimation, NRW in average conditions shall be 50%; in better conditions they shall be less than 50%, and in worse conditions they shall be more than 50%.
- In sub-sectors without existing networks, the NRW ratio shall be 25% and water loss shall be 20% initially.
- In sub-sectors in which the network is new or recently rehabilitated, and in those sub-sectors in which networks are to be rehabilitated soon by SEDAPAL projects, the current NRW shall be 30% and water loss shall be 20% initially. Though these sectors will not have rehabilitation works in the Project, their NRW will be reduced to 25% through the SIAC meter installation project and through SEDAPAL´s continuous repair works.

The Project will reduce the technical loss by replacing old pipes which are causing significant loss, and by establishing a distribution system which enables appropriate pressure control. In addition, micrometers will also be installed in this Project and in SEDAPAL's other projects in the Study area.

The effect brought about by replacing pipes and installing micrometers will appear even during the Project, but the effect brought about by improving pressure control, on the other hand, will appear gradually as the operation is adjusted to the new water supply system.

In the analysis, considering the two kinds of effects with different characteristics, it is assumed that the water leakage ratio will decrease gradually from 2015, when most of its construction work will be completed, until 2017, which is two years after Project completion.

The assumed NRW and water loss ratios of the sectors in demand analysis are presented in the table 3.1.2-17.

Table 3.1.2-17: Assumed Current NRW and Water Loss Ratios in Demand Forecast

NRW Ratio	Water Loss Ratio	Sectors*	Remarks
25.0%	20.0%	251 (56.0), 252 (56.0), 254 (56.0), 255 (53.9), 257 (53.9), 258 (53.9), 260 (56.0), 261 (40.8), 262 (40.8), 263 (40.8), 264 (40.8), 265 (40.8), 266 (40.8)	Sectors without existing networks
30.0%	20.0%	253 (53.9), 361 (33.0), 368B (33.0), 369B (33.0), 256 (53.9), 370 (33.0)	Sectors in which networks are recently installed or rehabilitated, or are soon to be rehabilitated
35.0%	25.0%	84A (34.0), 84B (34.0)	NRW was 33.1% in 2009
40.0%	30.0%	212A (36.0), 212B (36.0), 369A (33.0)	212A and 212B: NRW was 38.0% in 2009
45.0%	35.0%	83A (38.0), 83B (38.0)	NRW was 42.9% in 2009
50.0%	40.0%	85A (49.0), 85B (49.0), 85C (49.0), 346 (54.0), 347 (48.0), 368A (33.0)	85A, 85B and 85C: NRW was 50.1% in 2009
60.0%	50.0%	213 (56.0), 259 (58.0), 345 (49.0), 348A(45.0), 348B (45.0), 349A (45.0), 349B (45.0), 350 (45.0), 351 (48.0)	259: Average NRW of Callao was 55% in 2009

*: Values in ( ) are assumed water loss ratios in the Perfil
Source: JICA Study Team

Table 3.1.2-18: Projected Loss Rates in Demand Projection (%)

	Sectors of the Influence Area															
	83	84	85	212	213	259	345	346	347	348	349	350	351	361	368	369
Year -1	35.0	25	40.0	30.0	50.0	50.0	50.0	40.0	40.0	50.0	50.0	50.0	50.0	25.0	40.0	40.0
Year 0	25.0	22.5	30.0	25.0	40.0	40.0	40.0	30.0	30.0	40.0	40.0	40.0	40.0	15.0	30.0	30.0
Year 1	22.5	21.25	25.0	22.5	30.0	30.0	30.0	25.0	25.0	30.0	30.0	30.0	30.0	17.5	25.0	25.0
Year 2	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 3	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 5	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 6	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 7	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 8	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 9	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 10	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 11	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 12	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 13	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 14	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 15	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 16	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 17	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 18	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 19	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Year 20	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Source: JICA Study Team

11) Factors for Peak Demand and Storage Volume of Reservoir

In the analysis, peak factors are defined following the National Building Regulation of the Ministry of Housing, Construction and Sanitation (hereinafter “National Sanitation Standard”), as shown in table 3.1.2-19.

Table 3.1.2-19: Factors for Peak Demand and Storage Volume of Reservoir

Factor		Value	Remarks
Peak Demand	Daily Maximum Factor	1.3	Against daily average
	Hourly Maximum Factor	1.8	Against daily average
Storage Volume	Storage Factor	0.25	Against daily average (m^3/day)
	Volume for Fire Prevention	$50m^3$	Extra volume in addition to the volume calculated by daily average demand and the storage factor

Source: O.S 100, National Building Regulation of the Ministry of Housing, Construction and Sanitation

(3) Result of Analysis

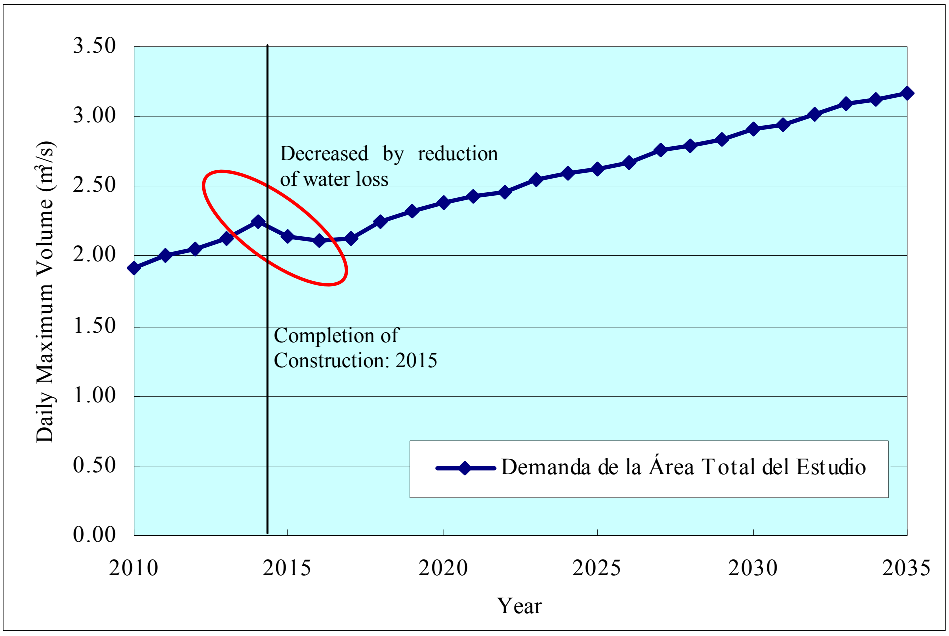
The demand analysis for water supply is carried out based on the conditions and assumptions above. The result of the analysis for the total Study area and the Area of Influence , are shown in the following tables and figures. Besides, number of connections by type of users is also shown.

Demand estimation has been carried out in detail for each sector and sub sector, considering its characteristics and which are shown in the appendix of Demand Study.

Table 3.1.2-20: Result of Water Demand Analysis for the Total Study Area

Year		Total Population	Cover Ratio	Served Population	Total Connection	Water Demand					Storage Demand (m^3)
						m^3/day	l/sec	m^3/year	QMD (m^3/seg)	QMH (m^3/seg)	
Base	2009	622,650	64.02%	398,590	77,573	124,115	1,436.51	45,301,810	1.87	2.59	34,179
-5	2010	636,573	67.58%	430,169	83,627	127,721	1,478.25	46,618,003	1.92	2.66	35,083
-4	2011	649,758	71.15%	462,290	89,783	133,187	1,541.52	48,613,401	2.00	2.77	36,448
-3	2012	662,250	74.73%	494,899	96,046	136,480	1,579.62	49,815,046	2.05	2.84	37,267
-2	2013	674,099	78.32%	527,958	102,409	141,400	1,636.57	51,610,965	2.13	2.95	38,500
-1	2014	685,338	81.92%	561,419	108,862	149,572	1,731.16	54,593,755	2.25	3.12	40,543
0	2015	696,012	85.52%	595,253	115,401	141,919	1,642.58	51,800,463	2.14	2.96	38,629
1	2016	706,154	89.13%	629,425	122,019	140,404	1,625.04	51,247,413	2.11	2.93	38,254
2	2017	715,805	92.75%	663,916	128,710	141,848	1,641.76	51,774,487	2.13	2.96	38,609
3	2018	724,997	96.37%	698,701	135,470	149,007	1,724.61	54,387,384	2.24	3.10	40,401
4	2019	733,754	100.00%	733,754	142,293	154,263	1,785.46	56,306,158	2.32	3.21	41,713
5	2020	742,109	100.00%	742,109	144,054	158,293	1,832.09	57,776,908	2.38	3.30	42,722
6	2021	750,112	100.00%	750,112	145,745	161,214	1,865.91	58,843,245	2.43	3.36	43,456
7	2022	758,100	100.00%	758,100	147,433	163,215	1,889.06	59,573,452	2.46	3.40	43,955
8	2023	766,068	100.00%	766,068	149,115	169,131	1,957.54	61,732,856	2.54	3.52	45,432
9	2024	774,012	100.00%	774,012	150,793	172,002	1,990.76	62,780,617	2.59	3.58	46,149
10	2025	781,931	100.00%	781,931	152,464	174,113	2,015.20	63,551,243	2.62	3.63	46,681
11	2026	789,827	100.00%	789,827	154,128	177,034	2,049.00	64,617,302	2.66	3.69	47,407
12	2027	797,459	100.00%	797,459	155,733	183,651	2,125.59	67,032,599	2.76	3.83	49,062
13	2028	804,833	100.00%	804,833	157,281	185,615	2,148.32	67,749,470	2.79	3.87	49,558
14	2029	811,961	100.00%	811,961	158,773	188,423	2,180.82	68,774,284	2.84	3.93	50,257
15	2030	818,848	100.00%	818,848	160,211	193,123	2,235.22	70,489,993	2.91	4.02	51,428
16	2031	825,503	100.00%	825,503	161,597	195,932	2,267.74	71,515,316	2.95	4.08	52,137
17	2032	831,937	100.00%	831,937	162,934	200,587	2,321.61	73,214,419	3.02	4.18	53,294
18	2033	838,158	100.00%	838,158	164,223	205,150	2,374.42	74,879,785	3.09	4.27	54,434
19	2034	844,171	100.00%	844,171	165,468	207,841	2,405.57	75,862,067	3.13	4.33	55,112
20	2035	849,998	100.00%	849,998	166,669	210,478	2,436.08	76,824,371	3.17	4.38	55,769

Source: JICA Study Team



Source: JICA Study Team

Figure 3.1.2-5: Result of Water Demand Analysis for the Total Study Area

Table 3.1.2-21: Projection of Connection in the Study Area

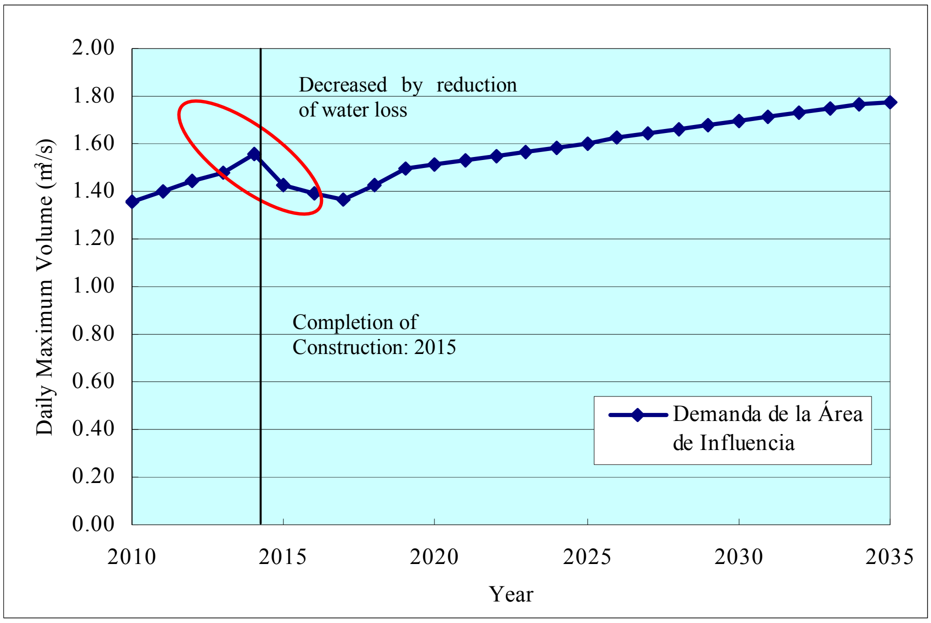
Year		Population	Coverage	Served Population	Connections						
					Domestic	Commercial	Industrial	Public	Social	Multiple Family	Total
-	2007	592,399			0	0	0	0	0	0	0
-	2008	607,943			0	0	0	0	0	0	0
Base	2009	622,650	64.02%	398,590	61,754	1,220	211	252	328	13,808	77,573
-5	2010	636,573	67.58%	430,169	66,775	1,245	219	258	355	14,776	83,627
-4	2011	649,758	71.15%	462,290	71,906	1,269	227	263	365	15,752	89,783
-3	2012	662,250	74.73%	494,899	77,141	1,291	236	268	376	16,735	96,046
-2	2013	674,099	78.32%	527,958	82,471	1,312	244	273	386	17,722	102,409
-1	2014	685,338	81.92%	561,419	87,891	1,331	254	278	396	18,713	108,862
0	2015	696,012	85.52%	595,253	93,395	1,350	263	282	405	19,706	115,401
1	2016	706,154	89.13%	629,425	98,978	1,367	273	287	415	20,700	122,019
2	2017	715,805	92.75%	663,916	104,634	1,383	283	291	424	21,695	128,710
3	2018	724,997	96.37%	698,701	110,360	1,398	294	295	433	22,690	135,470
4	2019	733,754	100.00%	733,754	116,150	1,413	305	299	442	23,684	142,293
5	2020	742,109	100.00%	742,109	117,687	1,426	316	303	450	23,872	144,054
6	2021	750,112	100.00%	750,112	119,166	1,439	328	306	458	24,047	145,745
7	2022	758,100	100.00%	758,100	120,641	1,452	340	310	467	24,223	147,433
8	2023	766,068	100.00%	766,068	122,111	1,465	353	314	475	24,399	149,115
9	2024	774,012	100.00%	774,012	123,575	1,478	366	317	483	24,574	150,793
10	2025	781,931	100.00%	781,931	125,032	1,491	380	321	491	24,749	152,464
11	2026	789,827	100.00%	789,827	126,483	1,503	394	324	500	24,924	154,128
12	2027	797,459	100.00%	797,459	127,878	1,516	409	328	508	25,095	155,733
13	2028	804,833	100.00%	804,833	129,220	1,528	424	331	515	25,263	157,281
14	2029	811,961	100.00%	811,961	130,509	1,539	440	334	522	25,428	158,773
15	2030	818,848	100.00%	818,848	131,748	1,551	456	337	529	25,590	160,211
16	2031	825,503	100.00%	825,503	132,938	1,562	473	340	535	25,749	161,597
17	2032	831,937	100.00%	831,937	134,081	1,573	491	343	541	25,905	162,934
18	2033	838,158	100.00%	838,158	135,180	1,583	509	346	547	26,058	164,223
19	2034	844,171	100.00%	844,171	136,236	1,593	528	349	552	26,209	165,468
20	2035	849,998	100.00%	849,998	137,252	1,603	548	351	557	26,357	166,669

Source: JICA Study Team

Table 3.1.2-22: Result of Water Demand Analysis for the Area of Influence

Year		Total Population	Cover Ratio	Served Population	Total Connection	Water Demand					Storage Demand (m^3)
						m^3/day	l/sec	m^3/year	QMD (m^3/seg)	QMH (m^3/seg)	
Base	2009	614,830	64.83%	398,570	77,524	86,739	1,003.92	31,659,723	1.31	1.81	24,386
-5	2010	628,300	68.33%	429,322	83,345	90,192	1,043.89	32,920,135	1.36	1.88	25,250
-4	2011	641,033	71.84%	460,527	89,241	93,124	1,077.83	33,990,353	1.40	1.94	25,981
-3	2012	653,072	75.36%	492,129	95,220	95,799	1,108.79	34,966,726	1.44	2.00	26,647
-2	2013	664,471	78.87%	524,092	101,272	98,194	1,136.50	35,840,728	1.48	2.05	27,249
-1	2014	675,263	82.39%	556,368	107,391	103,473	1,197.60	37,767,555	1.56	2.16	28,568
0	2015	685,495	85.91%	588,932	113,570	94,831	1,097.58	34,613,244	1.43	1.98	26,408
1	2016	695,200	89.43%	621,749	119,805	92,313	1,068.44	33,694,284	1.39	1.92	25,780
2	2017	704,420	92.96%	654,802	126,089	90,659	1,049.29	33,090,379	1.36	1.89	25,361
3	2018	713,186	96.48%	688,068	132,419	94,908	1,098.48	34,641,518	1.43	1.98	26,426
4	2019	721,527	100.00%	721,527	138,790	99,125	1,147.28	36,180,698	1.49	2.07	27,480
5	2020	729,472	100.00%	729,472	140,434	100,384	1,161.85	36,640,219	1.51	2.09	27,795
6	2021	737,074	100.00%	737,074	142,010	101,668	1,176.72	37,108,926	1.53	2.12	28,117
7	2022	744,680	100.00%	744,680	143,587	102,821	1,190.06	37,529,807	1.55	2.14	28,404
8	2023	752,284	100.00%	752,284	145,164	104,095	1,204.81	37,994,800	1.57	2.17	28,723
9	2024	759,883	100.00%	759,883	146,742	105,337	1,219.18	38,447,972	1.58	2.19	29,033
10	2025	767,476	100.00%	767,476	148,318	106,609	1,233.89	38,912,111	1.60	2.22	29,355
11	2026	775,063	100.00%	775,063	149,893	107,907	1,248.92	39,386,043	1.62	2.25	29,675
12	2027	782,399	100.00%	782,399	151,412	109,104	1,262.78	39,823,091	1.64	2.27	29,976
13	2028	789,492	100.00%	789,492	152,878	110,238	1,275.90	40,236,751	1.66	2.30	30,263
14	2029	796,351	100.00%	796,351	154,291	111,428	1,289.68	40,671,257	1.68	2.32	30,558
15	2030	802,983	100.00%	802,983	155,654	112,634	1,303.63	41,111,232	1.69	2.35	30,857
16	2031	809,395	100.00%	809,395	156,969	113,793	1,317.04	41,534,271	1.71	2.37	31,151
17	2032	815,597	100.00%	815,597	158,238	114,919	1,330.08	41,945,456	1.73	2.39	31,428
18	2033	821,597	100.00%	821,597	159,462	115,992	1,342.50	42,337,127	1.75	2.42	31,694
19	2034	827,403	100.00%	827,403	160,645	117,076	1,355.04	42,732,565	1.76	2.44	31,970
20	2035	833,032	100.00%	833,032	161,788	118,107	1,366.98	43,109,044	1.78	2.46	32,225

Source: JICA Study Team



Source: JICA Study Team

Figure 3.1.2-6: Result of Water Demand Analysis for the Area of Influence

Table 3.1.2-23: Projection of Connection in the Study Area

Year		Population	Coverage	Served Population	Connections						
					Domestic	Comercial	Industrial	Public	Social	Multiple Family	Total
-	2007	585,477			0	0	0	0	0	0	0
-	2008	600,574			0	0	0	0	0	0	0
Base	2009	614,830	64.83%	398,570	61,747	1,206	184	251	328	13,808	77,524
-5	2010	628,300	68.33%	429,322	66,536	1,231	191	257	355	14,776	83,345
-4	2011	641,033	71.84%	460,527	71,410	1,254	198	262	365	15,752	89,241
-3	2012	653,072	75.36%	492,129	76,361	1,276	205	267	376	16,735	95,220
-2	2013	664,471	78.87%	524,092	81,383	1,296	213	272	386	17,722	101,272
-1	2014	675,263	82.39%	556,368	86,469	1,315	221	277	396	18,713	107,391
0	2015	685,495	85.91%	588,932	91,616	1,333	229	281	405	19,706	113,570
1	2016	695,200	89.43%	621,749	96,817	1,350	238	286	415	20,700	119,805
2	2017	704,420	92.96%	654,802	102,068	1,365	247	290	424	21,695	126,089
3	2018	713,186	96.48%	688,068	107,366	1,380	256	294	433	22,690	132,419
4	2019	721,527	100.00%	721,527	112,707	1,394	266	298	442	23,684	138,790
5	2020	729,472	100.00%	729,472	114,128	1,407	276	302	450	23,872	140,434
6	2021	737,074	100.00%	737,074	115,493	1,420	286	305	458	24,047	142,010
7	2022	744,680	100.00%	744,680	116,860	1,432	297	309	467	24,223	143,587
8	2023	752,284	100.00%	752,284	118,226	1,444	308	312	475	24,399	145,164
9	2024	759,883	100.00%	759,883	119,593	1,457	319	316	483	24,574	146,742
10	2025	767,476	100.00%	767,476	120,958	1,469	331	320	491	24,749	148,318
11	2026	775,063	100.00%	775,063	122,321	1,482	343	323	500	24,924	149,893
12	2027	782,399	100.00%	782,399	123,633	1,494	356	327	508	25,095	151,412
13	2028	789,492	100.00%	789,492	124,895	1,505	370	330	515	25,263	152,878
14	2029	796,351	100.00%	796,351	126,108	1,517	383	333	522	25,428	154,291
15	2030	802,983	100.00%	802,983	127,274	1,528	398	336	529	25,590	155,654
16	2031	809,395	100.00%	809,395	128,395	1,539	413	339	535	25,749	156,969
17	2032	815,597	100.00%	815,597	129,472	1,549	428	342	541	25,905	158,238
18	2033	821,597	100.00%	821,597	130,509	1,559	444	345	547	26,058	159,462
19	2034	827,403	100.00%	827,403	131,506	1,569	461	348	552	26,209	160,645
20	2035	833,032	100.00%	833,032	132,466	1,579	478	350	557	26,357	161,788

Source: JICA Study Team

Table 3.1.2-24 Sub-Sector, Sector and Total Demand
(m^3/day) 1/4

Year	Sectors															
	83A-1	83A-2	83B-1	83B-2	84A-1	84A-2	84B-1	84B-2	85A	85B-1	85B-2	85B-3	85C	212A-1	212A-2	212B-1
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	1,786.91	2,872.36	1,292.82	4,674.37	2,858.58	1,985.11	2,579.04	1,060.79	2,833.17	2,122.89	5,382.53	883.31	2,465.38	2,816.58	1,711.42	1,319.81
2010	1,824.36	2,967.75	1,351.58	4,803.07	2,943.91	2,032.97	2,640.00	1,096.70	2,872.71	2,095.78	5,423.13	877.17	2,482.47	2,870.46	1,743.22	1,348.79
2011	1,845.90	3,041.57	1,411.33	4,893.49	3,009.12	2,067.40	2,684.00	1,129.03	2,876.51	2,078.21	5,450.81	893.18	2,478.59	2,914.67	1,772.22	1,375.39
2012	1,869.04	3,130.35	1,467.41	4,989.84	3,070.92	2,101.92	2,727.44	1,160.36	2,911.57	2,049.01	5,432.02	875.56	2,492.07	2,945.66	1,793.52	1,393.60
2013	1,888.79	3,194.53	1,520.17	5,059.52	3,141.84	2,135.16	2,766.50	1,188.96	2,927.64	2,004.84	5,420.69	863.32	2,500.91	2,977.66	1,816.81	1,414.16
2014	1,933.24	3,322.10	1,586.11	5,230.33	3,227.34	2,189.61	2,847.27	1,233.36	3,004.83	2,039.75	5,604.64	889.66	2,566.19	3,049.52	1,857.34	1,451.65
2015	1,710.55	2,986.53	1,431.08	4,678.16	3,202.99	2,169.27	2,830.67	1,234.61	2,629.28	1,778.98	4,953.09	785.85	2,243.11	2,909.78	1,774.19	1,385.67
2016	1,691.41	2,995.60	1,440.13	4,665.50	3,228.92	2,182.60	2,859.33	1,254.30	2,502.58	1,677.47	4,758.43	766.03	2,144.25	2,882.18	1,751.58	1,370.10
2017	1,669.01	3,001.76	1,446.51	4,651.86	3,252.51	2,194.38	2,884.71	1,274.07	2,400.55	1,597.48	4,609.41	738.52	2,046.97	2,844.56	1,731.01	1,355.52
2018	1,700.93	3,101.59	1,498.55	4,793.51	3,324.17	2,239.69	2,952.62	1,312.18	2,451.80	1,612.05	4,789.27	758.28	2,092.09	2,897.83	1,763.98	1,381.17
2019	1,729.61	3,198.94	1,549.05	4,924.48	3,394.70	2,284.56	3,021.39	1,349.72	2,496.62	1,626.00	4,916.35	779.38	2,149.41	2,948.33	1,794.29	1,405.56
2020	1,737.13	3,214.70	1,556.74	4,946.95	3,410.39	2,295.21	3,035.83	1,356.34	2,506.43	1,647.34	5,081.27	789.21	2,158.39	2,961.96	1,804.60	1,414.55
2021	1,745.29	3,228.36	1,562.89	4,968.69	3,425.51	2,305.30	3,049.82	1,363.20	2,526.41	1,666.28	5,256.36	798.43	2,166.03	2,975.56	1,813.05	1,421.02
2022	1,752.80	3,243.90	1,572.45	4,989.63	3,441.33	2,315.38	3,063.19	1,369.26	2,534.88	1,676.84	5,367.89	807.54	2,173.66	2,987.22	1,820.82	1,426.82
2023	1,760.08	3,259.81	1,579.49	5,010.57	3,455.88	2,335.48	3,077.75	1,374.81	2,551.74	1,709.32	5,532.81	826.92	2,200.57	3,000.28	1,829.27	1,431.96
2024	1,767.59	3,273.23	1,586.29	5,032.95	3,471.52	2,345.57	3,091.12	1,381.67	2,560.83	1,726.92	5,697.73	844.53	2,208.21	3,013.88	1,838.32	1,438.36
2025	1,775.65	3,298.72	1,593.89	5,054.03	3,486.08	2,355.08	3,104.48	1,387.73	2,569.92	1,738.09	5,872.82	853.75	2,215.85	3,025.54	1,846.77	1,445.43
2026	1,784.62	3,312.95	1,601.58	5,077.31	3,501.20	2,365.17	3,118.98	1,393.90	2,578.39	1,766.58	6,091.13	863.58	2,234.26	3,039.79	1,854.48	1,452.57
2027	1,792.78	3,327.40	1,607.73	5,098.25	3,517.25	2,375.94	3,133.03	1,400.64	2,606.14	1,785.53	6,256.06	880.57	2,250.39	3,052.19	1,863.00	1,457.71
2028	1,799.40	3,340.83	1,614.53	5,119.18	3,532.37	2,386.53	3,146.40	1,407.27	2,615.23	1,796.70	6,420.98	890.40	2,258.03	3,065.79	1,872.64	1,463.51
2029	1,807.57	3,355.94	1,621.57	5,141.57	3,546.93	2,396.61	3,159.20	1,412.82	2,623.70	1,815.03	6,649.46	907.40	2,266.28	3,078.05	1,880.50	1,469.25
2030	1,814.19	3,369.50	1,628.37	5,161.86	3,562.05	2,406.70	3,173.08	1,418.88	2,640.56	1,843.40	6,867.78	927.39	2,295.24	3,093.04	1,888.21	1,476.98
2031	1,833.53	3,383.17	1,634.52	5,194.62	3,586.13	2,416.78	3,196.58	1,425.05	2,660.79	1,861.73	7,086.09	944.38	2,303.49	3,104.70	1,902.58	1,483.45
2032	1,841.60	3,398.04	1,642.20	5,217.80	3,600.68	2,426.86	3,210.63	1,431.79	2,679.43	1,880.68	7,304.41	961.99	2,311.13	3,116.36	1,912.22	1,489.25
2033	1,849.11	3,412.50	1,648.35	5,238.09	3,616.50	2,436.89	3,224.50	1,437.85	2,696.29	1,909.17	7,522.73	971.21	2,327.26	3,130.70	1,921.33	1,494.99
2034	1,858.72	3,425.27	1,655.15	5,258.14	3,631.56	2,446.97	3,237.93	1,444.02	2,705.38	1,928.11	7,751.21	988.81	2,345.68	3,143.02	1,929.18	1,501.53
2035	1,865.35	3,439.50	1,661.30	5,280.53	3,646.69	2,457.74	3,251.29	1,450.08	2,713.85	1,945.71	8,021.58	1,005.80	2,353.31	3,156.61	1,936.90	1,508.60

Source: JICA Study Team

Table 3.1.2-24 Sub-Sector, Sector and Total Demand (m^3/day) 2/4

Year	Sectors															
	212B-2	213-1	213-2	213-3	251	252	253	254	255	256	257	258	259	260	261	262
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	1,099.65	3,286.95	67.78	133.07	1.20	1.68	20.40	2.63	0.60	6.28	0.84	19,381.59	2,638.57	8,403.60	9,587.00	0.56
2010	1,133.22	3,390.95	69.31	135.56	193.44	179.81	152.43	278.68	23.40	20.75	34.38	20,158.93	2,749.84	7,664.15	9,646.18	7.82
2011	1,162.43	3,478.54	69.50	138.05	380.93	335.91	280.85	548.47	47.40	34.44	63.43	20,635.03	2,820.25	7,678.11	11,630.58	15.63
2012	1,191.11	3,554.01	70.07	139.20	561.73	469.02	404.64	810.46	72.00	48.91	87.78	21,095.84	2,893.95	7,694.30	11,704.84	25.13
2013	1,214.05	3,622.13	70.26	140.35	735.00	575.40	523.82	1,058.91	97.80	61.44	106.80	21,571.08	2,948.86	9,592.32	11,786.92	34.62
2014	1,251.52	3,754.78	71.22	142.27	929.40	727.80	657.72	1,339.33	123.00	76.16	135.00	22,362.97	3,104.38	9,611.30	13,794.21	45.78
2015	1,201.08	3,233.78	60.15	119.36	1,126.80	882.00	768.74	1,623.34	149.40	87.95	163.20	23,154.25	2,717.38	9,632.52	13,891.36	57.51
2016	1,194.71	2,861.63	51.56	103.68	1,326.60	1,038.60	887.20	1,910.94	175.80	100.57	191.40	23,945.53	2,444.39	9,654.85	13,995.77	70.35
2017	1,184.99	2,579.53	45.71	91.32	1,528.20	1,196.40	1,003.92	2,200.33	202.20	113.40	220.80	24,775.30	2,239.64	9,806.78	16,024.83	83.75
2018	1,212.75	2,666.97	45.71	91.92	1,730.40	1,354.80	1,134.42	2,492.12	229.20	127.80	250.20	25,566.58	2,342.24	11,713.18	16,143.76	98.27
2019	1,238.46	2,739.46	46.31	92.52	1,934.40	1,513.80	1,266.20	2,785.69	256.20	142.20	280.20	26,358.46	2,464.96	11,739.98	16,269.94	113.34
2020	1,244.86	2,752.99	46.31	93.12	1,944.00	1,521.60	1,272.45	2,798.85	257.40	143.40	282.60	27,146.15	2,483.56	11,747.79	18,223.08	117.81
2021	1,252.67	2,765.23	46.91	93.12	1,952.40	1,528.20	1,278.02	2,812.00	258.60	144.60	284.40	28,720.31	2,502.76	11,755.05	18,258.25	122.28
2022	1,257.81	2,776.97	46.91	93.72	1,960.80	1,534.80	1,282.98	2,823.96	259.20	145.80	286.80	29,508.00	2,521.36	11,762.31	18,291.75	126.18
2023	1,263.69	2,788.59	46.91	94.32	1,969.20	1,541.40	1,289.23	2,836.52	260.40	146.40	289.20	30,295.08	2,540.56	13,649.72	20,240.98	130.09
2024	1,268.83	2,800.21	47.51	94.32	1,977.60	1,548.00	1,294.80	2,848.48	261.60	147.60	291.60	31,869.85	2,560.12	13,656.42	20,271.13	133.44
2025	1,274.12	2,811.95	47.51	94.92	1,986.60	1,554.60	1,299.77	2,860.43	262.80	148.80	294.00	32,657.53	2,579.80	13,662.00	20,299.60	137.35
2026	1,279.26	2,823.57	47.51	94.92	1,995.00	1,561.20	1,306.02	2,872.39	264.00	149.40	296.40	34,231.70	2,598.40	13,668.14	20,326.40	140.14
2027	1,287.07	2,834.59	48.11	95.52	2,003.40	1,567.80	1,311.58	2,884.35	265.20	151.20	298.20	35,806.46	2,618.20	15,554.43	22,269.48	143.49
2028	1,292.21	2,846.93	48.11	96.12	2,011.80	1,574.40	1,316.55	2,896.91	266.40	151.80	300.60	36,593.55	2,637.40	15,559.46	22,293.49	146.28
2029	1,297.43	2,861.00	48.11	96.12	2,020.20	1,581.00	1,322.80	2,908.87	267.60	153.00	303.00	38,168.31	2,657.20	15,564.48	22,316.94	149.08
2030	1,302.58	2,872.03	48.71	96.72	2,028.60	1,587.60	1,327.77	2,920.83	268.20	154.20	305.40	39,743.08	2,676.40	17,449.66	22,339.28	151.87
2031	1,308.45	2,883.77	48.71	97.32	2,037.00	1,594.20	1,333.33	2,933.98	269.40	154.80	307.80	41,355.13	2,696.67	17,454.13	22,359.93	154.66
2032	1,313.60	2,894.79	48.71	97.32	2,045.40	1,600.80	1,338.90	2,945.93	270.60	156.60	310.20	42,929.89	2,716.47	17,458.59	24,297.43	156.89
2033	1,319.48	2,907.72	49.31	97.92	2,053.80	1,607.40	1,344.55	2,957.89	271.80	157.20	312.60	44,504.06	2,736.87	19,343.21	24,316.42	159.13
2034	1,327.29	2,919.37	49.31	98.52	2,062.20	1,614.00	1,350.12	2,970.45	273.00	158.40	315.00	46,078.83	2,756.67	19,347.12	24,334.28	161.36
2035	1,332.43	2,930.39	49.31	98.52	2,070.60	1,620.60	1,355.08	2,982.41	274.20	159.60	317.40	47,653.59	2,776.47	19,350.47	24,351.03	163.59

Source: JICA Study Team

Table 3.1.2-24 Sub-Sector, Sector and Total Demand (m^3/day) 3/4

Year	Sectors															
	263	264	265	266	345	346-1	346-2	347-1	347-2	348A	348B-1	348B-2	349A-1	349A-2	349A-3	349B-1
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	0.56	0.56	0.56	0.56	607.75	891.03	1,717.10	2,071.73	1,708.93	1,343.21	2,961.50	203.57	2,520.64	515.99	1,300.66	1,164.33
2010	6.70	8.38	5.03	7.82	793.09	882.84	1,695.34	2,071.99	1,756.40	1,364.69	2,916.37	211.79	2,527.26	542.22	1,312.20	1,170.01
2011	13.40	16.75	10.05	16.19	932.95	871.35	1,669.44	2,060.47	1,799.53	1,352.29	2,831.74	219.53	2,509.62	563.48	1,311.09	1,159.65
2012	21.22	26.24	15.63	25.13	1,073.73	854.72	1,636.52	2,044.49	1,836.84	1,327.59	2,729.46	226.85	2,467.68	575.71	1,289.74	1,148.27
2013	29.59	36.85	21.78	35.18	1,217.71	841.33	1,606.56	2,021.73	1,870.47	1,288.87	2,601.53	233.75	2,407.18	577.82	1,259.09	1,122.55
2014	39.08	48.58	28.48	45.78	1,379.69	849.04	1,628.09	2,087.41	1,951.44	1,377.02	2,721.82	246.39	2,543.40	630.93	1,341.88	1,184.19
2015	48.58	61.42	35.73	57.51	1,287.48	741.55	1,412.21	1,843.78	1,742.71	1,209.51	2,368.57	214.98	2,233.87	569.17	1,187.22	1,038.94
2016	59.74	74.82	43.55	70.35	1,222.40	698.48	1,333.77	1,779.46	1,693.54	1,089.86	2,116.88	192.54	2,013.51	525.80	1,078.85	935.29
2017	70.91	89.33	51.93	84.31	1,175.68	659.88	1,265.00	1,715.99	1,649.07	1,002.52	1,928.77	176.38	1,848.25	493.90	996.38	858.10
2018	83.19	104.41	60.86	98.83	1,282.41	664.38	1,279.07	1,764.35	1,715.83	1,049.68	2,004.71	183.62	1,940.55	527.74	1,055.84	897.27
2019	96.03	120.60	69.79	113.90	1,390.65	668.23	1,291.82	1,812.65	1,778.11	1,098.04	2,081.21	191.52	2,028.25	561.57	1,108.87	937.64
2020	99.94	125.63	72.58	118.37	1,399.62	672.08	1,300.17	1,823.95	1,789.52	1,104.42	2,095.18	192.83	2,046.15	564.78	1,115.84	943.33
2021	103.29	130.09	75.38	122.83	1,407.87	675.92	1,308.55	1,836.17	1,800.80	1,110.13	2,107.93	194.15	2,058.73	568.63	1,122.72	949.01
2022	106.64	134.56	78.17	126.74	1,416.15	679.77	1,316.87	1,846.84	1,812.48	1,116.51	2,120.68	195.47	2,070.74	571.84	1,129.69	954.06
2023	109.99	138.47	80.40	130.65	1,436.15	682.95	1,325.11	1,858.70	1,823.22	1,122.88	2,134.03	196.13	2,083.31	575.60	1,136.02	964.99
2024	113.34	142.38	82.63	134.00	1,444.43	686.80	1,340.38	1,868.77	1,833.99	1,129.26	2,148.62	197.44	2,095.33	578.81	1,143.55	970.68
2025	116.13	146.28	84.87	137.91	1,452.68	692.00	1,348.07	1,880.08	1,845.64	1,134.98	2,161.37	198.76	2,107.35	582.02	1,149.88	975.72
2026	118.93	149.63	86.54	141.26	1,460.96	696.47	1,357.74	1,892.20	1,856.41	1,141.35	2,174.12	200.08	2,119.28	585.23	1,156.85	981.41
2027	121.72	152.98	88.78	144.05	1,469.21	699.66	1,364.77	1,903.51	1,869.24	1,147.73	2,186.31	201.39	2,131.29	588.43	1,163.73	987.10
2028	123.95	156.33	90.45	147.40	1,478.30	703.50	1,372.46	1,914.18	1,879.38	1,162.70	2,199.06	202.71	2,143.86	592.20	1,170.06	992.14
2029	126.74	159.13	92.13	150.19	1,486.55	707.35	1,380.71	1,926.04	1,891.66	1,169.07	2,211.81	203.37	2,155.88	596.05	1,177.03	998.38
2030	128.98	161.92	93.80	152.98	1,508.08	717.55	1,388.40	1,936.66	1,901.79	1,176.05	2,233.82	204.68	2,167.90	604.50	1,183.91	1,009.31
2031	131.21	164.71	95.48	155.22	1,515.64	721.40	1,396.86	1,948.24	1,912.56	1,181.76	2,246.57	206.00	2,185.71	607.70	1,190.24	1,014.36
2032	132.88	167.50	97.15	157.45	1,524.61	726.05	1,405.10	1,959.55	1,924.21	1,188.14	2,258.66	207.32	2,197.08	610.91	1,197.21	1,020.05
2033	135.12	169.73	98.27	160.24	1,532.17	729.89	1,412.80	1,975.61	1,934.89	1,193.85	2,271.41	208.63	2,209.10	614.68	1,204.10	1,025.09
2034	136.79	171.97	99.94	162.48	1,540.45	733.08	1,420.63	1,987.74	1,947.18	1,200.23	2,284.16	209.29	2,221.67	617.88	1,210.43	1,030.78
2035	138.47	174.20	101.06	164.15	1,548.70	736.93	1,429.50	1,998.44	1,958.22	1,206.60	2,296.91	210.61	2,233.69	621.09	1,217.40	1,035.83

Source: JICA Study Team

Table 3.1.2-24 Sub-Sector, Sector and Total Demand (m^3/day) 4/4

Year	Sectors															TOTAL
	349B-2	349B-3	349B-4	350-1	350-2	351-1	351-2	351-3	361	368A-1	368A-2	368B	369A	369B	370	
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	1,140.29	1,058.25	2.46	5,592.33	5,038.34	637.36	376.68	79.24	880.80	1,464.81	239.80	2,361.12	1,994.65	2,382.54	579.76	124,114.55
2010	1,191.72	1,064.07	71.98	5,679.44	5,190.25	702.63	424.11	85.07	1,050.82	1,607.92	265.88	2,563.11	2,103.79	2,548.64	686.09	127,720.56
2011	1,232.91	1,056.28	136.43	5,719.00	5,311.77	768.73	475.07	92.35	1,233.04	1,758.89	293.22	2,772.52	2,226.73	2,741.58	790.36	133,187.40
2012	1,257.89	1,045.35	197.23	5,756.90	5,440.69	837.06	526.65	98.17	1,425.18	1,913.07	322.50	2,990.55	2,331.95	2,923.52	879.78	136,479.58
2013	1,265.94	1,026.59	251.53	5,776.99	5,550.47	906.23	581.36	105.04	1,626.28	2,072.12	351.93	3,217.95	2,449.11	3,122.32	962.79	141,399.90
2014	1,365.85	1,078.67	317.24	5,973.09	5,799.87	987.25	639.60	112.32	1,848.59	2,261.42	383.92	3,450.73	2,618.58	3,340.67	1,131.12	149,571.93
2015	1,223.92	943.15	319.98	5,139.13	5,033.01	892.17	582.40	99.67	1,836.71	2,103.23	357.19	3,164.14	2,391.90	3,065.83	1,140.82	141,919.08
2016	1,122.54	852.97	321.93	4,544.13	4,544.05	825.11	543.03	91.37	2,116.17	2,120.97	360.88	3,150.93	2,381.18	3,046.28	1,329.51	140,403.87
2017	1,053.03	779.54	324.68	4,095.88	4,137.66	776.70	515.45	84.50	2,421.11	2,141.68	364.73	3,143.95	2,367.84	3,041.94	1,536.91	141,847.91
2018	1,118.60	812.73	367.68	4,208.82	4,289.84	832.80	556.40	89.70	2,670.07	2,299.73	392.31	3,337.44	2,512.73	3,222.50	1,712.46	149,006.53
2019	1,184.17	845.93	411.31	4,327.18	4,443.42	889.55	598.65	94.25	2,929.94	2,461.98	420.51	3,537.93	2,653.02	3,414.08	1,892.17	154,263.45
2020	1,191.78	856.85	413.88	4,404.03	4,512.30	913.38	614.25	96.85	3,019.71	2,537.30	433.11	3,647.11	2,732.39	3,517.26	1,945.35	158,292.90
2021	1,198.75	861.99	416.44	4,519.93	4,572.17	935.33	629.85	99.45	3,108.28	2,612.01	446.30	3,753.90	2,819.26	3,617.51	2,004.01	161,214.37
2022	1,205.81	867.03	419.01	4,591.97	4,638.09	958.50	644.80	102.05	3,196.85	2,686.14	458.90	3,861.06	2,896.88	3,725.74	2,061.96	163,214.94
2023	1,212.78	872.17	421.58	4,657.79	4,696.57	981.10	660.40	104.65	3,286.19	2,761.08	471.50	3,968.44	2,974.45	3,825.39	2,119.43	169,131.11
2024	1,219.75	876.66	424.14	4,729.83	4,760.91	1,004.28	676.00	106.60	3,375.36	2,835.79	484.10	4,075.23	3,060.70	3,933.67	2,178.10	172,001.69
2025	1,226.81	882.35	426.71	4,803.09	4,860.44	1,027.45	691.60	109.20	3,464.21	2,913.02	496.70	4,182.33	3,138.32	4,033.92	2,247.55	174,113.00
2026	1,233.78	886.84	429.28	4,874.35	4,927.60	1,049.79	707.20	111.80	3,553.50	2,987.73	509.89	4,289.12	3,223.96	4,135.30	2,304.23	177,033.70
2027	1,240.20	891.97	431.84	4,935.99	4,982.34	1,072.31	721.50	113.75	3,637.27	3,057.66	521.89	4,392.41	3,296.83	4,235.90	2,355.54	183,650.96
2028	1,247.81	897.02	434.41	5,004.88	5,034.89	1,093.61	735.80	116.35	3,715.08	3,123.61	533.29	4,487.58	3,364.94	4,326.41	2,408.85	185,614.99
2029	1,254.78	902.15	436.98	5,068.95	5,094.71	1,115.38	750.10	118.30	3,790.02	3,185.73	543.49	4,576.36	3,436.87	4,409.94	2,459.87	188,422.70
2030	1,266.44	906.64	439.54	5,124.82	5,144.30	1,134.73	763.10	120.90	3,858.83	3,243.07	553.69	4,659.75	3,497.74	4,495.03	2,504.25	193,123.27
2031	1,274.05	911.69	442.11	5,187.16	5,194.98	1,154.01	775.45	122.85	3,922.90	3,297.62	562.69	4,736.55	3,554.45	4,567.83	2,547.53	195,932.37
2032	1,281.02	916.82	444.68	5,238.65	5,292.12	1,172.06	787.80	124.80	3,984.19	3,348.36	571.68	4,809.74	3,607.01	4,635.84	2,591.63	200,587.45
2033	1,287.44	921.31	447.24	5,296.18	5,337.19	1,188.81	799.50	126.10	4,041.17	3,395.72	580.08	4,877.53	3,663.99	4,707.11	2,628.36	205,150.10
2034	1,294.41	927.00	449.81	5,397.40	5,382.10	1,204.98	810.55	128.05	4,093.83	3,439.27	587.28	4,940.83	3,711.69	4,767.31	2,665.51	207,841.28
2035	1,301.38	931.49	452.38	5,443.11	5,432.26	1,221.08	821.60	130.00	4,141.74	3,480.03	594.48	4,999.63	3,754.10	4,822.24	2,699.89	210,477.73

Source: JICA Study Team

Table 3.1.2-25: Demand Forecast of Secondary Networkper Sectors

Sector	Demand (Km)
83 A	34.12
83 B	49.28
84 A	60.90
84 B	45.78
85 A	18.89
85 B	26.81
85 C	18.64
212 A	53.39
212 B	29.11
213	41.09
259	16.06
345	13.58
346	17.49
347	53.09
348 A	8.10
348 B	22.04
349 A	31.47
349 B	28.33
350	78.17
351	7.07
368 A	29.13
369 A	26.77
Total	**709.31**

Source: JICA Study Team

Table 3.1.2-26: Storage Demand Forecast by Sector and by Reservoirs (m3)

RESERVOIR		Villa Sol R-1	Villa del Norte	Parque del Naranja	Cueto Fernandini	Olivos de Pro	Programa Confraternidad 2	Programa Confraternidad 1	Comite Aposte	Puerta de Pro R-1	Rio Santa R-1	Pro	Santa Luisa	Pro	Virgin de las Nieves	Virgin del Rosario	Rosario del Norte	Jazmines de Naranja	Vipol Naranjal	Cerro eo Choclo R-2	Cerro eo Choclo R-1
SUB SECTOR		83A-1	83A-2	83B-1	83B-2	84A-1	84A-2	84B-1	84B-2	85A	85B-1	85B-2	85B-3	85C	212A-1	212A-2	212B-1	212B-2	213-1	213-2	213-3
SECTOR		83A		83B		84A		84B		85A	85B			85C	212A		212B		213		
YEAR																					
	2009	547	818	423	1,269	815	596	745	365	808	631	1,396	321	666	804	528	430	375	922	67	83
-5	2010	556	842	438	1,301	836	608	760	374	818	624	1,406	319	671	868	536	487	383	948	67	84
-4	2011	561	860	453	1,323	852	617	771	382	819	620	1,413	323	670	879	543	494	391	970	67	85
-3	2012	567	883	467	1,347	868	625	782	390	828	612	1,408	319	673	886	548	498	398	989	68	85
-2	2013	572	899	480	1,365	885	634	792	397	832	601	1,405	316	675	894	554	504	404	1,006	68	85
-1	2014	583	931	497	1,408	907	647	812	408	851	610	1,451	322	692	912	564	513	413	1,039	68	86
0	2015	528	847	458	1,270	901	642	808	409	757	545	1,288	296	611	877	544	496	400	908	65	80
1	2016	523	849	460	1,266	907	646	815	414	726	519	1,240	292	586	871	538	493	399	815	63	76
2	2017	517	850	462	1,263	913	649	821	419	700	499	1,202	285	562	861	533	489	396	745	61	73
3	2018	525	875	475	1,298	931	660	838	428	713	503	1,247	290	573	874	541	495	403	767	61	73
4	2019	532	900	487	1,331	949	671	855	437	724	507	1,279	295	587	887	549	501	410	785	62	73
5	2020	534	904	489	1,337	953	674	859	439	727	512	1,320	297	590	890	551	504	411	788	62	73
6	2021	536	907	491	1,342	956	676	862	441	732	517	1,364	300	592	894	553	505	413	791	62	73
7	2022	538	911	493	1,347	960	679	866	442	734	519	1,392	302	593	897	555	507	414	794	62	73
8	2023	540	915	495	1,353	964	684	869	444	738	527	1,433	307	600	900	557	508	416	797	62	74
9	2024	542	918	497	1,358	968	686	873	445	740	532	1,474	311	602	903	560	510	417	800	62	74
10	2025	544	925	498	1,364	972	689	876	447	742	535	1,518	313	604	906	562	511	419	803	62	74
11	2026	546	928	500	1,369	975	691	880	448	745	542	1,573	316	609	910	564	513	420	806	62	74
12	2027	548	932	502	1,375	979	694	883	450	752	546	1,614	320	613	913	566	514	422	809	62	74
13	2028	550	935	504	1,380	983	697	887	452	754	549	1,655	323	615	916	568	516	423	812	62	74
14	2029	552	939	505	1,385	987	699	890	453	756	554	1,712	327	617	920	570	517	424	815	62	74
15	2030	554	942	507	1,390	991	702	893	455	760	561	1,767	332	624	923	572	519	426	818	62	74
16	2031	558	946	509	1,399	997	704	899	456	765	565	1,822	336	626	926	576	521	427	821	62	74
17	2032	560	950	511	1,404	1,000	707	903	458	770	570	1,876	340	628	929	578	522	428	824	62	74
18	2033	562	953	512	1,410	1,004	709	906	459	774	577	1,931	343	632	933	580	524	430	827	62	74
19	2034	565	956	514	1,415	1,008	712	909	461	776	582	1,988	347	636	936	582	525	432	830	62	75
20	2035	566	960	515	1,420	1,012	714	913	463	778	586	2,055	351	638	939	584	527	433	833	62	75

RESERVOIR		Márquez	Almeda del Pinar R-1	El Pinar R-2	San Felipe	LA Alborada R-2	Collique R-1	Collique R-2	RE-01	Collique R-3	Nueva Esperanza	Collique R-4	Collique R-5	Collique R-6	Collique R-7	Santa Isabel R-1	Santa Isabel R-2	Los Angeles R-1	Los Angeles R-2, R-3	Los Angeles R-4	RPA-6	RPA-1	RPA-7 La Ensenada
SUB SECTOR		259	345	346	347-1	347-2	348A	348B-1	348B-2	349A-1	349A-2	349A-3	349B-1	349B-2	349B-3	350-1	350-2	351-1	351-2	351-3	368A1	368A-2	369A
SECTOR		259	345	346	347		348A	348B		349A			349B			350		351			368A		369A
YEAR																							
	2009	760	252	752	618	527	436	840	101	730	229	425	391	385	365	1,498	1,360	259	144	70	516	110	599
-5	2010	787	298	745	618	539	441	829	103	732	236	428	393	398	366	1,520	1,398	276	156	71	552	116	626
-4	2011	805	333	735	615	550	438	808	105	727	241	428	390	408	364	1,530	1,428	292	169	73	590	123	657
-3	2012	823	368	723	611	559	432	782	107	717	244	422	387	414	361	1,539	1,460	309	182	75	628	131	683
-2	2013	837	404	712	605	568	422	750	108	702	244	415	381	416	357	1,544	1,488	327	195	76	668	138	712
-1	2014	876	445	719	622	588	444	780	112	736	258	435	396	441	370	1,593	1,550	347	210	78	715	146	755
0	2015	779	422	638	561	536	402	692	104	658	242	397	360	406	336	1,385	1,358	323	196	75	676	139	698
1	2016	711	406	608	545	523	372	629	98	603	231	370	334	381	313	1,236	1,236	306	186	73	680	140	695
2	2017	660	394	581	529	512	351	582	94	562	223	349	315	363	295	1,124	1,134	294	179	71	685	141	692
3	2018	686	421	586	541	529	362	601	96	585	232	364	324	380	303	1,152	1,172	308	189	72	725	148	728
4	2019	716	448	590	553	545	375	620	98	607	240	377	334	396	311	1,182	1,211	322	200	74	765	155	763
5	2020	721	450	593	556	547	376	624	98	612	241	379	336	398	314	1,201	1,228	328	204	74	784	158	783
6	2021	726	452	596	559	550	378	627	99	615	242	381	337	400	315	1,230	1,243	334	207	75	803	162	805
7	2022	730	454	599	562	553	379	630	99	618	243	382	339	401	317	1,248	1,260	340	211	76	822	165	824
8	2023	735	459	602	565	556	381	634	99	621	244	384	341	403	318	1,264	1,274	345	215	76	840	168	844
9	2024	740	461	607	567	558	382	637	99	624	245	386	343	405	319	1,282	1,290	351	219	77	859	171	865
10	2025	745	463	610	570	561	384	640	100	627	246	387	344	407	321	1,301	1,315	357	223	77	878	174	885
11	2026	750	465	614	573	564	385	644	100	630	246	389	345	408	322	1,319	1,332	362	227	78	897	177	906
12	2027	755	467	616	576	567	387	647	100	633	247	391	347	410	323	1,334	1,346	368	230	78	914	180	924
13	2028	759	470	619	579	570	391	650	101	636	248	393	348	412	324	1,351	1,359	373	234	79	931	183	941
14	2029	764	472	622	582	573	392	653	101	639	249	394	350	414	326	1,367	1,374	379	238	80	946	186	959
15	2030	769	477	626	584	575	394	658	101	642	251	396	352	417	327	1,381	1,386	384	241	80	961	188	974
16	2031	774	479	630	587	578	395	662	102	646	252	398	354	419	328	1,397	1,399	389	244	81	974	191	989
17	2032	779	481	633	590	581	397	665	102	649	253	399	355	420	329	1,410	1,423	393	247	81	987	193	1,002
18	2033	784	483	636	594	584	398	668	102	652	254	401	356	422	330	1,424	1,434	397	250	82	999	195	1,016
19	2034	789	485	638	597	587	400	671	102	655	254	403	358	424	332	1,449	1,446	401	253	82	1,010	197	1,028
20	2035	794	487	642	600	590	402	674	103	658	255	404	359	425	333	1,461	1,458	405	255	83	1,020	199	1,039

Source: JICA Study Team

Table 3.1.2-27: Transmission Lines Demand Forecast by Sector and by Sub-Sectors (QMD) (l/s)

RESERVOIR		Villa Sol R-1	Villa del Norte	Parque del Naranja	Cueto Fernandini	Olivos de Pro	Programa Confraternidad 2	Programa Confraternidad 1	Comite Aposte	Puerta de Pro R-1	Rio Santa R-1	Pro	Santa Luisa	Pro	Virgin de las Nieves	Virgin del Rosario	Rosario del Norte	Jazmines de Naranja	Vipol Naranjal	Cerro eo Choclo R-2	Cerro eo Choclo R-1
SUB SECTOR		83A-1	83A-2	83B-1	83B-2	84A-1	84A-2	84B-1	84B-2	85A	85B-1	85B-2	85B-3	85C	212A-1	212A-2	212B-1	212B-2	213-1	213-2	213-3
SECTOR		83A		83B		84A		84B		85A	85B			85C	212A		212B		213		
YEAR																					
	2009	26.89	43.22	19.45	70.33	43.01	29.87	38.80	15.96	42.63	31.94	80.99	13.29	37.09	42.38	25.75	19.86	16.55	49.46	1.02	2.00
-5	2010	27.45	44.65	20.34	72.27	44.29	30.59	39.72	16.50	43.22	31.53	81.60	13.20	37.35	43.19	26.23	20.29	17.05	51.02	1.04	2.04
-4	2011	27.77	45.76	21.24	73.63	45.28	31.11	40.38	16.99	43.28	31.27	82.01	13.44	37.29	43.86	26.67	20.69	17.49	52.34	1.05	2.08
-3	2012	28.12	47.10	22.08	75.08	46.21	31.63	41.04	17.46	43.81	30.83	81.73	13.17	37.50	44.32	26.99	20.97	17.92	53.47	1.05	2.09
-2	2013	28.42	48.07	22.87	76.13	47.27	32.13	41.63	17.89	44.05	30.17	81.56	12.99	37.63	44.80	27.34	21.28	18.27	54.50	1.06	2.11
-1	2014	29.09	49.99	23.87	78.70	48.56	32.95	42.84	18.56	45.21	30.69	84.33	13.39	38.61	45.88	27.95	21.84	18.83	56.50	1.07	2.14
0	2015	25.74	44.94	21.53	70.39	48.19	32.64	42.59	18.58	39.56	26.77	74.53	11.82	33.75	43.78	26.69	20.85	18.07	48.66	0.91	1.80
1	2016	25.45	45.07	21.67	70.20	48.58	32.84	43.02	18.87	37.65	25.24	71.60	11.53	32.26	43.37	26.35	20.61	17.98	43.06	0.78	1.56
2	2017	25.11	45.17	21.76	69.99	48.94	33.02	43.40	19.17	36.12	24.04	69.35	11.11	30.80	42.80	26.05	20.40	17.83	38.81	0.69	1.37
3	2018	25.59	46.67	22.55	72.12	50.02	33.70	44.43	19.74	36.89	24.26	72.06	11.41	31.48	43.60	26.54	20.78	18.25	40.13	0.69	1.38
4	2019	26.02	48.13	23.31	74.10	51.08	34.37	45.46	20.31	37.56	24.47	73.97	11.73	32.34	44.36	27.00	21.15	18.63	41.22	0.70	1.39
5	2020	26.14	48.37	23.42	74.43	51.31	34.53	45.68	20.41	37.71	24.79	76.45	11.87	32.48	44.57	27.15	21.28	18.73	41.42	0.70	1.40
6	2021	26.26	48.57	23.52	74.76	51.54	34.69	45.89	20.51	38.01	25.07	79.09	12.01	32.59	44.77	27.28	21.38	18.85	41.61	0.71	1.40
7	2022	26.37	48.81	23.66	75.08	51.78	34.84	46.09	20.60	38.14	25.23	80.77	12.15	32.71	44.95	27.40	21.47	18.93	41.78	0.71	1.41
8	2023	26.48	49.05	23.77	75.39	52.00	35.14	46.31	20.69	38.39	25.72	83.25	12.44	33.11	45.14	27.52	21.55	19.01	41.96	0.71	1.42
9	2024	26.60	49.25	23.87	75.73	52.23	35.29	46.51	20.79	38.53	25.98	85.73	12.71	33.23	45.35	27.66	21.64	19.09	42.13	0.71	1.42
10	2025	26.72	49.63	23.98	76.04	52.45	35.44	46.71	20.88	38.67	26.15	88.36	12.85	33.34	45.52	27.79	21.75	19.17	42.31	0.71	1.43
11	2026	26.85	49.85	24.10	76.39	52.68	35.59	46.93	20.97	38.80	26.58	91.65	12.99	33.62	45.74	27.90	21.86	19.25	42.48	0.71	1.43
12	2027	26.97	50.07	24.19	76.71	52.92	35.75	47.14	21.07	39.21	26.87	94.13	13.25	33.86	45.92	28.03	21.93	19.37	42.65	0.72	1.44
13	2028	27.07	50.27	24.29	77.02	53.15	35.91	47.34	21.17	39.35	27.03	96.61	13.40	33.97	46.13	28.18	22.02	19.44	42.84	0.72	1.45
14	2029	27.20	50.49	24.40	77.36	53.37	36.06	47.53	21.26	39.48	27.31	100.05	13.65	34.10	46.31	28.29	22.11	19.52	43.05	0.72	1.45
15	2030	27.30	50.70	24.50	77.67	53.60	36.21	47.74	21.35	39.73	27.74	103.33	13.95	34.53	46.54	28.41	22.22	19.60	43.21	0.73	1.46
16	2031	27.59	50.90	24.59	78.16	53.96	36.36	48.10	21.44	40.04	28.01	106.62	14.21	34.66	46.71	28.63	22.32	19.69	43.39	0.73	1.46
17	2032	27.71	51.13	24.71	78.51	54.18	36.52	48.31	21.54	40.32	28.30	109.90	14.47	34.77	46.89	28.77	22.41	19.76	43.56	0.73	1.46
18	2033	27.82	51.35	24.80	78.81	54.41	36.67	48.52	21.63	40.57	28.73	113.19	14.61	35.02	47.11	28.91	22.49	19.85	43.75	0.74	1.47
19	2034	27.97	51.54	24.90	79.12	54.64	36.82	48.72	21.73	40.71	29.01	116.63	14.88	35.29	47.29	29.03	22.59	19.97	43.93	0.74	1.48
20	2035	28.07	51.75	25.00	79.45	54.87	36.98	48.92	21.82	40.83	29.28	120.70	15.13	35.41	47.50	29.14	22.70	20.05	44.09	0.74	1.48

RESERVOIR		Márquez	Almeda del Pinar R-1	El Pinar R-2	San Felipe	LA Alborada R-2	Collique R-1	Collique R-2	RE-01	Collique R-3	Nueva Esperanza	Collique R-4	Collique R-5	Collique R-6	Collique R-7	Santa Isabel R-1	Santa Isabel R-2	Los Angeles R-1	Los Angeles R-2, R-3	Los Angeles R-4	RPA-6	RPA-1	RPA-7 La Ensenada
SUB SECTOR		259	345	346	347-1	347-2	348A	348B-1	348B-2	349A-1	349A-2	349A-3	349B-1	349B-2	349B-3	350-1	350-2	351-1	351-2	351-3	368A1	368A-2	369A
SECTOR		259	345	346	347		348A	348B		349A			349B			350		351			368A		369A
YEAR																							
	2009	39.70	9.14	39.25	31.17	25.71	20.21	44.56	3.06	37.93	7.76	19.57	17.52	17.16	15.92	84.14	75.81	9.59	5.67	1.19	22.04	3.61	30.01
-5	2010	41.37	11.93	38.79	31.18	26.43	20.53	43.88	3.19	38.03	8.16	19.74	17.60	17.93	16.01	85.45	78.09	10.57	6.38	1.28	24.19	4.00	31.65
-4	2011	42.43	14.04	38.23	31.00	27.08	20.35	42.61	3.30	37.76	8.48	19.73	17.45	18.55	15.89	86.05	79.92	11.57	7.15	1.39	26.46	4.41	33.50
-3	2012	43.54	16.16	37.48	30.76	27.64	19.98	41.07	3.41	37.13	8.66	19.41	17.28	18.93	15.73	86.62	81.86	12.59	7.92	1.48	28.78	4.85	35.09
-2	2013	44.37	18.32	36.83	30.42	28.14	19.39	39.14	3.52	36.22	8.69	18.94	16.89	19.05	15.45	86.92	83.51	13.64	8.75	1.58	31.18	5.30	36.85
-1	2014	46.71	20.76	37.27	31.41	29.36	20.72	40.95	3.71	38.27	9.49	20.19	17.82	20.55	16.23	89.87	87.27	14.85	9.62	1.69	34.03	5.78	39.40
0	2015	40.89	19.37	32.41	27.74	26.22	18.20	35.64	3.23	33.61	8.56	17.86	15.63	18.42	14.19	77.32	75.73	13.42	8.76	1.50	31.65	5.37	35.99
1	2016	36.78	18.39	30.58	26.77	25.48	16.40	31.85	2.90	30.30	7.91	16.23	14.07	16.89	12.83	68.37	68.37	12.41	8.17	1.37	31.91	5.43	35.83
2	2017	33.70	17.69	28.96	25.82	24.81	15.08	29.02	2.65	27.81	7.43	14.99	12.91	15.84	11.73	61.63	62.26	11.69	7.76	1.27	32.22	5.49	35.63
3	2018	35.24	19.30	29.25	26.55	25.82	15.79	30.16	2.76	29.20	7.94	15.89	13.50	16.83	12.23	63.33	64.55	12.53	8.37	1.35	34.60	5.90	37.81
4	2019	37.09	20.92	29.49	27.27	26.75	16.52	31.31	2.88	30.52	8.45	16.68	14.11	17.82	12.73	65.11	66.86	13.38	9.01	1.42	37.04	6.33	39.92
5	2020	37.37	21.06	29.67	27.44	26.93	16.62	31.52	2.90	30.79	8.50	16.79	14.19	17.93	12.89	66.26	67.89	13.74	9.24	1.46	38.18	6.52	41.11
6	2021	37.66	21.18	29.86	27.63	27.10	16.70	31.72	2.92	30.98	8.56	16.89	14.28	18.04	12.97	68.01	68.79	14.07	9.48	1.50	39.30	6.72	42.42
7	2022	37.94	21.31	30.04	27.79	27.27	16.80	31.91	2.94	31.16	8.60	17.00	14.36	18.14	13.05	69.09	69.79	14.42	9.70	1.54	40.42	6.90	43.59
8	2023	38.23	21.61	30.22	27.97	27.43	16.90	32.11	2.95	31.35	8.66	17.09	14.52	18.25	13.12	70.08	70.67	14.76	9.94	1.57	41.54	7.09	44.75
9	2024	38.52	21.73	30.50	28.12	27.59	16.99	32.33	2.97	31.53	8.71	17.21	14.61	18.35	13.19	71.17	71.63	15.11	10.17	1.60	42.67	7.28	46.05
10	2025	38.82	21.86	30.69	28.29	27.77	17.08	32.52	2.99	31.71	8.76	17.30	14.68	18.46	13.28	72.27	73.13	15.46	10.41	1.64	43.83	7.47	47.22
11	2026	39.10	21.98	30.91	28.47	27.93	17.17	32.71	3.01	31.89	8.81	17.41	14.77	18.56	13.34	73.34	74.14	15.80	10.64	1.68	44.95	7.67	48.51
12	2027	39.39	22.11	31.06	28.64	28.13	17.27	32.90	3.03	32.07	8.85	17.51	14.85	18.66	13.42	74.27	74.97	16.13	10.86	1.71	46.01	7.85	49.61
13	2028	39.68	22.24	31.24	28.80	28.28	17.49	33.09	3.05	32.26	8.91	17.61	14.93	18.77	13.50	75.30	75.76	16.45	11.07	1.75	47.00	8.02	50.63
14	2029	39.98	22.37	31.41	28.98	28.46	17.59	33.28	3.06	32.44	8.97	17.71	15.02	18.88	13.57	76.27	76.66	16.78	11.29	1.78	47.93	8.18	51.71
15	2030	40.27	22.69	31.69	29.14	28.61	17.70	33.61	3.08	32.62	9.10	17.81	15.19	19.06	13.64	77.11	77.40	17.07	11.48	1.82	48.80	8.33	52.63
16	2031	40.57	22.80	31.87	29.31	28.78	17.78	33.80	3.10	32.89	9.14	17.91	15.26	19.17	13.72	78.05	78.17	17.36	11.67	1.85	49.62	8.47	53.48
17	2032	40.87	22.94	32.06	29.48	28.95	17.88	33.98	3.12	33.06	9.19	18.01	15.35	19.27	13.79	78.82	79.63	17.64	11.85	1.88	50.38	8.60	54.27
18	2033	41.18	23.05	32.24	29.73	29.11	17.96	34.18	3.14	33.24	9.25	18.12	15.42	19.37	13.86	79.69	80.30	17.89	12.03	1.90	51.09	8.73	55.13
19	2034	41.48	23.18	32.41	29.91	29.30	18.06	34.37	3.15	33.43	9.30	18.21	15.51	19.48	13.95	81.21	80.98	18.13	12.20	1.93	51.75	8.84	55.85
20	2035	41.78	23.30	32.60	30.07	29.46	18.15	34.56	3.17	33.61	9.35	18.32	15.59	19.58	14.02	81.90	81.74	18.37	12.36	1.96	52.36	8.94	56.49

Source: JICA Study Team

Table 3.1.2-28: Sector Inlet Pipes Demand Forecast by Sub.Sectors (QMH) (l/s)

RESERVOIR		Villa Sol R-1	Villa del Norte	Parque del Naranja	Cueto Fernandini	Olivos de Pro	Programa Confratemidad 2	Programa Confratemidad 1	Comite Aposte	Puerta de Pro R-1	Rio Santa R-1	Pro	Santa Luisa	Pro	Virgin de las Nieves	Virgin del Rosario	Rosario del Norte	Jazmines de Naranja	Vipol Naranjal	Cerro eo Choclo R-2	Cerro eo Choclo R-1
SUB SECTOR		83A-1	83A-2	83B-1	83B-2	84A-1	84A-2	84B-1	84B-2	85A	85B-1	85B-2	85B-3	85C	212A-1	212A-2	212B-1	212B-2	213-1	213-2	213-3
SECTOR		83A		83B		84A		84B		85A	85B			85C	212A		212B		213		
YEAR																					
	2009	37.23	59.84	26.93	97.38	43.01	41.36	53.73	22.10	59.02	44.23	112.14	18.40	51.36	58.68	35.65	27.50	22.91	68.48	1.41	2.77
-5	2010	38.01	61.83	28.16	100.06	44.29	42.35	55.00	22.85	59.85	43.66	112.98	18.27	51.72	59.80	36.32	28.10	23.61	70.64	1.44	2.82
-4	2011	38.46	63.37	29.40	101.95	45.28	43.07	55.92	23.52	59.93	43.30	113.56	18.61	51.64	60.72	36.92	28.65	24.22	72.47	1.45	2.88
-3	2012	38.94	65.22	30.57	103.96	46.21	43.79	56.82	24.17	60.66	42.69	113.17	18.24	51.92	61.37	37.36	29.03	24.81	74.04	1.46	2.90
-2	2013	39.35	66.55	31.67	105.41	47.27	44.48	57.64	24.77	60.99	41.77	112.93	17.99	52.10	62.03	37.85	29.46	25.29	75.46	1.46	2.92
-1	2014	40.28	69.21	33.04	108.97	48.56	45.62	59.32	25.70	62.60	42.49	116.76	18.53	53.46	63.53	38.69	30.24	26.07	78.22	1.48	2.96
0	2015	35.64	62.22	29.81	97.46	48.19	45.19	58.97	25.72	54.78	37.06	103.19	16.37	46.73	60.62	36.96	28.87	25.02	67.37	1.25	2.49
1	2016	35.24	62.41	30.00	97.20	48.58	45.47	59.57	26.13	52.14	34.95	99.13	15.96	44.67	60.05	36.49	28.54	24.89	59.62	1.07	2.16
2	2017	34.77	62.54	30.14	96.91	48.94	45.72	60.10	26.54	50.01	33.28	96.03	15.39	42.65	59.26	36.06	28.24	24.69	53.74	0.95	1.90
3	2018	35.44	64.62	31.22	99.86	50.02	46.66	61.51	27.34	51.08	33.58	99.78	15.80	43.59	60.37	36.75	28.77	25.27	55.56	0.95	1.91
4	2019	36.03	66.64	32.27	102.59	51.08	47.60	62.95	28.12	52.01	33.88	102.42	16.24	44.78	61.42	37.38	29.28	25.80	57.07	0.96	1.93
5	2020	36.19	66.97	32.43	103.06	51.31	47.82	63.25	28.26	52.22	34.32	105.86	16.44	44.97	61.71	37.60	29.47	25.93	57.35	0.96	1.94
6	2021	36.36	67.26	32.56	103.51	51.54	48.03	63.54	28.40	52.63	34.71	109.51	16.63	45.13	61.99	37.77	29.60	26.10	57.61	0.98	1.94
7	2022	36.52	67.58	32.76	103.95	51.78	48.24	63.82	28.53	52.81	34.93	111.83	16.82	45.28	62.23	37.93	29.73	26.20	57.85	0.98	1.95
8	2023	36.67	67.91	32.91	104.39	52.00	48.66	64.12	28.64	53.16	35.61	115.27	17.23	45.85	62.51	38.11	29.83	26.33	58.10	0.98	1.96
9	2024	36.82	68.19	33.05	104.85	52.23	48.87	64.40	28.78	53.35	35.98	118.70	17.59	46.00	62.79	38.30	29.97	26.43	58.34	0.99	1.96
10	2025	36.99	68.72	33.21	105.29	52.45	49.06	64.68	28.91	53.54	36.21	122.35	17.79	46.16	63.03	38.47	30.11	26.54	58.58	0.99	1.98
11	2026	37.18	69.02	33.37	105.78	52.68	49.27	64.98	29.04	53.72	36.80	126.90	17.99	46.55	63.33	38.64	30.26	26.65	58.82	0.99	1.98
12	2027	37.35	69.32	33.49	106.21	52.92	49.50	65.27	29.18	54.29	37.20	130.33	18.35	46.88	63.59	38.81	30.37	26.81	59.05	1.00	1.99
13	2028	37.49	69.60	33.64	106.65	53.15	49.72	65.55	29.32	54.48	37.43	133.77	18.55	47.04	63.87	39.01	30.49	26.92	59.31	1.00	2.00
14	2029	37.66	69.92	33.78	107.12	53.37	49.93	65.82	29.43	54.66	37.81	138.53	18.90	47.21	64.13	39.18	30.61	27.03	59.60	1.00	2.00
15	2030	37.80	70.20	33.92	107.54	53.60	50.14	66.11	29.56	55.01	38.40	143.08	19.32	47.82	64.44	39.34	30.77	27.14	59.83	1.01	2.01
16	2031	38.20	70.48	34.05	108.22	53.96	50.35	66.60	29.69	55.43	38.79	147.63	19.67	47.99	64.68	39.64	30.91	27.26	60.08	1.01	2.03
17	2032	38.37	70.79	34.21	108.70	54.18	50.56	66.89	29.83	55.82	39.18	152.18	20.04	48.15	64.92	39.84	31.03	27.37	60.31	1.01	2.03
18	2033	38.52	71.09	34.34	109.13	54.41	50.77	67.18	29.96	56.17	39.77	156.72	20.23	48.48	65.22	40.03	31.15	27.49	60.58	1.03	2.04
19	2034	38.72	71.36	34.48	109.54	54.64	50.98	67.46	30.08	56.36	40.17	161.48	20.60	48.87	65.48	40.19	31.28	27.65	60.82	1.03	2.05
20	2035	38.86	71.66	34.61	110.01	54.87	51.20	67.74	30.21	56.54	40.54	167.12	20.95	49.03	65.76	40.35	31.43	27.76	61.05	1.03	2.05

RESERVOIR		Márquez	Almeda del Pinar R-1	El Pinar R-2	San Felipe	LA Alborada R-2	Collique R-1	Collique R-2	RE-01	Collique R-3	Nueva Esperanza	Collique R-4	Collique R-5	Collique R-6	Collique R-7	Santa Isabel R-1	Santa Isabel R-2	Los Angeles R-1	Los Angeles R-2, R-3	Los Angeles R-4	RPA-6	RPA-1	RPA-7 La Ensenada
SUB SECTOR		259	345	346	347-1	347-2	348A	348B-1	348B-2	349A-1	349A-2	349A-3	349B-1	349B-2	349B-3	350-1	350-2	351-1	351-2	351-3	368A1	368A-2	369A
SECTOR		259	345	346	347		348A	348B		349A			349B			350		351			368A		369A
YEAR																							
	2009	54.97	12.66	54.33	43.16	35.60	27.98	61.70	4.24	52.51	10.75	27.10	24.26	23.76	22.05	116.51	104.97	13.28	7.85	1.65	30.52	5.00	41.56
-5	2010	57.29	16.52	53.71	43.17	36.59	28.43	60.76	4.41	52.65	11.30	27.34	24.38	24.83	22.17	118.32	108.13	14.64	8.84	1.77	33.50	5.54	43.83
-4	2011	58.76	19.44	52.93	42.93	37.49	28.17	58.99	4.57	52.28	11.74	27.31	24.16	25.69	22.01	119.15	110.66	16.02	9.90	1.92	36.64	6.11	46.39
-3	2012	60.29	22.37	51.90	42.59	38.27	27.66	56.86	4.73	51.41	11.99	26.87	23.92	26.21	21.78	119.94	113.35	17.44	10.97	2.05	39.86	6.72	48.58
-2	2013	61.43	25.37	51.00	42.12	38.97	26.85	54.20	4.87	50.15	12.04	26.23	23.39	26.37	21.39	120.35	115.63	18.88	12.11	2.19	43.17	7.33	51.02
-1	2014	64.67	28.74	51.61	43.49	40.66	28.69	56.70	5.13	52.99	13.14	27.96	24.67	28.46	22.47	124.44	120.83	20.57	13.33	2.34	47.11	8.00	54.55
0	2015	56.61	26.82	44.87	38.41	36.31	25.20	49.35	4.48	46.54	11.86	24.73	21.64	25.50	19.65	107.07	104.85	18.59	12.13	2.08	43.82	7.44	49.83
1	2016	50.92	25.47	42.34	37.07	35.28	22.71	44.10	4.01	41.95	10.95	22.48	19.49	23.39	17.77	94.67	94.67	17.19	11.31	1.90	44.19	7.52	49.61
2	2017	46.66	24.49	40.10	35.75	34.36	20.89	40.18	3.67	38.51	10.29	20.76	17.88	21.94	16.24	85.33	86.20	16.18	10.74	1.76	44.62	7.60	49.33
3	2018	48.80	26.72	40.49	36.76	35.75	21.87	41.76	3.83	40.43	10.99	22.00	18.69	23.30	16.93	87.68	89.37	17.35	11.59	1.87	47.91	8.17	52.35
4	2019	51.35	28.97	40.83	37.76	37.04	22.88	43.36	3.99	42.26	11.70	23.10	19.53	24.67	17.62	90.15	92.57	18.53	12.47	1.96	51.29	8.76	55.27
5	2020	51.74	29.16	41.09	38.00	37.28	23.01	43.65	4.02	42.63	11.77	23.25	19.65	24.83	17.85	91.75	94.01	19.03	12.80	2.02	52.86	9.02	56.92
6	2021	52.14	29.33	41.34	38.25	37.52	23.13	43.92	4.04	42.89	11.85	23.39	19.77	24.97	17.96	94.17	95.25	19.49	13.12	2.07	54.42	9.30	58.73
7	2022	52.53	29.50	41.59	38.48	37.76	23.26	44.18	4.07	43.14	11.91	23.54	19.88	25.12	18.06	95.67	96.63	19.97	13.43	2.13	55.96	9.56	60.35
8	2023	52.93	29.92	41.84	38.72	37.98	23.39	44.46	4.09	43.40	11.99	23.67	20.10	25.27	18.17	97.04	97.85	20.44	13.76	2.18	57.52	9.82	61.97
9	2024	53.34	30.09	42.23	38.93	38.21	23.53	44.76	4.11	43.65	12.06	23.82	20.22	25.41	18.26	98.54	99.19	20.92	14.08	2.22	59.08	10.09	63.76
10	2025	53.75	30.26	42.50	39.17	38.45	23.65	45.03	4.14	43.90	12.13	23.96	20.33	25.56	18.38	100.06	101.26	21.41	14.41	2.28	60.69	10.35	65.38
11	2026	54.13	30.44	42.80	39.42	38.68	23.78	45.29	4.17	44.15	12.19	24.10	20.45	25.70	18.48	101.55	102.66	21.87	14.73	2.33	62.24	10.62	67.17
12	2027	54.55	30.61	43.01	39.66	38.94	23.91	45.55	4.20	44.40	12.26	24.24	20.56	25.84	18.58	102.83	103.80	22.34	15.03	2.37	63.70	10.87	68.68
13	2028	54.95	30.80	43.25	39.88	39.15	24.22	45.81	4.22	44.66	12.34	24.38	20.67	26.00	18.69	104.27	104.89	22.78	15.33	2.42	65.08	11.11	70.10
14	2029	55.36	30.97	43.50	40.13	39.41	24.36	46.08	4.24	44.91	12.42	24.52	20.80	26.14	18.79	105.60	106.14	23.24	15.63	2.46	66.37	11.32	71.60
15	2030	55.76	31.42	43.88	40.35	39.62	24.50	46.54	4.26	45.16	12.59	24.66	21.03	26.38	18.89	106.77	107.17	23.64	15.90	2.52	67.56	11.54	72.87
16	2031	56.18	31.58	44.13	40.59	39.85	24.62	46.80	4.29	45.54	12.66	24.80	21.13	26.54	18.99	108.07	108.23	24.04	16.16	2.56	68.70	11.72	74.05
17	2032	56.59	31.76	44.40	40.82	40.09	24.75	47.06	4.32	45.77	12.73	24.94	21.25	26.69	19.10	109.14	110.25	24.42	16.41	2.60	69.76	11.91	75.15
18	2033	57.02	31.92	44.64	41.16	40.31	24.87	47.32	4.35	46.02	12.81	25.09	21.36	26.82	19.19	110.34	111.19	24.77	16.66	2.63	70.74	12.08	76.33
19	2034	57.43	32.09	44.87	41.41	40.57	25.00	47.59	4.36	46.28	12.87	25.22	21.47	26.97	19.31	112.45	112.13	25.10	16.89	2.67	71.65	12.23	77.33
20	2035	57.84	32.26	45.13	41.63	40.80	25.14	47.85	4.39	46.54	12.94	25.36	21.58	27.11	19.41	113.40	113.17	25.44	17.12	2.71	72.50	12.38	78.21

Source: JICA Study Team

Table 3.1.2-29: Water Connections Demand Forecast by Sub-Sectors (Units)

SECTOR		83A		83B		84A		84B		85A	85B			85C	212A		212B		213			259	345	346	347		348A	348B		349A			349B			350		351			368A		369A
SUB SECTOR		83A-1	83A-2	83B-1	83B-2	84A-1	84A-2	84B-1	84B-2	85A	85B-1	85B-2	85B-3	85C	212A-1	212A-2	212B-1	212B-2	213-1	213-2	213-3	259	345	346	347-1	347-2	348A	348B-1	348B-2	349A-1	349A-2	349A-3	349B-1	349B-2	349B-3	350-1	350-2	351-1	351-2	351-3	368A1	368A-2	369A
YEAR																																											
	2009	1,609	2,487	1,273	4,068	4,477	3,109	4,021	1,669	2,184	918	894	287	1,657	3,344	2,084	1,612	1,358	3,003	68	130	2,282	415	2,605	2,050	1,795	841	2,034	178	1,749	340	894	784	764	747	3,839	3,448	598	361	76	1,761	297	2,179
-5	2010	1,657	2,622	1,345	4,253	4,638	3,213	4,172	1,748	2,262	937	926	306	1,717	3,465	2,150	1,672	1,416	3,154	70	133	2,435	554	2,641	2,126	1,888	911	2,150	189	1,879	388	973	844	859	796	3,998	3,638	663	407	82	1,954	330	2,363
-4	2011	1,705	2,754	1,418	4,433	4,793	3,313	4,318	1,824	2,337	956	959	324	1,775	3,578	2,214	1,729	1,472	3,303	71	136	2,590	694	2,678	2,204	1,983	981	2,265	200	2,010	437	1,052	903	954	846	4,154	3,829	732	456	89	2,158	365	2,556
-3	2012	1,750	2,887	1,489	4,612	4,944	3,409	4,461	1,900	2,410	974	990	342	1,833	3,684	2,274	1,781	1,525	3,444	72	138	2,747	838	2,712	2,280	2,079	1,052	2,381	211	2,143	487	1,133	964	1,052	897	4,314	4,025	803	506	95	2,370	402	2,753
-2	2013	1,793	3,019	1,559	4,786	5,091	3,504	4,601	1,974	2,480	989	1,022	361	1,891	3,788	2,334	1,833	1,575	3,582	73	140	2,907	984	2,746	2,358	2,173	1,124	2,499	222	2,275	537	1,214	1,025	1,150	948	4,472	4,223	876	559	102	2,592	440	2,958
-1	2014	1,836	3,148	1,629	4,957	5,234	3,595	4,737	2,049	2,549	1,003	1,056	379	1,948	3,883	2,389	1,882	1,624	3,717	74	142	3,069	1,131	2,780	2,436	2,269	1,197	2,617	234	2,410	589	1,296	1,086	1,248	999	4,629	4,421	955	615	109	2,825	480	3,170
0	2015	1,876	3,274	1,698	5,125	5,372	3,682	4,868	2,121	2,616	1,018	1,089	398	2,003	3,973	2,446	1,927	1,672	3,845	75	143	3,232	1,281	2,812	2,512	2,366	1,270	2,735	245	2,546	640	1,378	1,148	1,349	1,051	4,786	4,621	1,034	672	116	3,066	521	3,386
1	2016	1,916	3,401	1,767	5,291	5,507	3,766	4,998	2,191	2,681	1,031	1,121	418	2,058	4,061	2,498	1,971	1,719	3,973	75	145	3,400	1,432	2,844	2,592	2,465	1,343	2,854	256	2,683	692	1,463	1,210	1,450	1,105	4,942	4,824	1,116	731	124	3,313	564	3,608
2	2017	1,953	3,526	1,834	5,454	5,639	3,848	5,124	2,262	2,745	1,043	1,155	437	2,111	4,142	2,549	2,013	1,762	4,096	76	146	3,568	1,586	2,875	2,668	2,562	1,419	2,974	268	2,821	745	1,546	1,273	1,554	1,158	5,097	5,028	1,201	793	131	3,569	608	3,835
3	2018	1,991	3,650	1,902	5,616	5,767	3,929	5,246	2,331	2,808	1,054	1,187	455	2,166	4,222	2,600	2,053	1,805	4,218	76	147	3,739	1,741	2,904	2,745	2,660	1,493	3,093	279	2,960	798	1,633	1,335	1,657	1,210	5,251	5,231	1,288	856	139	3,833	654	4,066
4	2019	2,026	3,772	1,968	5,775	5,893	4,009	5,369	2,399	2,868	1,064	1,219	475	2,220	4,298	2,647	2,091	1,845	4,336	77	148	3,915	1,898	2,930	2,822	2,758	1,569	3,213	291	3,099	851	1,717	1,399	1,760	1,262	5,404	5,436	1,376	921	146	4,104	701	4,301
5	2020	2,035	3,791	1,978	5,803	5,921	4,028	5,395	2,411	2,882	1,071	1,229	479	2,233	4,319	2,661	2,103	1,855	4,358	77	149	3,946	1,911	2,949	2,840	2,776	1,579	3,235	293	3,120	856	1,728	1,408	1,772	1,272	5,498	5,518	1,413	945	150	4,230	722	4,434
6	2021	2,045	3,808	1,986	5,829	5,948	4,046	5,420	2,423	2,897	1,078	1,240	482	2,244	4,338	2,674	2,113	1,865	4,378	78	149	3,978	1,924	2,968	2,859	2,794	1,588	3,255	295	3,140	862	1,739	1,417	1,783	1,280	5,590	5,596	1,447	969	154	4,355	744	4,566
7	2022	2,054	3,825	1,996	5,855	5,976	4,064	5,444	2,434	2,909	1,083	1,249	485	2,255	4,356	2,686	2,122	1,873	4,397	78	150	4,009	1,936	2,987	2,876	2,812	1,598	3,275	297	3,159	867	1,750	1,425	1,794	1,288	5,679	5,674	1,483	992	159	4,479	765	4,696
8	2023	2,063	3,844	2,005	5,881	6,002	4,084	5,470	2,444	2,923	1,091	1,259	489	2,270	4,376	2,699	2,130	1,882	4,416	78	151	4,041	1,949	3,005	2,895	2,829	1,608	3,296	298	3,179	873	1,760	1,435	1,805	1,296	5,768	5,752	1,518	1,016	163	4,604	786	4,826
9	2024	2,072	3,861	2,014	5,908	6,030	4,102	5,494	2,456	2,936	1,096	1,269	494	2,281	4,395	2,711	2,140	1,890	4,435	79	151	4,074	1,961	3,025	2,911	2,846	1,618	3,318	300	3,198	878	1,772	1,444	1,816	1,303	5,857	5,828	1,554	1,040	166	4,729	807	4,958
10	2025	2,082	3,879	2,023	5,934	6,056	4,119	5,518	2,467	2,949	1,102	1,280	497	2,292	4,413	2,724	2,149	1,898	4,454	79	152	4,107	1,973	3,045	2,929	2,864	1,627	3,338	302	3,217	883	1,782	1,452	1,827	1,312	5,946	5,905	1,590	1,064	170	4,854	828	5,088
11	2026	2,092	3,896	2,033	5,962	6,083	4,137	5,544	2,478	2,961	1,109	1,291	501	2,305	4,433	2,736	2,160	1,906	4,473	79	152	4,138	1,985	3,067	2,948	2,881	1,637	3,358	304	3,236	888	1,793	1,461	1,838	1,319	6,034	5,983	1,625	1,088	174	4,979	850	5,220
12	2027	2,102	3,914	2,041	5,988	6,111	4,156	5,569	2,490	2,977	1,116	1,301	505	2,318	4,452	2,749	2,168	1,916	4,491	80	153	4,171	1,997	3,083	2,966	2,901	1,647	3,377	306	3,255	893	1,804	1,470	1,848	1,327	6,119	6,056	1,660	1,110	177	5,096	870	5,342
13	2028	2,110	3,931	2,050	6,014	6,138	4,175	5,593	2,502	2,990	1,122	1,311	509	2,329	4,471	2,762	2,177	1,924	4,511	80	154	4,203	2,010	3,101	2,983	2,917	1,657	3,397	308	3,275	899	1,814	1,478	1,860	1,335	6,202	6,126	1,693	1,132	181	5,206	889	5,456
14	2029	2,120	3,949	2,059	6,041	6,164	4,193	5,616	2,512	3,002	1,128	1,323	513	2,341	4,490	2,774	2,186	1,932	4,531	80	154	4,236	2,022	3,120	3,002	2,936	1,667	3,417	309	3,294	905	1,825	1,488	1,871	1,343	6,280	6,196	1,725	1,154	184	5,310	906	5,565
15	2030	2,128	3,966	2,068	6,066	6,191	4,211	5,641	2,523	3,016	1,135	1,334	518	2,355	4,511	2,786	2,196	1,940	4,549	81	155	4,268	2,035	3,138	3,019	2,952	1,678	3,438	311	3,313	911	1,837	1,498	1,882	1,350	6,357	6,262	1,755	1,174	188	5,406	923	5,667
16	2031	2,138	3,983	2,076	6,093	6,218	4,229	5,667	2,534	3,030	1,141	1,345	522	2,367	4,529	2,799	2,206	1,949	4,568	81	156	4,302	2,046	3,157	3,037	2,969	1,687	3,458	313	3,334	916	1,847	1,506	1,894	1,358	6,431	6,328	1,785	1,193	191	5,497	938	5,762
17	2032	2,148	4,001	2,086	6,121	6,244	4,247	5,692	2,546	3,043	1,148	1,356	527	2,378	4,547	2,812	2,215	1,957	4,586	81	156	4,335	2,059	3,177	3,055	2,987	1,697	3,477	315	3,352	921	1,858	1,515	1,905	1,366	6,502	6,392	1,813	1,212	194	5,582	953	5,850
18	2033	2,157	4,019	2,094	6,146	6,272	4,265	5,717	2,557	3,057	1,155	1,367	530	2,391	4,567	2,826	2,224	1,966	4,607	82	157	4,369	2,070	3,195	3,073	3,004	1,706	3,497	317	3,371	927	1,869	1,523	1,915	1,373	6,571	6,452	1,839	1,230	196	5,661	967	5,934
19	2034	2,168	4,035	2,103	6,171	6,299	4,283	5,741	2,568	3,070	1,162	1,379	535	2,404	4,586	2,838	2,234	1,976	4,626	82	158	4,402	2,083	3,212	3,092	3,023	1,716	3,517	318	3,391	932	1,879	1,532	1,926	1,382	6,641	6,512	1,864	1,247	199	5,734	979	6,012
20	2035	2,176	4,052	2,111	6,198	6,326	4,302	5,765	2,579	3,082	1,167	1,389	539	2,415	4,605	2,850	2,243	1,984	4,644	82	158	4,435	2,095	3,232	3,109	3,040	1,726	3,537	320	3,410	937	1,890	1,540	1,937	1,389	6,704	6,569	1,889	1,264	202	5,802	991	6,083

Source: JICA Study Team

3.1.3 Sewerage

Assumptions and considerations with regard to population, the project horizon, and the persons per household that have been applied in the water supply projections are also used to project sewerage flows.

In this Study it is assumed that the sewerage house connection coverage will be the same as the water supply house connection coverage. This is because each household will have greater water availability with the Project, and it will therefore require a sewerage connection to discharge its sewerage flows.

The sewerage production rate discharged into the sewerage networks is assumed to be 80%, according to the National Sanitation Standards (*Reglamento Nacional de Estructuras*, or RNE); this is the standard technical parameter that will be kept same throughout the project horizon.

In this Study, sewer network demand is investigated from 2 aspects: sewer pipes that cannot meet future conveyance need, and sewer pipes that are or expected to be in bad condition. The first aspect will ensure proper liquid movement and the second aspect will ensure proper O&M by reducing or eliminating clogs and collapses.

Base information for the demand calculation has been carried out with the drainage areas, as defined in the *Perfil* study for the Study area. The number of connections is shown in Table 3.1.3-2. Amount of the total flow is given in the Table 3.1.3-3.

A hydraulic calculation is carried out to check the carrying capacity of the existing pipes. The pipes with insufficient capacity to carry the future demand need to be replaced. Amount of length to be replaced is shown in Table 3.1.3-1. The Hydraulic Calculation is presented in detail in the Annex B.B.2

Table 3.1.3-1: Hydraulic Modeling Results, Length of Pipe in km

Area	Hydraulic Capacity	Tractive Force
Collique	0,033	0,009
Comas	0,713	1,089
Marquez	0,007	
Los Olivos	1,989	3,158
Total	2,742	4,256

Source: JICA Study Team

Sewer demand can also be considered from the physical state or condition. In this type of analysis, availability or supply of good pipes (in length) will be checked against demand (total of all existing pipes, also in length).Table 3.1.3-4 shows this sewerage pipeline demand.

Table 3.1.3-2: Sewerage Connections by Categories According to Drainage Areas

Drainage Area	Social	Domestic	Commercial	Industrial	Government	Communal, single meter	Totals
AD-A1	9	2.438	90	7	8	866	3.418
AD-A2	4	2.269	81	9	1	676	3.040
AD-AG1	3	1.017	3		1	78	1.102
AD-AG2	14	2.010	70	1	14	1.177	3.286
AD-AG3	5	839	28	1	6	370	1.249
AD-AG4	13	2.071	48	3	6	768	2.909
ADC-1	4	1.076	6		4	156	1.246
ADC-2	13	1.739	14		9	200	1.975
ADC-3	6	620			1	60	687
ADC-4	5	650	7		3	133	798
ADC-5	7	1.564	1		5	174	1.751
ADC-6	5	1.185	9		5	247	1.451
AD-CH1	13	2.961	81	7	10	934	4.006
AD-CH2	1	1.339	26		3	279	1.648
AD-CH3	5	1.870	94	26	4	658	2.657
AD-CO1	5	1.982	35	2	10	973	3.007
AD-CO2	4	2.374	76	5	6	563	3.028
AD-M1	8	2.000	16	1	6	121	2.152
AD-N1	5	1.603	73	4	11	1.389	3.085
AD-N2	4	2.183	62	5	3	763	3.020
AD-PL1	2	3.135	13		7	294	3.451
AD-PL2	11	2.913	14		4	252	3.194
AD-R1	7	603	55	66	7	375	1.113
AD-R2	5	1.924	28	3	3	609	2.572
AD-T1	5	1.481	25	2	6	256	1.775
AD-T2	2	613	1		1	56	673
AD-T3	2	566	6	2	1	80	657
AD-T4	5	1.610	37	3	3	361	2.019
AD-T5	1	991	14	2	2	236	1.246
AD-T6	1	156	3	2	1	29	192
Total	174	47.782	1.016	151	151	13.132	62.407

Source: JICA Study Team

Table 3.1.3-3: Amount of Total Sewerage Flow

Year		Flow m^3/Year
-	2007	0,00
-	2008	0,00
Base	2009	119.071,56
-5	2010	122.758,16
-4	2011	125.792,92
-3	2012	128.537,39
-2	2013	130.980,75
-1	2014	137.233,86
0	2015	124.193,94
1	2016	119.251,10
2	2017	115.412,68
3	2018	120.093,72
4	2019	124.721,65
5	2020	126.388,05
6	2021	128.093,91
7	2022	129.622,22
8	2023	131.314,04
9	2024	132.962,51
10	2025	134.652,07
11	2026	136.378,20
12	2027	137.966,26
13	2028	139.467,51
14	2029	141.045,11
15	2030	142.644,95
16	2031	144.179,71
17	2032	145.670,05
18	2033	147.088,80
19	2034	148.520,14
20	2035	149.882,09

Source: JICA Study Team

The demand according to the length of piping is presented in the following table:

Table 3.1.3-4: Demand in the Project by Km of Piping

Drainage Area	Pipes Demand (Km)
A16	7.52
A18	11.53
A19	5.73
AD-0	1.70
AD-01B	0.95
AD-A1	30.31
AD-A2	24.16
AD-AG1	4.68
AD-AG2	29.91
AD-AG3	12.13
AD-AG4	26.44
ADC-1	10.08
ADC-2	13.52
ADC-3	4.97
ADC-4	6.91
ADC-5	13.70
ADC-6	11.38
AD-CA1	8.80
AD-CA3	0.82
AD-CH1	32.03
AD-CH2	12.58
AD-CH3	21.88
AD-CH4	30.87
AD-CO1	20.84
AD-CO2	26.83
AD-M1	13.32
AD-N1	24.57
AD-N2	23.53
AD-P2	0.46
AD-PL1	22.18
AD-PL2	22.59
AD-R1	14.81
AD-R2	17.36
AD-T1	14.54
AD-T2	6.61
AD-T3	0.04
AD-T4	12.54
AD-T5	10.06
AD-T6	2.61
PT1	22.99
PT2	6.59
PT3	13.00
PT4	11.70
PT5	8.78
PT6	25.44
PT7	7.54
SA-57	0.03
Total general	651.56

Source: JICA Study Team

Table 3.1.3-5 Sewerage demand by drainage area

Drainage Areas by Sub-Sector			**Flow per Drainage Vs Sub-sector**			
Drainage Area	Sub-Sector	Area (m^2) Sub-sector	Sewerage Demand by Sub-Sector (l/s)	Total Area (m^2)	Unit Flow (l/s/m^2)	**Sewerage Average Demand per Drainage Areas (l/s)**
AD-A1	256	300.0714	1.1822	3,745,476.84	3.1564E-07	0.000
	212 A-1	56117.4399	23.38	1,140,644.93	2.04992E-05	1.150
	212 A-2	744987.1526	14.35	758,289.58	1.89207E-05	14.096
	212 B-2	39735.90718	9.87	448,299.17	2.20162E-05	0.875
	251	15995.54834	15.34	1,975,160.60	7.76533E-06	0.124
	252	2585.61844	12.00	1,015,615.54	1.18199E-05	0.031
	83 B-2	450324.4991	39.12	1,258,881.99	3.10712E-05	13.992
	84 B-1	9657.54414	27.01	1,190,798.74	2.26844E-05	0.219
	84 B-2	180.75662	10.74	427,365.06	2.51338E-05	0.005
Total AD-A1		**1319884.538**				**30.491**
AD-A2	256	6759.77091	1.18	3,745,476.84	3.1564E-07	0.002
	212 A-1	384900.1209	23.38	1,140,644.93	2.04992E-05	7.890
	212 A-2	158.03185	14.35	758,289.58	1.89207E-05	0.003
	212 B-1	164543.091	11.17	529,834.56	2.10912E-05	3.470
	212 B-2	408558.9006	9.87	448,299.17	2.20162E-05	8.995
Totales		**964919.9152**				**20.361**
AD-AG1	348 B-1	10954.35678	17.01	150,386.34	0.000113136	1.239
	349 A-1	16584.58848	16.55	997,163.78	1.65929E-05	0.275
	350-1	25853.54601	40.32	1,305,244.85	3.08902E-05	0.799
	351-1	271312.5519	9.05	283,149.08	3.19445E-05	8.667
	351-2	268143.6154	6.09	270,031.46	2.25378E-05	6.043
	351-3	156658.7601	0.96	165,555.96	5.81654E-06	0.911
Totales		**749507.4186**				**17.935**
AD-AG2	348 B-1	6468.06285	17.01	150,386.34	0.000113136	0.732
	350-1	1087782.602	40.32	1,305,244.85	3.08902E-05	33.602
	350-2	31797.65067	40.24	1,529,571.44	2.63073E-05	0.837
	351-1	11811.14352	9.05	283,149.08	3.19445E-05	0.377
Totales		**1137859.459**				**35.547**
AD-AG3	347-2	28595.86244	14.51	1,262,194.72	1.14921E-05	0.329
	350-2	463595.8969	40.24	1,529,571.44	2.63073E-05	12.196
Totales		**492191.7593**				**12.525**
AD-AG4	348 A	3300.58369	8.94	599,566.46	1.49071E-05	0.049
	347-1	731985.1924	14.80	1,262,194.72	1.17282E-05	8.585
	347-2	13492.55455	14.51	1,262,194.72	1.14921E-05	0.155
	348 B-1	152414.4943	17.01	150,386.34	0.000113136	17.244
	349 A-1	66680.88116	16.55	997,163.78	1.65929E-05	1.106
	350-1	191608.6581	40.32	1,305,244.85	3.08902E-05	5.919
	350-2	7124.92489	40.24	1,529,571.44	2.63073E-05	0.187
Totales		**1166607.289**				**33.245**
AD-AG5	348 A	315829.7642	8.94	599,566.46	1.49071E-05	4.708
	347-1	12651.59457	14.80	1,262,194.72	1.17282E-05	0.148
	348 B-1	6817.3951	17.01	150,386.34	0.000113136	0.771
Totales		**335298.7539**				**5.628**
ADC-1	349 A-3	139178.816	9.02	412,169.42	2.18787E-05	3.045
	349 B-1	211080.4738	7.67	502,957.81	1.52553E-05	3.220
	349 B-2	299006.3465	9.64	668,705.39	1.44157E-05	4.310
	349 B-3	164528.8718	6.90	488,315.42	1.41301E-05	2.325
	349 B-4	311753.9112	3.35	369,257.78	9.07476E-06	2.829

Drainage Areas by Sub-Sector			Flow per Drainage Vs Sub-sector			
Drainage Area	Sub-Sector	Area (m^2) Sub-sector	Sewerage Demand by Sub-Sector (l/s)	Total Area (m^2)	Unit Flow ($l/s/m^2$)	**Sewerage Average Demand per Drainage Areas (l/s)**
Totales		**1125548.419**				**15.729**
ADC-2	348 A	2699.66328	8.94	599,566.42	1.49071E-05	0.040
	348 B-1	75871.33328	17.01	150,386.34	0.000113136	8.584
	349 A-1	84387.48095	16.55	997,163.78	1.65929E-05	1.400
	349 A-3	125826.6774	9.02	412,169.42	2.18787E-05	2.753
	349 B-1	85679.11038	7.67	502,957.81	1.52553E-05	1.307
	349 B-2	364924.6418	9.64	668,705.39	1.44157E-05	5.261
	349 B-3	323786.5464	6.90	488,315.42	1.41301E-05	4.575
	349 B-4	57503.85953	3.35	369,257.78	9.07476E-06	0.522
Totales		**1120679.313**				**24.442**
ADC-3	349 A-1	155806.9326	16.55	997,163.78	1.65929E-05	2.585
	349 A-3	112598.805	9.02	412,169.42	2.18787E-05	2.464
	349 B-1	206198.2237	7.67	502,957.81	1.52553E-05	3.146
	349 B-2	4774.40986	9.64	668,705.39	1.44157E-05	0.069
	351-2	876.79179	6.09	270,031.46	2.25378E-05	0.020
	351-3	8897.17943	0.96	165,555.96	5.81654E-06	0.052
Totales		**489152.3423**				**8.335**
ADC-4	348 B-1	76559.17595	17.01	150,386.34	0.000113136	8.662
	349 A-1	266453.4613	16.55	997,163.78	1.65929E-05	4.421
	349 A-3	34565.09694	9.02	412,169.42	2.18787E-05	0.756
Totales		**377577.7342**				**13.839**
ADC-5	348 B-1	212167.131	7.67	150,386.34	5.10204E-05	10.825
	348 B-2	61658.37441	9.64	150,386.34	6.41005E-05	3.952
	349 A-1	294947.2344	16.55	997,163.78	1.65929E-05	4.894
	349 A-2	376842.2072	4.60	376,842.19	1.22085E-05	4.601
Totales		**945614.947**				**24.272**
ADC-6	348 A	277736.4111	8.94	599,566.46	1.49071E-05	4.140
	347-1	1947.53296	14.80	1,262,194.72	1.17282E-05	0.023
	348 B-1	132475.2913	7.67	150,386.34	5.10204E-05	6.759
	348 B-2	88727.96575	9.64	150,386.34	6.41005E-05	5.688
	349 A-1	112303.2199	16.55	997,163.78	1.65929E-05	1.863
	351-2	1011.03607	6.09	270,031.46	2.25378E-05	0.023
Totales		**614201.457**				**18.496**
AD-CH1	85 A	497438.1299	20.10	642,626.91	3.12819E-05	15.561
	85 C	638278.6214	17.43	648,074.63	2.68981E-05	17.168
	84 A-1	105012.2036	27.01	1,496,540.38	1.805E-05	1.895
	85 B-1	250046.6253	14.41	580,643.66	2.48219E-05	6.207
	85 B-2	20105.74932	59.42	490,118.79	0.000121234	2.438
Totales		**1510881.33**				**43.269**
AD-CH2	85 A	2169.85191	20.10	642,626.91	3.12819E-05	0.068
	84 A-1	351786.4621	27.01	1,496,540.38	1.805E-05	6.350
	84 A-2	104979.5545	18.21	806,584.85	2.25711E-05	2.370
Totales		**458935.8685**				**8.787**
AD-CH3	85 A	142252.1994	20.10	642,626.91	3.12819E-05	4.450
	83 A-1	112741.6273	13.82	468,169.68	2.95136E-05	3.327
	84 A-1	567.64514	27.01	1,496,540.38	1.805E-05	0.010
	84 A-2	190772.0142	18.21	806,584.85	2.25711E-05	4.306
	84 B-1	188546.8939	24.08	1,190,798.74	2.02248E-05	3.813
	85 B-1	328774.6243	14.41	580,643.66	2.48219E-05	8.161
	85 B-2	379.87176	59.42	490,118.79	0.000121234	0.046
	85 B-3	5243.03791	7.45	612,116.35	1.21715E-05	0.064

Drainage Areas by Sub-Sector			Flow per Drainage Vs Sub-sector			
Drainage Area	Sub-Sector	Area (m^2) Sub-sector	Sewerage Demand by Sub-Sector (l/s)	Total Area (m^2)	Unit Flow ($l/s/m^2$)	**Sewerage Average Demand per Drainage Areas (l/s)**
Totales		**969277.9139**				**24.178**
AD-CO1	83 A-2	6022.12196	25.48	1,032,456.35	2.46768E-05	0.149
	83 B-1	21.7675	12.31	433,638.91	2.83783E-05	0.001
	83 B-2	795859.7972	39.12	1,258,881.99	3.10712E-05	24.728
	84 B-2	85.10318	10.74	427,365.06	2.51338E-05	0.002
Totales		**801988.7899**				**24.878**
AD-CO2	256	10252.34375	1.18	3,745,476.84	3.1564E-07	0.003
	212 A-1	696620.2532	23.38	1,140,644.93	2.04992E-05	14.280
	212 B-1	365291.4301	11.17	529,834.56	2.10912E-05	7.704
	212 B-2	4.30207	9.87	448,299.17	2.20162E-05	0.000
Totales		**1072168.329**				**21.988**
AD-M1	259	367667.6447	20.57	1,030,511.98	1.99575E-05	7.338
	258	344.9842	352.99	3,681,034.37	9.58941E-05	0.033
Totales		**368012.6289**				**7.371**
AD-N1	83 A-2	765356.7715	25.48	1,032,456.35	2.46768E-05	18.887
	83 B-1	433589.9032	12.31	433,638.91	2.83783E-05	12.305
	83 B-2	6970.97947	39.12	1,258,881.99	3.10712E-05	0.217
	84 B-2	190.16168	10.74	427,365.06	2.51338E-05	0.005
Totales		**1206107.816**				**31.413**
AD-N2	212 A-2	12764.71791	14.35	758,289.58	1.89207E-05	0.242
	83 A-2	5654.13866	25.48	1,032,456.35	2.46768E-05	0.140
	83 B-2	4356.59829	39.12	1,258,881.99	3.10712E-05	0.135
	84 B-1	446060.4914	24.08	1,190,798.74	2.02248E-05	9.021
	84 B-2	426909.0688	10.74	427,365.06	2.51338E-05	10.730
Totales		**895745.015**				20.268
AD-PL1	84 A-1	1037069.083	27.01	1,496,540.38	1.805E-05	18.719
	84 A-2	51221.54014	18.21	806,584.85	2.25711E-05	1.156
Totales		**1088290.623**				**19.875**
AD-PL2	213-1	268024.0177	21.71	1,573,029.00	1.37992E-05	3.699
	213-2	3873.04254	0.37	17,151.13	2.12976E-05	0.082
	213-3	14827.06614	0.73	36,602.25	1.99374E-05	0.296
	84 A-1	174.82546	27.01	1,496,540.38	1.805E-05	0.003
	84 A-2	458938.1334	18.21	806,584.85	2.25711E-05	10.359
	84 B-1	335565.9842	24.08	1,190,798.74	2.02248E-05	6.787
Totales		**1081403.069**				**21.225**
AD-R1	85 A	251.37374	20.10	642,626.91	3.12819E-05	0.008
	85 C	2786.19085	17.43	648,074.63	2.68981E-05	0.075
	85 B-1	1822.44768	14.41	580,643.66	2.48219E-05	0.045
	85 B-2	469479.7558	59.42	490,118.79	0.000121234	56.917
	85 B-3	589247.297	7.45	612,116.35	1.21715E-05	7.172
Totales		**1063587.065**				**64.217**
AD-R2	83 A-1	355414.7859	13.82	468,169.68	2.95136E-05	10.490
	83 A-2	254948.2252	25.48	1,032,456.35	2.46768E-05	6.291
	84 B-1	191294.4149	24.08	1,190,798.74	2.02248E-05	3.869
	85 B-3	1564.2315	7.45	612,116.35	1.21715E-05	0.019
Totales		**803221.6575**				**20.669**
AD-T1	345	29718.93073	11.47	3,639,432.32	3.1521E-06	0.094
	350-2	648021.9245	40.24	1,529,571.44	2.63073E-05	17.048
Totales		**677740.8552**				**17.141**
AD-T2	345	42944.91718	11.47	3,639,432.32	3.1521E-06	0.135
	347-2	395402.6288	14.51	1,262,194.72	1.14921E-05	4.544

Drainage Areas by Sub-Sector			**Flow per Drainage Vs Sub-sector**			
Drainage Area	Sub-Sector	Area (m^2) Sub-sector	Sewerage Demand by Sub-Sector (l/s)	Total Area (m^2)	Unit Flow ($l/s/m^2$)	**Sewerage Average Demand per Drainage Areas (l/s)**
	350-2	321315.875	40.24	1,529,571.44	2.63073E-05	8.453
Totales		**759663.4209**				**13.132**
AD-T3	347-2	501641.4504	14.51	1,262,194.72	1.14921E-05	5.765
	350-2	57245.52259	40.24	1,529,571.44	2.63073E-05	1.506
Totales		**558886.973**				**7.271**
AD-T4	346-2	388571.9004	10.59	595,740.18	1.77743E-05	6.907
	347-2	267696.7198	14.51	1,262,194.72	1.14921E-05	3.076
	350-2	327.66622	40.24	1,529,571.44	2.63073E-05	0.009
Totales		**656596.2864**				**9.992**
AD-T5	345	17822.93642	11.47	3,639,432.32	3.1521E-06	0.056
	346-1	277634.7755	5.46	525,841.68	1.03809E-05	2.882
	346-2	207168.2853	10.59	595,740.18	1.77743E-05	3.682
	347-2	55346.981	14.51	1,262,194.72	1.14921E-05	0.636
Totales		**557972.9782**				**0.000**
AD-T6	346-1	248206.9091	5.46	525,841.68	1.03809E-05	2.577
Totales		**248206.9091**				**2.577**

Source: JICA Study Team

Hydraulic capacity of the collectors that receive the overflows from the reservoirs and tanks in the implementation zone was checked.

The following criteria were considered for the database:

- Inflow to the reservoirs from the sub – sector: Qmd.
- The most unfavorable scenario has been considered when water flow coming in the reservoir is the maximum daily flow. In order not to over stress the collectors, a scenario in which maximum overflowing occurs is analyzed. Consumption and draining to sewerage network have been analyzed in order to define the highest water flow through overflow pipe, which will be defined by the maximum daily flow minus a minimal consumption flow. An evaluation flow of QMD – 0.25QP has been considered. In appendix B2 detailed calculation is shown..

The following criteria were considered for evaluation:

- As this is an unforeseeable and unfortunate event, and it requires immediate intervention, it is stated that the pipe can work at 100% capacity but not under pressure.
- If the hydraulic level is higher than 100% of the pipe hydraulic depth, this section is to be replaced. In some cases replacement with better type of material would be enough, keeping same dimension and slope of the pipe, in other cases, diameter and slope will be changed in order to improve the draining capacity.

Sewer Cad has been used for scenario simulation, and results are shown in Attachment B2.

Table 3.1.3-6 Hydraulic Capacity of Reservoirs Overflow Discharge Collectors in the Study Area (Data Base)

Section	Reservoir	Section From	Section To	Maximum flow Q max	DESIGN Elevation Cap Start	Elevation Cap End	Elevation Bottom Start	Elevation Bottom End	Elevation Height Start	Elevation Height End	Depth Start	Depth End	Height Start	Height End	Length L	Accum. Length Lac	Pipe slope S (per thousand)	Commercial Diameter	Material	Hydraulic Depth Relation y/D	Tractive Force t	Tractive Force (t>1 Pa)
		N°	N°	m^3/s	m.a.s.l.						m		m	m	m	m	%o	mm	-	-	Pa	
1	Virgen de las nieves	R	1	0.0368	35.11	34.97	33.98	33.83	33.98	33.83	1.13	1.14	0.00	0.00	14.26	14.26	10.52	200.00	PVC	0.70	6.113	OK
2	Virgen de las nieves	1	2	0.0368	34.97	32.95	33.08	32.92	33.08	32.92	1.89	0.03	0.00	0.00	22.87	22.87	7.00	250.00	CSN	0.64	4.907	OK
3	Virgen de las nieves	2	3	0.0368	32.95	35.02	32.92	32.61	32.92	32.61	0.03	2.41	0.00	0.00	56.37	56.37	5.50	250.00	CSN	0.69	3.979	OK
4	Rosario del norte	R	4	0.0176	44.9	44.87	43.35	43.03	43.35	43.03	1.55	1.84	0.00	0.00	29.5	29.50	10.85	200.00	PVC	0.43	4.804	OK
5	Rosario del norte	4	5	0.0176	44.87	44.9	43.03	42.39	43.03	42.39	1.84	2.51	0.00	0.00	58.74	58.74	10.90	250.00	CSN	0.36	5.000	OK
6	Rosario del norte	5	6	0.0176	44.9	44.12	42.39	41.65	42.39	41.65	2.51	2.47	0.00	0.00	113	113.00	6.55	250.00	CSN	0.41	3.503	OK
7	Rosario del norte	6	7	0.0176	44.12	43.33	41.65	41.17	41.65	41.17	2.47	2.16	0.00	0.00	77.26	77.26	6.21	250.00	CSN	0.42	3.383	OK
8	Rosario del norte	7	8	0.0176	43.33	43.2	41.17	40.7	41.17	40.70	2.16	2.50	0.00	0.00	57.82	57.82	8.13	250.00	CSN	0.39	4.188	OK
9	Rosario del norte	8	9	0.0176	43.2	42.89	40.7	40.3	40.70	40.30	2.50	2.59	0.00	0.00	53.64	53.64	7.46	250.00	CSN	0.40	3.917	OK
10	Rosario del norte	9	10	0.0176	42.89	42.77	40.3	39.95	40.30	39.95	2.59	2.82	0.00	0.00	47.03	47.03	7.44	250.00	CSN	0.40	3.910	OK
11	Rosario del norte	10	11	0.0176	42.77	42.42	39.95	39.57	39.95	39.57	2.82	2.85	0.00	0.00	54.24	54.24	7.01	250.00	CSN	0.41	3.747	OK
12	Rosario del norte	11	12	0.0176	42.42	41.95	39.57	39.11	39.57	39.11	2.85	2.84	0.00	0.00	62.02	62.02	7.42	250.00	CSN	0.40	3.896	OK
13	Rosario del norte	12	13	0.0176	41.95	41.67	39.11	38.6	39.11	38.60	2.84	3.07	0.00	0.00	64.97	64.97	7.85	250.00	CSN	0.39	4.045	OK
14	Rosario del norte	13	14	0.0176	41.67	41.06	38.6	38.09	38.60	38.09	3.07	2.97	0.00	0.00	47.26	47.26	10.79	250.00	CSN	0.36	5.235	OK
15	Rosario del norte	14	15	0.0176	41.06	40.36	38.09	37.58	38.09	37.58	2.97	2.78	0.00	0.00	52.3	52.30	9.75	250.00	CSN	0.37	4.831	OK
16	Rosario del norte	15	16	0.0176	40.36	39.62	37.58	37.07	37.58	37.07	2.78	2.55	0.00	0.00	46.28	46.28	11.02	300.00	CSN	0.28	5.234	OK
17	Rosario del norte	16	17	0.0176	39.62	39.16	37.07	36.56	37.07	36.56	2.55	2.60	0.00	0.00	56.57	56.57	9.02	300.00	CSN	0.29	4.410	OK
18	Rosario del norte	17	18	0.0176	39.16	38.43	36.56	36.05	36.56	36.05	2.60	2.38	0.00	0.00	56.57	56.57	9.02	300.00	CSN	0.29	4.410	OK
19	Rosario del norte	18	19	0.0176	38.43	38.06	36.05	35.37	36.05	35.37	2.38	2.69	0.00	0.00	46.57	46.57	14.60	300.00	CSN	0.26	6.515	OK
20	Rosario del norte	19	20	0.0176	38.06	37.69	35.37	34.85	35.37	34.85	2.69	2.84	0.00	0.00	30.31	30.31	17.16	300.00	CSN	0.25	7.402	OK
21	Virgen del rosario	R	21	0.0226	49	48.85	46.95	46.75	46.95	46.75	2.05	2.10	0.00	0.00	24.36	24.36	8.21	250.00	PVC	0.39	4.230	OK
22	Virgen del rosario	21	22	0.0226	48.85	47.66	46.75	46.17	46.75	46.17	2.10	1.49	0.00	0.00	86.24	86.24	6.73	250.00	PVC	0.41	3.597	OK
23	Virgen del rosario	22	23	0.0226	47.66	47.52	46.17	46.02	46.17	46.02	1.49	1.50	0.00	0.00	21.92	21.92	6.84	250.00	PVC	0.41	3.660	OK
24	Virgen del rosario	23	24	0.0226	47.52	47.51	46.02	45.84	46.02	45.84	1.50	1.67	0.00	0.00	25.55	25.55	7.05	250.00	PVC	0.40	3.701	OK
25	Virgen del rosario	24	25	0.0226	47.51	47.24	45.84	45.61	45.84	45.61	1.67	1.63	0.00	0.00	30.01	30.01	7.66	250.00	PVC	0.39	3.949	OK
26	Virgen del rosario	25	26	0.0226	47.24	46.71	45.61	45.12	45.61	45.12	1.63	1.59	0.00	0.00	53.07	53.07	9.23	250.00	PVC	0.37	4.574	OK
27	Virgen del rosario	26	27	0.0226	46.71	46.37	45.12	44.61	45.12	44.61	1.59	1.76	0.00	0.00	69.61	69.61	7.33	250.00	PVC	0.40	3.849	OK
28	Virgen del rosario	27	28	0.0226	46.37	45.72	44.61	44.07	44.61	44.07	1.76	1.65	0.00	0.00	55.62	55.62	9.71	250.00	PVC	0.37	4.810	OK
29	Virgen del rosario	28	29	0.0226	45.72	45.38	44.07	43.77	44.07	43.77	1.65	1.61	0.00	0.00	38.1	38.10	7.87	250.00	PVC	0.39	4.057	OK
30	Virgen del rosario	29	30	0.0226	45.38	45.04	43.77	43.68	43.77	43.68	1.61	1.36	0.00	0.00	18.67	18.67	4.82	250.00	PVC	0.45	2.756	OK
31	Virgen del rosario	30	31	0.0226	45.04	44.65	43.68	42.88	43.68	42.88	1.36	1.77	0.00	0.00	81.15	81.15	9.86	250.00	PVC	0.37	4.884	OK
32	Virgen del rosario	31	32	0.0226	44.65	44.37	42.88	42.73	42.88	42.73	1.77	1.64	0.00	0.00	28.86	28.86	5.20	200.00	PVC	0.63	2.895	OK
33	Virgen del rosario	32	33	0.0226	44.37	43.5	42.73	41.94	42.73	41.94	1.64	1.56	0.00	0.00	62.68	62.68	12.60	250.00	PVC	0.34	5.845	OK
34	Jazmines del naranjal	R	34	0.0155	46.98	46.58	45.79	45.19	45.79	45.19	1.19	1.39	0.00	0.00	52	52.00	11.54	200.00	PVC	0.40	4.849	OK
35	Jazmines del naranjal	34	35	0.0155	46.58	46.28	45.19	44.71	45.19	44.71	1.39	1.57	0.00	0.00	76.71	76.71	6.26	200.00	PVC	0.47	2.946	OK
36	Jazmines del naranjal	35	36	0.0155	46.28	46.36	44.71	43.95	44.71	43.95	1.57	2.41	0.00	0.00	54.33	54.33	13.99	200.00	PVC	0.38	5.657	OK
37	Jazmines del naranjal	36	37	0.0155	46.36	46.12	43.95	43.3	43.95	43.30	2.41	2.82	0.00	0.00	57.69	57.69	11.27	200.00	PVC	0.40	4.735	OK
38	Jazmines del naranjal	37	38	0.0155	46.12	45.33	43.3	41.69	43.30	41.69	2.82	3.64	0.00	0.00	62.72	62.72	25.67	300.00	CSN	0.21	9.511	OK
39	Jazmines del naranjal	38	39	0.0155	45.33	45.26	41.69	41.4	41.69	41.40	3.64	3.86	0.00	0.00	31.38	31.38	9.24	300.00	CSN	0.27	4.259	OK
40	Cueto Fernandini	R	40	0.0615	58.91	58.71	57.44	57.19	57.44	57.19	1.47	1.52	0.00	0.00	25.19	25.19	9.92	250.00	PVC	0.67	7.100	OK
41	Cueto Fernandini	40	41	0.0615	58.71	58.27	57.19	56.87	57.19	56.87	1.52	1.40	0.00	0.00	36.07	36.07	8.87	250.00	PVC	0.70	6.445	OK
42	Cueto Fernandini	41	42	0.0615	58.27	57.88	56.87	56.55	56.87	56.55	1.40	1.33	0.00	0.00	32.12	32.12	9.96	250.00	PVC	0.67	7.127	OK
43	Cueto Fernandini	42	43	0.0615	57.88	57.88	56.55	56.3	56.55	56.30	1.33	1.58	0.00	0.00	26.52	26.52	9.43	250.00	PVC	0.68	6.786	OK
44	Cueto Fernandini	43	44	0.0615	57.88	57.48	56.3	55.87	56.30	55.87	1.58	1.61	0.00	0.00	42.28	42.28	10.17	250.00	PVC	0.66	7.231	OK
45	Cueto Fernandini	44	45	0.0615	57.48	57.23	55.87	55.46	55.87	55.46	1.61	1.77	0.00	0.00	45.48	45.48	9.01	250.00	PVC	0.70	6.549	OK
46	Parque naranjal	R	46	0.0194	64	63.73	61.96	61.54	61.96	61.54	2.04	2.19	0.00	0.00	35.94	35.94	11.69	200.00	PVC	0.45	5.345	OK
47	Parque naranjal	46	47	0.0194	63.73	63.45	61.54	60.92	61.54	60.92	2.19	2.53	0.00	0.00	36.94	36.94	16.78	200.00	PVC	0.40	7.054	OK
48	Parque naranjal	47	48	0.0194	63.45	63.21	60.92	60.49	60.92	60.49	2.53	2.72	0.00	0.00	36.74	36.74	11.70	200.00	PVC	0.45	5.353	OK
49	Parque naranjal	48	49	0.0194	63.21	62.9	60.49	60.18	60.49	60.18	2.72	2.72	0.00	0.00	35.04	35.04	8.85	200.00	PVC	0.48	4.225	OK
50	Parque naranjal	49	50	0.0194	62.9	62.31	60.18	59.91	60.18	59.91	2.72	2.40	0.00	0.00	36.44	36.44	7.41	200.00	PVC	0.51	3.679	OK
51	Parque naranjal	50	51	0.0194	62.31	61.86	59.91	59.33	59.91	59.33	2.40	2.53	0.00	0.00	69.85	69.85	8.30	200.00	PVC	0.49	4.019	OK
52	Parque naranjal	51	52	0.0194	61.86	61.49	59.33	59	59.33	59.00	2.53	2.49	0.00	0.00	52.19	52.19	6.32	200.00	PVC	0.54	3.250	OK
53	Parque naranjal	52	53	0.0194	61.49	61.1	59	58.49	59.00	58.49	2.49	2.61	0.00	0.00	71.04	71.04	7.18	200.00	PVC	0.52	3.607	OK
54	Parque naranjal	53	54	0.0194	61.1	60.69	58.49	58.12	58.49	58.12	2.61	2.57	0.00	0.00	51.89	51.89	7.13	200.00	PVC	0.52	3.583	OK
55	Parque naranjal	54	55	0.0194	60.69	60.4	58.37	57.96	58.37	57.96	2.32	2.44	0.00	0.00	52.98	52.98	7.74	200.00	PVC	0.50	3.796	OK

Section	Reservoir	Section		Maximum flow	DESIGN																	
					Elevation						Depth		Height		Length	Accum. Length	Pipe slope	Commercial Diameter	Material	Hydraulic Depth Relation	Tractive Force	Tractive Force (t>1 Pa)
					Cap		Bottom		Height													
		From	To	Q max	Start	End	Start	End	Start	End	Start	End	Start	End	L	Lac	S (per thousand)			y/D	t	
		N°	N°	m^3/s	m.a.s.l.						m		m	m	m	m	%o	mm	-	-	Pa	
56	Comité Aposte	R	56	0.0169																		
57	Comité Aposte	56	57	0.0169	59.67	59.28	58.22	57.68	58.22	57.68	1.45	1.60	0.00	0.00	40.25	40.25	13.42	200.00	PVC	0.40	5.638	OK
58	Comité Aposte	57	58	0.0169	59.28	58.9	57.68	57.21	57.68	57.21	1.60	1.69	0.00	0.00	43.21	43.21	10.88	200.00	PVC	0.42	4.738	OK
59	Comité Aposte	58	59	0.0169	58.9	58.57	57.21	56.72	57.21	56.72	1.69	1.85	0.00	0.00	56.14	56.14	8.73	200.00	PVC	0.45	3.992	OK
60	Comité Aposte	59	60	0.0169	58.57	58.12	56.72	56.24	56.72	56.24	1.85	1.88	0.00	0.00	58.44	58.44	8.21	250.00	CSN	0.37	4.134	OK
61	Comité Aposte	60	61	0.0169	58.12	58.04	56.24	55.88	56.24	55.88	1.88	2.16	0.00	0.00	55.41	55.41	6.50	250.00	CSN	0.40	3.468	OK
62	Comité Aposte	61	62	0.0169	58.04	58.6	55.88	55.6	55.88	55.60	2.16	3.00	0.00	0.00	32.34	32.34	8.66	250.00	CSN	0.37	4.358	OK
63	Patria nueva	R	63	0.0615	84.69	78.1	83.9	77.13	83.90	77.13	0.79	0.97	0.00	0.00	48.75	48.75	138.87	200.00	PVC	0.43	61.496	OK
64	Patria nueva	63	64	0.0615	78.1	76.88	77.13	76.34	77.13	76.34	0.97	0.54	0.00	0.00	10.12	10.12	78.06	200.00	PVC	0.50	38.290	OK
65	Patria nueva	64	65	0.0615	76.88	72.45	76.34	71.8	76.34	71.80	0.54	0.65	0.00	0.00	16.27	16.27	279.04	200.00	PVC	0.35	105.937	OK
66	Patria nueva	65	66	0.0615	72.45	68.44	71.8	67.74	71.80	67.74	0.65	0.70	0.00	0.00	15.92	15.92	255.03	200.00	PVC	0.36	98.971	OK
67	Patria nueva	66	67	0.0615	68.44	65.3	67.74	64.52	67.74	64.52	0.70	0.78	0.00	0.00	10.09	10.09	319.13	200.00	PVC	0.34	118.401	OK
68	Patria nueva	67	68	0.0615	65.3	58.16	64.52	57.46	64.52	57.46	0.78	0.70	0.00	0.00	14.36	14.36	491.64	200.00	PVC	0.30	164.851	OK
69	Patria nueva	68	69	0.0615	58.16	57.07	57.46	55.75	57.46	55.75	0.70	1.32	0.00	0.00	14.36	14.36	119.08	200.00	PVC	0.45	54.461	OK
70	Patria nueva	69	70	0.0615	57.07	57.04	55.75	54.8	55.75	54.80	1.32	2.24	0.00	0.00	49.38	49.38	19.24	200.00	PVC	0.86	11.422	OK
71	Patria nueva	70	71	0.0615	57.04	55.54	54.8	53.94	54.80	53.94	2.24	1.60	0.00	0.00	34.48	34.48	24.94	200.00	PVC	0.75	14.764	OK
72	Cisterna Patria nueva	C	72	0.0879	57.45	56.97	56.1	55.74	56.10	55.74	1.35	1.23	0.00	0.00	30	30.00	12.00	250.00	PVC	0.85	8.926	OK
73	Cisterna Patria nueva	72	73	0.0879	56.97	55.53	55.74	54.33	55.74	54.33	1.23	1.20	0.00	0.00	74.51	74.51	18.92	250.00	PVC	0.69	13.691	OK
74	Cisterna Patria nueva	73	74	0.0879	55.53	54.85	54.33	53.55	54.33	53.55	1.20	1.30	0.00	0.00	66.01	66.01	11.82	250.00	PVC	0.86	8.769	OK
75	Cisterna Patria nueva	74	75	0.0879	54.85	53.77	53.55	52.27	53.55	52.27	1.30	1.50	0.00	0.00	58.65	58.65	21.82	250.00	PVC	0.65	15.420	OK
76	Villa del norte	R	76	0.0401	68.7	68.42	67.12	66.68	67.12	66.68	1.58	1.74	0.00	0.00	33.71	33.71	13.05	200.00	PVC	0.69	7.555	OK
77	Villa del norte	76	77	0.0401	68.42	67.96	66.68	65.98	66.68	65.98	1.74	1.98	0.00	0.00	66.26	66.26	10.56	200.00	PVC	0.75	6.253	OK
78	Villa del norte	77	78	0.0401	67.96	67.58	65.98	65.4	65.98	65.40	1.98	2.18	0.00	0.00	56.9	56.90	10.19	200.00	PVC	0.76	6.050	OK
79	Villa del norte	78	79	0.0401	67.58	67.01	65.4	65	65.40	65.00	2.18	2.01	0.00	0.00	44.29	44.29	9.03	200.00	PVC	0.80	5.390	OK
80	Villa del norte	79	80	0.0401	67.01	66.08	65	64.68	65.00	64.68	2.01	1.40	0.00	0.00	12.61	12.61	25.38	200.00	PVC	0.55	13.189	OK
81	Villa del norte	80	81	0.0401	66.08	66.08	64.68	63.55	64.68	63.55	1.40	2.53	0.00	0.00	49.54	49.54	22.81	200.00	PVC	0.57	12.097	OK
82	Confraternidad 2	R	82	0.0286	78.42	78.21	76.95	76.51	76.95	76.51	1.47	1.70	0.00	0.00	41.8	41.80	10.53	200.00	PVC	0.59	5.686	OK
83	Confraternidad 2	82	83	0.0286	78.21	78.11	76.51	76.25	76.51	76.25	1.70	1.86	0.00	0.00	13.47	13.47	19.30	200.00	PVC	0.49	9.343	OK
84	Confraternidad 2	83	84	0.0286	78.11	77.77	76.25	75.89	76.25	75.89	1.86	1.88	0.00	0.00	35.38	35.38	10.18	200.00	PVC	0.59	5.496	OK
85	Confraternidad 2	84	85	0.0286	77.77	77.35	75.89	75.5	75.89	75.50	1.88	1.85	0.00	0.00	49.76	49.76	7.84	200.00	PVC	0.65	4.430	OK
86	Confraternidad 2	85	86	0.0286	77.35	78.09	75.5	75.1	75.50	75.10	1.85	2.99	0.00	0.00	49.91	49.91	8.01	200.00	PVC	0.64	4.497	OK
87	Confraternidad 2	86	87	0.0286	78.09	76.84	75.1	74.7	75.10	74.70	2.99	2.14	0.00	0.00	48.88	48.88	8.18	200.00	PVC	0.64	4.592	OK
88	Confraternidad 2	87	88	0.0286	76.84	76.68	74.7	74.19	74.70	74.19	2.14	2.49	0.00	0.00	34.3	34.30	14.87	200.00	PVC	0.52	7.471	OK
89	Río Santa	R	89	0.0226	88.55	88.26	87.3	85.57	87.30	85.57	1.25	2.69	0.00	0.00	27	27.00	64.07	200.00	PVC	0.31	22.063	OK
90	Río Santa	89	90	0.0226	88.26	87.69	84.97	84.3	84.97	84.30	3.29	3.39	0.00	0.00	50.02	50.02	13.39	200.00	PVC	0.47	6.307	OK
91	Río Santa	90	91	0.0226	87.69	87.57	85.3	83.97	85.30	83.97	2.39	3.60	0.00	0.00	56.8	56.80	23.42	200.00	PVC	0.40	9.841	OK
92	Río Santa	91	92	0.0226	87.57	86.58	85.76	83.68	85.76	83.68	1.81	2.90	0.00	0.00	54.6	54.60	38.10	200.00	PVC	0.35	14.463	OK
93	Río Santa	92	93	0.0226	86.58	85.59	83.68	83.29	83.68	83.29	2.90	2.30	0.00	0.00	51.82	51.82	7.53	200.00	PVC	0.56	3.951	OK
94	Santa Luísa	R	94	0.0167	94.43	95.28	91.57	91.26	91.57	91.26	2.86	4.02	0.00	0.00	36	36.00	8.61	350.00	CSN	0.21	4.052	OK
95	Santa Luísa	94	95	0.0167	94.43	95.28	91.26	91.03	91.26	91.03	3.17	4.25	0.00	0.00	42.52	42.52	5.41	350.00	CSN	0.23	2.758	OK
96	Puerta de Pro	96	97	0.0316	102.32	100.54	101.17	99.54	101.17	99.54	1.15	1.00	0.00	0.00	65	65.00	25.08	200.00	PVC	0.48	11.976	OK
97	Puerta de Pro	97	98	0.0316	100.54	96.33	99.54	95.44	99.54	95.44	1.00	0.89	0.00	0.00	12.08	12.08	339.40	200.00	PVC	0.24	94.293	OK
98	Puerta de Pro	98	99	0.0316	96.33	93.28	95.44	92.06	95.44	92.06	0.89	1.22	0.00	0.00	10.45	10.45	323.44	200.00	PVC	0.24	89.859	OK
99	Puerta de Pro	99	100	0.0316	93.28	92.31	92.06	90.98	92.06	90.98	1.22	1.33	0.00	0.00	11.02	11.02	98.00	200.00	PVC	0.33	35.534	OK
100	Puerta de Pro	100	101	0.0316	92.31	91.5	90.98	89.89	90.98	89.89	1.33	1.61	0.00	0.00	30.46	30.46	35.78	200.00	PVC	0.43	15.846	OK
101	Puerta de Pro	101	102	0.0316	91.5	90.25	89.89	88.79	89.89	88.79	1.61	1.46	0.00	0.00	30.14	30.14	36.50	200.00	PVC	0.43	16.161	OK
102	Puerta de Pro	102	103	0.0316	90.25	88.3	88.79	86.8	88.79	86.80	1.46	1.50	0.00	0.00	43.16	43.16	46.11	200.00	PVC	0.40	19.377	OK
103	Olivos de Pro			0.0000																		
104	Olivos de Pro	104	105	0.0425	83.08	82.88	80.95	79.4	80.95	79.40	2.13	3.48	0.00	0.00	120.13	120.13	12.90	250.00	CSN	0.56	8.603	OK
105	Olivos de Pro	105	106	0.0425	81	79.9	79.4	78.6	79.40	78.60	1.60	1.30	0.00	0.00	35.07	35.07	22.81	250.00	CSN	0.47	13.642	OK
106	Olivos de Pro	106	107	0.0425	79.9	78.18	78.6	76.97	78.60	76.97	1.30	1.21	0.00	0.00	46.54	46.54	35.02	200.00	PVC	0.51	17.392	OK
107	Olivos de Pro	107	108	0.0425	78.18	78.26	76.97	76.5	76.97	76.50	1.21	1.76	0.00	0.00	18.63	18.63	25.23	200.00	PVC	0.57	13.379	OK
108	Pro	109	110	0.0930	93.5	92.1	90.5	90.2	90.50	90.20	3.00	1.90	0.00	0.00	16.4	16.40	18.29	300.00	CSN	0.60	15.194	OK
109	Pro	110	111	0.0930	92.1	90.97	90.2	88.75	90.20	88.75	1.90	2.22	0.00	0.00	82.61	82.61	17.55	300.00	CSN	0.61	14.689	OK
110	Pro	111	112	0.0930	90.97	89.19	88.75	87.97	88.75	87.97	2.22	1.22	0.00	0.00	71.17	71.17	10.96	300.00	CSN	0.72	9.785	OK

Section	Reservoir	Section		Maximum flow	DESIGN																		
					Elevation						Depth		Height		Length	Accum. Length	Pipe slope	Commercial Diameter	Material	Hydraulic Depth Relation	Tractive Force	Tractive Force (t>1 Pa)
					Cap		Bottom		Height													
		From	To	Q max	Start	End	Start	End	Start	End	Start	End	Start	End	L	Lac	S (per thousand)			y/D	t	
		N°	N°	m^3/s	m.a.s.l.						m		m	m	m	m	%o	mm	-	-	Pa	
111	Pro	112	113	0.0930	89.19	87.97	87.97	86.42	87.97	86.42	1.22	1.55	0.00	0.00	65.82	65.82	23.55	300.00	CSN	0.55	18.665	OK
112	Reservorio nueva esperanza	114	115	0.0103	355.2	350.57	352.34	349.72	352.34	349.72	2.86	0.85	0.00	0.00	22.48	22.48	116.55	200.00	PVC	0.18	25.085	OK
113	Reservorio nueva esperanza	115	116	0.0103	350.57	342.87	349.72	341.77	349.72	341.77	0.85	1.10	0.00	0.00	16.12	16.12	493.18	200.00	PVC	0.12	72.958	OK
114	Reservorio nueva esperanza	116	117	0.0103	342.87	334.97	341.77	333.82	341.77	333.82	1.10	1.15	0.00	0.00	20.44	20.44	388.94	200.00	PVC	0.13	62.041	OK
115	Reservorio nueva esperanza	117	118	0.0103	334.97	327.07	333.82	325.87	333.82	325.87	1.15	1.20	0.00	0.00	17.17	17.17	463.02	200.00	PVC	0.12	68.496	OK
116	Reservorio nueva esperanza	118	119	0.0103	327.07	319.52	325.87	317.92	325.87	317.92	1.20	1.60	0.00	0.00	8.1	8.10	981.48	200.00	PVC	0.10	122.280	OK
117	Reservorio nueva esperanza	119	120	0.0103	319.52	311.32	317.92	309.97	317.92	309.97	1.60	1.35	0.00	0.00	13.84	13.84	574.42	200.00	PVC	0.12	84.977	OK
118	Reservorio nueva esperanza	120	121	0.0103	311.32	303.28	309.97	302.02	309.97	302.02	1.35	1.26	0.00	0.00	44.41	44.41	179.01	200.00	PVC	0.16	34.631	OK
119	Reservorio nueva esperanza	121	122	0.0103	303.28	297.71	302.02	296.27	302.02	296.27	1.26	1.44	0.00	0.00	40.03	40.03	143.64	200.00	PVC	0.17	29.366	OK
120	Reservorio nueva esperanza	122	123	0.0103	297.71	291.92	296.27	290.48	296.27	290.48	1.44	1.44	0.00	0.00	46.24	46.24	125.22	200.00	PVC	0.17	25.599	OK
121	Der1.7	124	125	0.0315	162.89	162.22	160.82	159.98	160.82	159.98	2.07	2.24	0.00	0.00	42.75	42.75	19.65	450.00	CSN	0.18	9.664	OK
122	Der1.7	125	126	0.0315	162.22	155.86	159.98	154.09	159.98	154.09	2.24	1.77	0.00	0.00	182.02	182.02	32.36	450.00	CSN	0.16	14.304	OK
123	Der1.7	126	127	0.0315	155.86	153.27	154.09	151.64	154.09	151.64	1.77	1.63	0.00	0.00	81.7	81.70	29.99	450.00	CSN	0.16	13.256	OK
124	El pinar R1	128	129	0.0166	153	151.56	148.75	148.29	148.75	148.29	4.25	3.27	0.00	0.00	61.48	61.48	7.48	350.00	CSN	0.21	3.521	OK
125	El pinar R1	129	130	0.0166	151.56	151.07	148.29	147.98	148.29	147.98	3.27	3.09	0.00	0.00	62.48	62.48	4.96	350.00	CSN	0.24	2.626	OK
126	El pinar R1	124	131	0.0166	151.07	150.22	147.98	147.51	147.98	147.51	3.09	2.71	0.00	0.00	88.55	88.55	5.31	350.00	CSN	0.23	2.706	OK
127	Alborada R2	132	133	0.0228		163.1	161.88	161.28	161.88	161.28		1.82	0.00	0.00	9.67	9.67	62.05	200.00	PVC	0.31	21.365	OK
128	Alborada R2	133	134	0.0228	163.1	162.48	161.48	161.28	161.48	161.28	1.62	1.20	0.00	0.00	16.58	16.58	12.06	200.00	PVC	0.49	5.839	OK
129	Alborada R2	134	135	0.0228	162.48	162.13	161.28	160.92	161.28	160.92	1.20	1.21	0.00	0.00	48.77	48.77	7.38	200.00	PVC	0.57	3.915	OK
130	Alborada R2	135	136	0.0228	162.13	162.41	160.92	160.43	160.92	160.43	1.21	1.98	0.00	0.00	66.51	66.51	7.37	200.00	PVC	0.57	3.907	OK
131	Alborada R2	136	137	0.0228	162.41	162.56	160.43	160.28	160.43	160.28	1.98	2.28	0.00	0.00	11.41	11.41	13.15	200.00	PVC	0.48	6.278	OK
132	Collique R4	138	139	0.0142	314.83	311.15	313.33	309.94	313.33	309.94	1.50	1.21	0.00	0.00	48.13	48.13	70.43	200.00	PVC	0.23	18.849	OK
133	Collique R4	139	140	0.0142	311.15	305.26	309.94	303.6	309.94	303.60	1.21	1.66	0.00	0.00	53.83	53.83	117.78	200.00	PVC	0.21	29.093	OK
134	Collique R4	140	141	0.0142	305.26	300.32	303.6	298.47	303.60	298.47	1.66	1.85	0.00	0.00	45.75	45.75	112.13	200.00	PVC	0.21	27.698	OK
135	Collique R4	141	142	0.0142	300.32	294.64	298.47	293.4	298.47	293.40	1.85	1.24	0.00	0.00	56.82	56.82	89.23	200.00	PVC	0.22	22.969	OK
136	Collique R4	142	143	0.0142	294.64	286.26	293.4	284.24	293.40	284.24	1.24	2.02	0.00	0.00	49.87	49.87	183.68	200.00	PVC	0.18	39.533	OK
137	R5-CR	144	145	0.0121	334.92	334.32	333.15	332.83	333.15	332.83	1.77	1.49	0.00	0.00	22	22.00	14.55	200.00	PVC	0.32	5.140	OK
138	R5-CR	145	146	0.0121	334.32	333.84	332.83	331.41	332.83	331.41	1.49	2.43	0.00	0.00	28.44	28.44	49.93	200.00	PVC	0.24	13.871	OK
139	Collique R6	147	148	0.0152		369.03	369.1	367.82	369.10	367.82		1.21	0.00	0.00	45.99	45.99	27.83	200.00	PVC	0.31	9.583	OK
140	Collique R6	148	149	0.0152	369.03	369.45	367.82	367.15	367.82	367.15	1.21	2.30	0.00	0.00	43.98	43.98	15.23	200.00	PVC	0.36	5.912	OK
141	Collique R6	149	150	0.0152	369.45	371.38	367.15	366.46	367.15	366.46	2.30	4.92	0.00	0.00	36.1	36.10	19.11	200.00	PVC	0.34	7.091	OK
142	Collique R6	150	151	0.0152	371.38	367.13	367.46	365.76	367.46	365.76	3.92	1.37	0.00	0.00	43.33	43.33	39.23	200.00	PVC	0.28	12.424	OK
143	Collique R7	152	153	0.0155	414.22	412.86	412.65	411.14	412.65	411.14	1.57	1.72	0.00	0.00	49.4	49.40	30.57	200.00	PVC	0.31	10.525	OK
144	Collique R7	153	154	0.0155	412.86	409.07	411.14	407.73	411.14	407.73	1.72	1.34	0.00	0.00	50.4	50.40	67.66	200.00	PVC	0.25	19.461	OK
145	Collique R7	154	155	0.0155	409.07	406.97	407.73	405.48	407.73	405.48	1.34	1.49	0.00	0.00	30	30.00	75.00	200.00	PVC	0.24	20.836	OK
146	Collique R7	155	156	0.0155	406.97	405.52	405.48	403.49	405.48	403.49	1.49	2.03	0.00	0.00	60	60.00	33.17	200.00	PVC	0.30	11.121	OK
147	Collique R7	156	157	0.0155	405.52	400.08	403.49	398.85	403.49	398.85	2.03	1.23	0.00	0.00	64.12	64.12	72.36	200.00	PVC	0.24	20.104	OK
148	Collique R7	157	158	0.0155	400.08	396.2	398.85	393.76	398.85	393.76	1.23	2.44	0.00	0.00	69.3	69.30	73.45	200.00	PVC	0.24	20.405	OK
149	Confraternidad	R	159	0.0379	71.36	70.15	69.5	69.09	69.50	69.09	1.86	1.06	0.00	0.00	20	20.00	20.50	200.00	PVC	0.57	10.872	OK
150	Confraternidad	159	160	0.0379	70.15	70.38	69.09	68.56	69.09	68.56	1.06	1.82	0.00	0.00	64.81	64.81	8.18	200.00	PVC	0.80	4.881	OK
151	Confraternidad	160	161	0.0379	70.38	69.66	68.56	68.06	68.56	68.06	1.82	1.60	0.00	0.00	53.49	53.49	9.35	250.00	PVC	0.75	5.533	OK
152	Confraternidad	161	162	0.0379	69.66	69	68.06	67.1	68.06	67.10	1.60	1.90	0.00	0.00	50.1	50.10	19.16	250.00	PVC	0.58	10.256	OK
153	Confraternidad	162	163	0.0379	69	69.03	67.1	66.86	67.10	66.86	1.90	2.17	0.00	0.00	22.12	22.12	10.85	200.00	PVC	0.71	6.329	OK
154	Confraternidad	163	164	0.0379	69.03	68.44	66.86	66.09	66.86	66.09	2.17	2.35	0.00	0.00	49.95	49.95	15.42	250.00	PVC	0.62	8.523	OK
155	Confraternidad	164	165	0.0379	68.44	67.3	66.09	65.3	66.09	65.30	2.35	2.00	0.00	0.00	52.11	52.11	15.16	250.00	PVC	0.63	8.444	OK

Source: JICA Study Team

3.2 Supply Analysis

3.2.1 Water Supply

(1) Target Items of Analysis

The water supply system can be divided into two separate main sub-systems, which are water production and water distribution. The water production supply can be represented by the volume of water resources and the capacity of the water treatment plant. The water distribution supply can be represented by the capacity of pipeline and the storage capacity of reservoirs. It is not necessary to explain the pipeline´s capacity here because the existing and planned pipes related to water distribution in the Study area will be analyzed within the hydraulic calculation, and the Study will plan for a distribution network with enough capacity, which is explained in Section 3.4.

(2) Water Resources and Production

1) General Description of Current Water Supply

At present, SEDAPAL has two water treatment plants, which are the La Atarjea Water Treatment Plant (La Atarjea WTP) and the Chillón Water Treatment Plant (Chillón WTP). The La Atarjea WTP has a capacity of 17.5 m^3/s, and its water source is the Rímac River. The Chillón WTP has capacity of 2.5 m^3/s, and its water source is the Chillón River.

Capacity and actual production of the WTPs and the wells are shown in Table 3.2.1-1. Distribution areas of the La Atarjea WTP and the Chillón WTP in the Project´s Area of Influence are presented in Figure 3.2.1-1. As shown in the table, the Chillón WTP is producing much less than its capacity because of low river flow from December to March. Existing wells, called the Chillón wells, are supplementing the water supply, especially during the dry season.

At present, the area with existing networks in the Study Area is receiving its water supply from the two WTPs above and from wells. The water distribution system from the La Atarjea WTP is mainly supplying water to the southern part of the area, which includes the Callao, Los Olivos, and San Martín de Porres districts. The water distribution system from the Chillón WTP, on the other hand, is mainly supplying water to the northern part of the area, which includes the Comas, Carabayllo, and Puente Piedra districts.

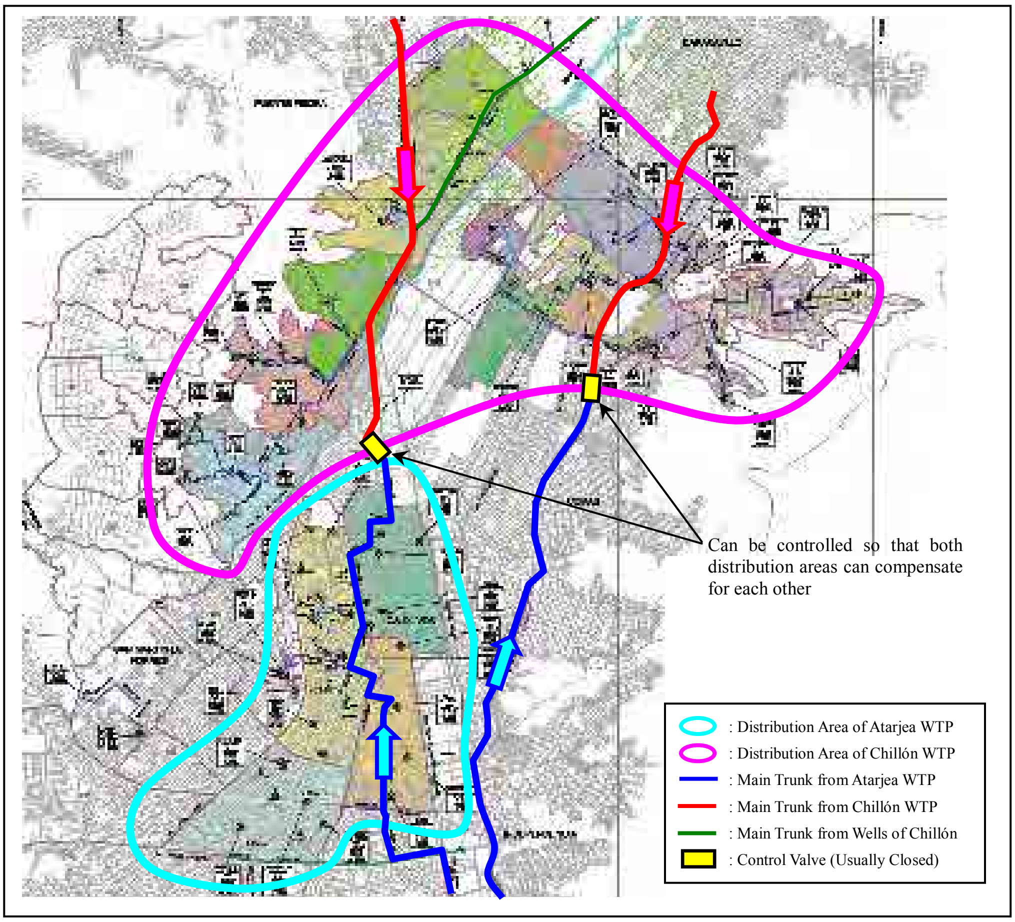
It is noted that the two distribution networks are connected with each other so that they can compensate the other’s production when it is not enough.

Out of the approximately 20m^3/s of total production, supply to the Project´s Area of Influence is estimated to be an average of 1.13m^3/s using consumption data from the SEDAPAL cadastre and the current water loss ratio.

Table 3.2.1-1: Capacity and Current Production of SEDAPAL WTPs and Wells

<table>
<tr><th colspan="2">Facility</th><th>Capacity (m^3/s)</th><th>Estimated Average Supply to the Study Area (m^3/s)*1</th></tr>
<tr><td rowspan="3">WTP</td><td>La Atarjea WTP</td><td>17.5</td><td>0.61*2</td></tr>
<tr><td>Chillón WTP</td><td>2.5</td><td rowspan="4">0.52*2</td></tr>
<tr><td>Total</td><td>20.0</td></tr>
<tr><td rowspan="2">Wells</td><td>Chillón Wells</td><td>-</td></tr>
<tr><td>Other Wells</td><td>-</td></tr>
<tr><td colspan="3">**TOTAL**</td><td>**1.13**</td></tr>
</table>

*1: Estimated from SEDAPAL's cadastre and current effectiveness ratio
*2: Estimated from water consumption and water loss ratio, but the supply by the interconnection is not considered.
Source: JICA Study Team



Source: JICA Study Team

Figure 3.2.1-1: Distribution Area of La Atarjea and Chillón WTPs

2) Enhancement Plan of Water Production

As explained in 2.5.8(4), SEDAPAL is constructing the Huachipa WTP under the project "Huachipa Water Treatment Plant Project-Lima North Main", funded by JICA. The Huachipa WTP will supply 5 m^3/s of water to the North Lima Area through a main transmission pipe, which is also being constracted simultaneously.

In addition, SEDAPAL has planned some other projects to increase water production, and they have announced their intention to execute some of the projects in the 2009 Master Plan. However, as explained in 2.5.8 (4), the implementation schedule is not shown in the Master Plan.

3) Water Distribution Plan for Huachipa WTP

(a) Plan for Huachipa WTP (Huachipa Water Treatment Plant Project-Lima North Main)

According to the Huachipa WTP design, the planned distribution to the Lima Norte I and Lima Norte II Areas is a total of $2.9m^3/s$. Respective water demands in the Lima Norte I and Lima Norte II Areas are not clear in the plan, but it can be estimated based on their areas as $0.8m^3/s$ and $2.1m^3/s$, respectively.

More detailed information on the distribution plan was explained in 2.5.8 (5).

(b) Plan of Lima Norte I Project

According to the feasibility study of the Lima Norte I Project, water demand in the area to be fed by the Huachipa WTP was forecasted as shown in Table 3.2.1-2.

It is noted that the forecasted water demand for the target period increased significantly to $1.31m^3/s$ from $0.8m^3/s$, which is the estimated value of water demand applied in the Huachipa Water Treatment Plant Project-Lima North Main.

Table 3.2.1-2: Water Demand Forecast in Area of Influence of Huachipa WTP of Lima Norte I Project

Year		Water Demand (Daily Maximum: m^3/s)
1	2011	1.006
2	2012	1.025
3	2013	1.041
4	2014	1.057
5	2015	1.073
6	2016	1.089
7	2017	1.104
8	2018	1.118
9	2019	1.134
10	2020	1.150
11	2021	1.164
12	2022	1.180
13	2023	1.196
14	2024	1.211
15	2025	1.228
16	2026	1.244
17	2027	1.261
18	2028	1.279
19	2029	1.296
20	2030	1.314

Source: Proyecto Optimizacion del Sistema de Agua Potable y Alcantarillado, Sectorización, Rehabilitación de Catastro – Área de Influencia Planta Huachipa – Area de Drenaje Comas – Chillón Lima, and JICA Study Team

4) Issues to be solved in Analysis of Supply to Lima Norte II Area

In detecting the amount of water supply to the Lima Norte II Area, there are some unknown conditions involved, which are explained below;

- Planned supply to the Lima Norte I and Lima Norte II Project Areas in the design of Huachipa WTP can be estimated as $0.8m^3/s$ and $2.1m^3/s$, respectively. Although the demand in the Lima Norte I area increased to 1.3 m^3/s in its feasibility study, the study did not mention the balance of demand and supply in the Lima Norte Area comprehensively including areas I and II.
- A part of the planned distribution area of the Huachipa WTP, namely the northern part of Collique, is not covered by Lima Norte I or Lima Norte II. This implies that the area has been separated from the distribution area of the Huachipa WTP, but it is not clear.
- Water demand in 2035 in the Area of Influence is $1.82m^3/s$, which will exceed the expected supply from the Huachipa WTP. This means that other sources should supply to the Area of Influence, such as the La Atarjea WTP and the Chillón WTP. This situation shall be considered in the Study to meet this demand. However, this issue cannot be solved by a study specified to a confined area, like the present Study, but only by a perspective study designed to forecast water demand in the entire Lima area in a consistent manner and to establish a synthetic production and distribution plan.

5) Supply Analysis in the Study

As explained above, it is impossible for the Study to detect the precise supply capacity to the Area of Influence. However, in order to evaluate the balance of demand and supply of the Huachipa WTP and to propose a future water distribution plan for the Area of Influence, a supply analysis is carried out based on the following conditions and assumptions:

i) The total supply of Lima Norte I and Lima Norte II is 2.9m3/s.

ii) The water demand in the Lima Norte I Area is 1.31m3/s in 2030, which complies with the Lima Norte I Feasibility Study.

iii) Water demand for the Study area and planned water supply from the La Atarjea WTP and the Chillón WTP should be considered after the supply-demand analysis is carried out.

iv) Underground water is used only for emergency purpose. Therefore, water from wells shall not be counted in the supply analysis of the Table 3.2.1-3.

Table 3.2.1-3: Conditions of Supply Analysis

<table>
<tr><th colspan="2">Conditions</th><th>Supply</th><th>Remarks</th></tr>
<tr><td rowspan="4">Production for Lima Norte Area</td><td>Huachipa WTP</td><td>2.9 m^3/s</td><td></td></tr>
<tr><td>La Atarjea WTP</td><td>-</td><td rowspan="2">To be considered if the supply of the Huachipa WTP is not enough</td></tr>
<tr><td>Chillón WTP</td><td>-</td></tr>
<tr><td>Wells</td><td>0 m^3/s</td><td>Not to be counted as usual water source; for emergency purposes only.</td></tr>
<tr><td colspan="2">Supply to Lima Norte I from Huachipa WTP</td><td>1.31 m^3/s in 2030</td><td>See Table 3.2.1-2</td></tr>
</table>

Source: JICA Study Team

The table 3.2.1-4 shows the result of the supply analysis:

Table 3.2.1-4: Result of Supply Analysis for the Area of Influence

Year		Supply from Huachipa to Lima North (m^3/s)	Supply to Lima Norte I (m^3/s)	Supply to Lima Norte II (m^3/s)
Base	2009	2.90	1.00	1.90
-5	2010	2.90	1.00	1.90
-4	2011	2.90	1.01	1.89
-3	2012	2.90	1.02	1.88
-2	2013	2.90	1.04	1.86
-1	2014	2.90	1.06	1.84
0	2015	2.90	1.07	1.83
1	2016	2.90	1.09	1.81
2	2017	2.90	1.10	1.80
3	2018	2.90	1.12	1.78
4	2019	2.90	1.13	1.77
5	2020	2.90	1.15	1.75
6	2021	2.90	1.16	1.74
7	2022	2.90	1.18	1.72
8	2023	2.90	1.20	1.70
9	2024	2.90	1.21	1.69
10	2025	2.90	1.23	1.67
11	2026	2.90	1.24	1.66
12	2027	2.90	1.26	1.64
13	2028	2.90	1.28	1.62
14	2029	2.90	1.30	1.60
15	2030	2.90	1.31	1.59
16	2031	2.90	1.32	1.58
17	2032	2.90	1.33	1.57
18	2033	2.90	1.34	1.56
19	2034	2.90	1.35	1.55
20	2035	2.90	1.36	1.54

Source: JICA Study Team

(Remarks: The water supply capacity from Huachipa WTP to Lima North (I) and (II) Project Areas is estimated at 2.9 m3/s. The supply capacity to Lima North (I) area is set to meet the demand projection in the area (from 1.0 to 2.36 m3/s), and the supply capacity to Lima North (II) area is to set to meet the remaining amount.)

(3) Storage in Reservoirs

Each sub-sector in the Study Area has its own reservoir. The reservoir "supply" can be presented as the storage capacity of the reservoir. The capacities are shown in Table 3.2.1-5.

Table 3.2.1-5 Storage Supply

Sector	Sub Sector	Name	Supply (m^3)
83A	83A-1	Villa sol	1,300
	83A-2	Villa del norte	1,800
83B	83B-1	Parque del naranjal	1,400
	83B-2	Cueto Fernandini	1,500
84A	84A-1	Olivos de pro	1,500
	84A-2	Programa confraternidad	1,600
84B	84B-1	Programa confraternidad	1,600
	84B-2	Comité aposte	500
85A	85A	Puerta de pro	1,100
85B	85B-1	Rio santa r	570
	85B-2	PRO	1,900
	85B-3	Santa luisa	500
85C	85C	PRO	1,900
259	259	Marquez	1,200
212A	212A-1	Virgen de las Nieves	1,500
	212A-2	Virgen del Rosario	1,200
212B	212B-1	Rosario del Norte	1,200
	212B-2	Jazmines de Naranjal	1,200
213	213-1	Vipol Naranjal	1,900
	213-2	Cerro el Choclo 1	100
	213-3	Cerro el Choclo 2	100
351	351-1	Los Angeles R1	400
	351-2	Los Angeles R2	150
		Los Angeles R4	100
	351-3	Los Angeles R3	100
347	347-1	San Felipe	670
	347-2	Alborada 1	1,200
345	345	Alameda del Pinar R-1	1,300
346	346-2	El pinar R-1	1,200
350	350-1	Santa Isabel R-1	1,400
	350-2	Santa Isabel R-2	1,500
348A	348A	Collique R-1	1,100
348B	348B-1	Collique R-2	1,500
	348B-2	Re-02	100
349A	349A-1	Collique R-3	1,100
	349A-2	Nueva Esperanza	400
	349A-3	Collique R-4	1,000
349B	349B-1	Collique R-5	800
	349B-2	Collique R-6	800
	349B-3	Collique R-7	550
368A	368A-1	RPA – 6	2,000
	368A-2	RPA – 1	500
368B	368B	RPA – 2	1,500
		RP – 17	100
		RPA – 5	150
		RPA – 4	200
		RPA – 3	600
		RP – 16	100
369	369A	RPA - 17 La Ensenada	3,000
	369B	Laderas de Chillón R-1	400
		Laderas de Chillón R-2	200
		Laderas de Chillón R-3	100
		RP-11	100
		RP-12	250

Source: JICA Study Team

(4) Primary and Secondary Networks

The supply of primary and secondary networks, including pipeline and pumping stations, is calculated during hydraulic calculation procedure explained in Appendix B2.1. Capacities of these facilities against the demand are also evaluated.

Table 3.2.1-6 Primary Networks Supply in the Project Area

Name	Total Supply (l/s)
Atarjea Los Olivos [1]	649.01
Chillón – Comas[2]	345.00
Chillón – Puente Piedra[3]	243.00

1.- Based on SCADA system reading
2.- Estimated base don sectors 345,346,347,348,349,350,y 351
3.- Estimated base don sectors 361,368,369,370

Source: JICA Study Team

Table 3.2.1-7 Transmission Lines Supply in Sectors

Sector	Description	Total Supply (l/s)
83	Ingreso directo a red	138.04[1]
84	Ingreso directo a red	121.71[1]
85	Ingreso directo a red	165.07[1]
212	Ingreso directo a red	89.41[1]
213	Tubería de HD	34.78[1]
259	No existe	
345	Tubería de HD	11.93[2]
346	Tubería de HD[2]	39.25[2]
347	Tubería HD	56.88[2]
350	Tubería de HD	159.95[2]
351	Tubería de HD	16.45[2]

1.- One week flow sampling from June 14 to 23, 2009
2.- Estimated flow in demand forecast (2009)

Source: JICA Study Team

Table 3.2.1-8 Pumping Lines Supply in Sectors

Sector	Material	Total Supply (l/s)
259	AC	0.00
348	AC	0.00
349	AC	0.00
351	HD	19.4

Source: JICA Study Team

Table 3.2.1-9 Secondary Distribution Network Optimized Supply

Sector	Total Supply (Km)
83 A	15.41
83 B	19.07
84 A	49.27
84 B	33.02
85 A	13.59
85 B	15.21
85 C	6.48
212 A	47.06
212 B	26.55
213	32.77
259	12.19
345	13.37
346	14.72
347	47.89
348 A	5.85
348 B	16.62
349 A	17.46
349 B	14.84
350	21.32
351	6.08
368 A	26.81
369 A	25.21
Total	**480.79**

Source: JICA Study Team

3.2.2 Sewerage

Primary sewerage collectors will be evaluated in the so called "Primary Collector Rehabilitation for the Lima Norte I and Lima Norte II Potable Water and Sewerage Network Rehabilitation Projects" study. In this Study, only secondary collectors are considered.

From the physical condition aspect, the supply means the length of pipes in good condition. In order to define the supply of secondary networks, it is first necessary to explain which pipes are in poor condition and need to be replaced, and then the offer can be defined.

(1) Rehabilitation of Sewerage Systems

The rehabilitation or replacement of the pipes has been defined based on two forms of evaluation:

- By the capacity of the pipes
- By the conservation condition of the pipes

These forms of evaluation are detailed below:

1) Capacity of Pipes

In order to determine the hydraulic capacity of the pipes, the dimensions of the pipes were evaluated, as were the hydraulic conditions determined by the strength of the thrust pressure. The hydraulic verification of the sewers was carried out by using Version 10.1 of SewerCad, the hydraulic simulation and sewerage design software

The current regulations that had to be considered were based on:

- The sanitation regulation OS 70 (sewerage networks) of the National Sanitation Standard
- Regulation for development of Water and Sanitation Projects in Urban Settings in Metropolitan Lima – CTPS.PR-02, REVISION: 02-2010 and previous editions; for the criteria not indicated in the National Sanitation Standard.

In terms of the technical criteria employed for the evaluation, the following were considered:

- Maximum water depth: 75% of the pipe diameter
- Tractive Tension: 1.5 MPa
- Flow in initial sections: 1.5 lps
- According to the Regulation for development of Water and Sanitation Projects in Urban Settings in Metropolitan Lima – CTPS.PR-02, REVISION: 02-2010, the minimum diameter for conventional sewerage is 200 mm.
- An initial analysis was done regarding this diameter, and it was not included in the hydraulic simulation, considering that there is an over-dimensioning for security measures.
- In the initial sections, the SEDAPAL regulation was considered that establishes that networks should have diameters equal to or greater than 200 mm, with slopes between 8% and 10%; for this reason, a hydraulic verification was not necessary for

the said initial sections, as they already complied with the minimum velocity and its impacts.

- The Roughness Coefficient was 0.018 for the CSN pipes, considering their age. This coefficient was determined based on the inspection study of manholes and pipes.

The results of the evaluation of the capacity of pipes using the SewerCad software report that 6,266 m of pipes do not fulfill the hydraulic conditions on one or more aspects, namely, capacity (draining flow is higher than pipe capacity), Tractive Force (concrete pipes with tractive force is less than 1 MPa and PVC pipes with tractive force less than 0.6 MPa).

Appendix B 2.2 presents a detailed analysis of the evaluation of hydraulic capacity using the SewerCad Software.

Moreover, in sub-sector 85B-3, in which there are many industries, site inspections found clog of pipes due to lack of conveyance capacity of the pipes. Some industries have wells that serve as their own water source and they are not registered in the list of SEDAPAL wells. Under such a situation, wastewater flow used in the hydraulic calculation (80% of water consumption) can be smaller than the actual flow. It is recommended that flow investigation be carried out in the detailed design (DD) stage in order to secure enough capacity of the sewer pipes.

Table 3.2.2-1: Sections to be rehabilitated in Collique (Comas)

Label	Start Node	Stop Node	Invert (Start) (m)	Invert (Stop) (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Diameter (mm)	Material	Flow (L/s)	Length (m)
2	2	3	341.08	340.90	342.88	342	200	PVC	5.92	8.5
3	3	4	340.09	336.24	342	337.79	200	PVC	7.08	60
86	86	87	214.8	213.71	217.07	216.59	350	PVC	110.16	24.1
87	87	88	213.71	211.2	216.59	212.83	350	PVC	111.14	51.8

Source: JICA Study Team

Table 3.2.2-2: Sections to be Rehabilitated in Carabayllo and Comas Alto between Trapiche, San Felipe and Tupac Amaru

Label	Start Node	Stop Node	Invert (Start) (m)	Invert (Stop) (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Diameter (mm)	Material	Flow (L/s)	Length (m)
8	208	237	163.79	162.61	165.53	164.82	250	PVC	11.75	55.2
25	225	226	165.92	165.56	168.26	167.26	200	PVC	29.38	49.1
28	228	229	164.3	163.76	166	165.69	200	PVC	35.24	56.1
29	229	236	163.76	162.99	165.69	164.93	200	PVC	38.18	54.9
36	236	237	162.99	162.61	164.93	164.82	200	PVC	44.06	54.6
37	237	238	162.61	162.46	164.82	165.03	300	PVC	58.74	17.1
38	238	239	162.46	162.11	165.03	164.45	300	PVC	58.74	57.3
109	309	310	173.15	173.04	175.54	175.63	250	PVC	2.98	38.7
111	311	312	172.88	172.75	175.79	175.87	300	PVC	23.53	56.4
112	312	313	172.75	172.63	175.87	175.95	300	PVC	26.46	54.9
113	313	314	172.63	172.49	175.95	176	300	PVC	29.4	63.1
114	314	OF-1	172.49	172.46	176	176.15	300	PVC	32.33	15.2
123	324	325	168.18	168.06	170.33	169.97	300	PVC	23.48	51.2
124	325	326	168.06	167.96	169.97	169.87	300	PVC	26.41	39.3
125	326	327	167.96	167.84	169.87	169.52	300	PVC	29.35	32.3
138	341	342	169.14	169.01	171.19	170.82	250	PVC	2.94	42.7
139	342	343	169.01	168.88	170.82	170.71	250	PVC	2.94	44.5
140	343	344	168.88	168.78	170.71	170.55	250	PVC	5.88	46.6
141	344	345	168.78	168.7	170.55	170.39	250	PVC	8.84	42.4
142	345	346	168.7	168.57	170.39	170.29	250	PVC	11.78	41.8
143	346	OF-4	168.57	168.34	170.29	170.1	250	PVC	14.71	43
145	349	350	163.4	163.24	166.1	166.17	200	PVC	6.03	75.9
146	350	351	163.24	162.38	166.17	165.04	200	PVC	9.12	51.2
147	351	353	162.38	161.01	165.04	163.2	200	PVC	10.03	54.6
166	370	371	163	162.26	164.95	164.88	300	PVC	3.22	54.9
167	371	372	162.26	161.74	164.88	165.13	300	PVC	4.12	77.4
184	390	OF-14	147.27	147.02	150.23	149.63	200	PVC	7.53	50.3
202	409	410	140.39	140.36	142.8	142.85	300	PVC	2.42	9.1
203	410	411	140.36	140.26	142.85	142.62	300	PVC	2.42	35.1
204	411	412	140.26	140.1	142.62	142.46	300	PVC	4.72	70.7
205	412	413	140.1	139.94	142.46	142.62	300	PVC	5.66	70.7
211	425	426	143.51	143.3	145.4	145.15	250	PVC	2.61	58.2
212	426	427	143.3	142.94	145.15	144.6	250	PVC	2.61	86
253	471	472	133.24	133.12	135.62	134.75	200	PVC	1.68	51.2
262	480	481	126.13	125.92	127.43	127.01	200	PVC	13.31	41.1
263	481	482	125.92	125.61	127.01	126.95	200	PVC	14.97	61.9
269	421	422	134.2	134.1	135.7	135.67	200	PVC	23.51	20.4
271	423	OF-13	133.65	133.16	135.37	135.25	200	PVC	26.84	74.7
CO-1	277	OF-18	152.95	152.62	155.43	155.38	200	PVC	76.41	6.1

Source: JICA Study Team

Table 3.2.2-3: Sections to be Rehabilitated in Los Olivos

Label	Start Node	Stop Node	Invert (Start) (m)	Invert (Stop) (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Diameter (mm)	Material	Flow (L/s)	Length (m)
18	13	19	86.7	86.52	89.91	90.08	200	PVC	22.41	33.2
19	19	20	86.52	86.29	90.08	90.24	200	PVC	23.71	49.7
38	38	39	92.94	92.91	95.56	95.53	200	PVC	1.52	9.1
48	48	49	92.09	91.77	94.4	94.13	250	CSN	3.2	70.4
95	95	96	86.52	86.14	88.3	87.94	200	PVC	30.29	52.1
96	96	97	86.14	85.77	87.94	87.56	200	PVC	30.39	46.9
97	97	98	85.77	85.52	87.56	87.52	200	PVC	30.49	25
98	98	99	85.52	85.27	87.52	87.17	200	PVC	30.59	33.5
99	99	100	85.27	84.63	87.17	86.2	200	PVC	30.69	85.6
102	102	103	83.24	82.48	84.94	84.22	250	PVC	61.02	69.8
103	103	104	82.48	81.71	84.22	83.73	300	PVC	71.09	71.9
104	104	105	80.95	80.21	83.73	82.47	350	PVC	81.5	97.2
105	105	106	80.21	79.5	82.47	81.85	350	PVC	81.6	104.2
106	106	107	79.5	79.06	81.85	81.7	350	PVC	81.7	61.3
107	107	108	79.06	78.88	81.7	81.78	350	PVC	81.8	24.1
108	108	109	78.88	78.53	81.78	81.12	350	PVC	81.9	44.2
109	109	110	78.53	78.07	81.12	80.26	350	PVC	82	61.3
110	110	111	78.07	77.37	80.26	79.47	350	PVC	82.1	122.2
111	111	112	77.37	76.66	79.47	78.58	350	PVC	82.2	90.5
112	112	113	76.66	76.00	78.58	78.22	350	PVC	82.3	100.6
114	114	115	79.9	79.3	82.1	81.92	200	PVC	0.1	61.3
115	115	116	79.3	78.68	81.92	81.76	200	PVC	0.2	61.3
132	132	133	75.09	75.03	77.57	77.28	300	PVC	22.51	51.8
162	161	162	74.24	74.12	76.15	76.04	200	PVC	25.38	23.5
167	163	167	73.76	73.66	75.44	75.45	250	PVC	42.28	23.5
168	167	168	73.66	73.57	75.45	75.35	300	PVC	46.46	15.5
169	168	169	73.57	73.35	75.35	75.39	300	PVC	50.66	68.9
170	169	170	73.35	73.05	75.39	76.24	300	PVC	53.64	94.5
171	170	171	73.05	72.85	76.24	75.4	300	PVC	53.74	60.7
172	171	172	72.87	72.64	75.4	75.41	300	PVC	53.84	59.4
200	199	200	70.31	70.19	72.65	72.78	250	PVC	4.68	57
219	218	219	68.56	68.35	71.57	71.02	250	PVC	2.25	56.7
235	233	234	63.11	62.98	66	65.56	250	PVC	1.85	45.4
236	234	235	62.98	62.89	65.56	65.42	250	PVC	3.5	31.4
265	263	264	55.49	55.2	57.84	57.36	200	PVC	12.82	51.5
266	264	265	55.2	55.06	57.36	57.3	200	PVC	13.96	51.2
278	276	277	50.83	50.47	52.76	52.32	200	PVC	25.3	56.4
299	297	298	54.04	53.8	56.06	55.65	200	PVC	8.79	56.7
300	298	299	53.8	52.95	55.65	54.97	200	PVC	8.89	62.2
306	305	306	61.37	61.28	65.02	64.86	250	CSN	1.92	50
307	306	302	61.28	61.22	64.86	64.75	300	CSN	2.02	53.9
309	307	308	60.75	60.65	64.25	64.09	300	PVC	5.47	56.4

310	308	309	60.65	60.55	64.09	63.88	350	PVC	5.57	56.
326	324	325	59.2	59.15	61.65	61.5	300	PVC	23.4	54.3
329	328	329	60.5	60.1	63.55	63	250	CSN	1.25	53.9
362	360	361	56.42	56.16	58.57	58.12	300	PVC	1.68	58.5
371	368	369	47.49	47.28	50.35	49.8	300	PVC	1.15	59.7
387	383	384	56.58	56.51	59.01	58.95	250	CSN	1.76	30.8
388	384	385	56.51	56.27	58.95	59.28	250	PVC	1.76	75
389	385	623	56.27	55.98	59.28	59.67	250	PVC	1.76	78.6
421	418	419	46.64	46.5	50.55	50.6	250	PVC	5.52	58.5
438	1434	434	51.15	51.01	52.73	52.81	200	PVC	1.61	14.9
446	440	441	53.54	53.45	56.3	56.2	200	PVC	13.63	129.2
454	442	628	52.1	52.08	54.5	53.5	300	PVC	15.13	68
465	459	460	31.49	31.39	33.57	33.5	200	PVC	4.09	58.5
470	464	465	200	470	464	465	200	PVC	7.45	54.6
475	469	632	29.14	29.01	32.32	32.32	300	PVC	3.99	58.5
476	470	471	42.6	42.36	45.05	44.9	250	CSN	0.62	58.8
478	472	473	41.29	41.12	43.3	43.33	250	PVC	1.5	77.1
486	480	481	37.75	37.66	39.98	39.72	250	PVC	6.51	52.4
493	481	488	37.66	37.57	39.72	39.6	250	CSN	11.03	53.3
487	482	483	38.45	38.2	39.64	39.6	250	CSN	0.61	53.9
488	483	484	38.2	38.06	39.6	39.79	250	CSN	1.45	48.2
489	484	485	38.06	37.98	39.79	39.79	250	CSN	2.07	52.7
490	485	486	38.01	37.81	39.79	39.8	250	CSN	2.68	45.4
491	486	487	37.81	37.72	39.8	39.7	250	PVC	3.3	51.8
492	487	481	37.72	37.62	39.7	39.72	250	CSN	3.91	54.9
504	498	499	33.08	32.50	34.97	32.95	250	PVC	1.58	22.9
505	499	497	32.50	32.08	32.95	35.02	250	PVC	1.64	56.4
510	502	503	33.28	33.01	35.1	35	250	PVC	1.27	81.4
526	518	519	27.09	26.9	29.46	29.1	250	PVC	1.89	51.8
532	524	525	25	24.8	27.2	27.06	300	PVC	8.82	70.4
533	525	526	24.8	24.65	27.06	26.95	300	PVC	11.02	67.1

Source: JICA Study Team

Table 3.2.2-4: Sections to be Rehabilitated in Marquez

Label	Start Node	Stop Node	Invert (Start) (m)	Invert (Stop) (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Diameter (mm)	Material	Flow (L/s)	Length (m)
23	24	25	2.04	2.03	3.46	3.51	300	PVC	37.15	7

Source: JICA Study Team

2) Conservation Condition of Pipes

Section 2.5.9 defined the diagnosis of the current situation in the secondary sewerage networks in the Study Area. The results obtained can help define some of the criteria given in this section for CSN pipe replacement in the zones identified in the Study Area.

(a) Pipe Replacement Criteria for Age

Figure 2.5.9-7 showed a distribution map by age of pipes with an age contour of 5 years. According to the CSN pipe manufacturers, the service life of the pipes is 30 years. Replacement is recommended for pipes over 30 years old.

(b) Pipe Replacement Criteria for Physical Conditions

- Figure 2.5.9-9 showed the location of the manholes evaluated during the study of manholes and pipes. In this map, it can be observed that the zones shown in blue and red are the areas identified with grades 4 and 5 corrosion, respectively.
- It is recommended that pipes in zones defined with corrosion of grades 4 and 5 are replaced.
- Comparing with Figure 2.5.9-7, it can be observed that the zones of heavy corrosion coincide with the zones with the oldest installed piping.

(c) Pipe Replacement Criteria for H_2S Measurement

Figure 2.5.9-10 shows the location of the manholes where H2S emissions have been found in ranges greater than 3ppm. The calculations indicate that the remaining service life of the pipes is less than 10 years.

The location of these manholes where the H2S levels were measured coincide with the areas defined as replacement zones, using the replacement criteria for age of pipe and physical conditions.

(d) Pipe Replacement Criteria for Incidents of Collapse

Figure 2.5.9-14 shows the incidents of collapse. As indicated in Section 2.5.9(4), the incidents of collapse indicate the zones where SEDAPAL has made replacements for pipes that have suffered collapse. With this criterion, it is to be expected that around these areas, there are pipes that are in near collapse condition. Replacement is recommended for pipes in zones where this type of incidence has occurred.

Similarly to the cases with the previously established criteria, the zones with greater incidence of collapses coincide with the zones previously identified in the aforementioned criteria.

(e) Pipe Replacement for Sample Probing

Figure 2.5.9-15 shows the locations of test pits where samples were taken. The probing sites where high grade corrosion was found are indicated in Table 2.5.9-21, and they coincide with the zones established in the previous criteria. Replacement is recommended for the CSN pipes in the areas surrounding the probing sites: 1, 6, 8, 9, 10 and 11.

(f) Pipe Replacement Criteria in Low Slope Zones

As was described in Section 2.5.9(4), the low slope zones, such as the low areas of Collique and Los Olivos, are the areas where the greatest indices of pipe corrosion are found. The reasons for the strong corrosion are explained in Appendix A5.2: Pipe Corrosion.

(g) Others

- Replacement of the pipes has been considered for sections whose one stretch of sewerage pipe is passing under homes, making access difficult for the operation and maintenance of the sewers. This situation arises because the homes expanded into the municipal reserve land.
- For this reason, replacement of secondary sewerage pipes has been defined in the zone of Av. Los Alisos.
- Appendix B 2.2 presents a detailed analysis of the problems found through the field inspection as well as the result of the hydraulic calculation.

(2) Definition of Project Implementation Zones

Based on the previous experiences, some project implementation zones is to be proposed, where sewerage pipes will be replaced.. In selecting these zones, the costs of replacement and the users benefit must be considered, among other things. All of the criteria established in the previous paragraphs are summarized in Figure 3.2.2-1.

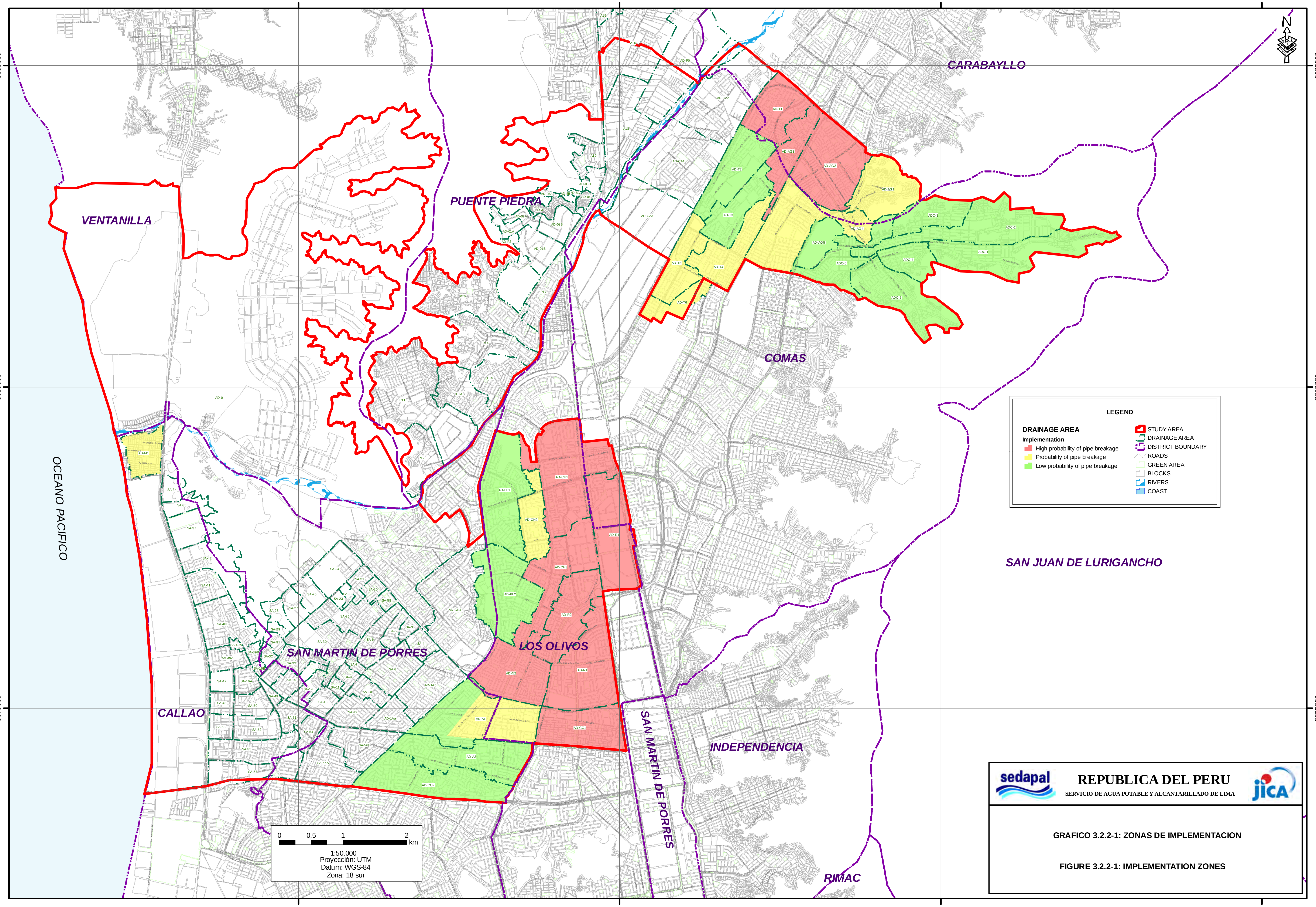


GRAFICO 3.2.2-1: ZONAS DE IMPLEMENTACION

FIGURE 3.2.2-1: IMPLEMENTATION ZONES

According to this map, 3 implementation zones have been identified:

- Zone with low probability of Pipe Breakage: this zone has been assigned the color green.
- The results of the field work indicate that in this zone, the pipes are in good condition. Replacement of CSN pipes would not be required in these areas. Nevertheless, because these sections of sewerage pipe have not been studied in their entirety, it is possible that there are some sections of piping that need replacement; for this reason, it has been considered that the replacement in this zone could fluctuate between 10 and 20%.
- Zone with medium probability of pipe breakage: this zone has been assigned the color yellow. These are zones where manholes have been found both in good condition and with significant indication of corrosion. These pipes are less than 15 years old in some cases.
- As with the areas with low probability of pipe breakage, in this yellow zone, there has not been an evaluation of 100% of the sections of pipeline; thus, it is proposed that the replacement of pipes should be between 40 and 60% for the sections of pipes in this area.
- Zone with high probability of pipe breakage: this zone has been assigned the color red. In this zone, a strong process of corrosion has been identified, and it is the zone with the oldest pipes. The recommendation is to replace 100% of the CSN pipes. Nevertheless, because there has not been an evaluation of 100% of the pipeline, it is possible that there are some sections of pipe that are in a good state of conservation. For this reason, the range of replacement varies between 85 and 95%.

In conclusion, considering that the Study has defined these implementation zones in a quantitative form, specific areas have not been qualitatively defined where the replacements will be carried out; these should be identified in the Detailed Design stage.

Table 3.2.2-5 shows the different replacement alternatives in the zones identified previously.

Table 3.2.2-5: CSN Pipe Replacement Alternatives in the Study Area

Alternatives	1	2	3
Green Zone	10 %	15%	20%
Yellow Zone	40 %	50%	60%
Red Zone	85 %	90%	95%

Source: JICA Study Team

Of the three alternatives presented in the Table 3.2.2-5, after making an analysis from different points of view such as cost, age, corrosion condition and field valuation level, Alternative N° 2 has been defined as the most coherent for execution of pipe replacement in the Study Area.

(3) Calculation of Supply

From the definitions for the implementation zone described in Item 2.5.9 (3), it has been defined that 36.48% of the total number of secondary networks in the Project area are in poor condition. A percentage of infrastructure is offered in the “with project” situation; therefore, optimized supply appears in Table3.2.2-6.

In this sense, the secondary network supply has been contemplated by lineal meters, as the gap could not be clearly and accurately defined in terms of flow when the relevant balance was carried out.

Table 3.2.2.6: Sewerage Network Optimized Supply

Drainage Area	Supply of pipes in good condition (Km)
A16	7.52
A18	11.53
A19	5.73
AD-0	1.70
AD-01B	0.95
AD-A1	20.84
AD-A2	21.22
AD-AG1	3.72
AD-AG2	6.04
AD-AG3	1.33
AD-AG4	14.39
ADC-1	8.57
ADC-2	11.50
ADC-3	4.22
ADC-4	5.87
ADC-5	11.65
ADC-6	9.67
AD-CA1	8.80
AD-CA3	0.82
AD-CH1	10.28
AD-CH2	6.57
AD-CH3	2.30
AD-CH4	30.87
AD-CO1	2.85
AD-CO2	23.58
AD-M1	7.45
AD-N1	7.43
AD-N2	3.28
AD-P2	0.46
AD-PL1	18.85
AD-PL2	19.57
AD-R1	2.32
AD-R2	2.57
AD-T1	4.57
AD-T2	6.26
AD-T3	0.03
AD-T4	6.35
AD-T5	5.03
AD-T6	1.31
PT1	22.99
PT2	6.59
PT3	13.00
PT4	11.70
PT5	8.78
PT6	25.44
PT7	7.54
SA-57	0.03
Total	414.07

Source: JICA Study Team

3.3 Supply – Demand Analysis

3.3.1 Water Supply

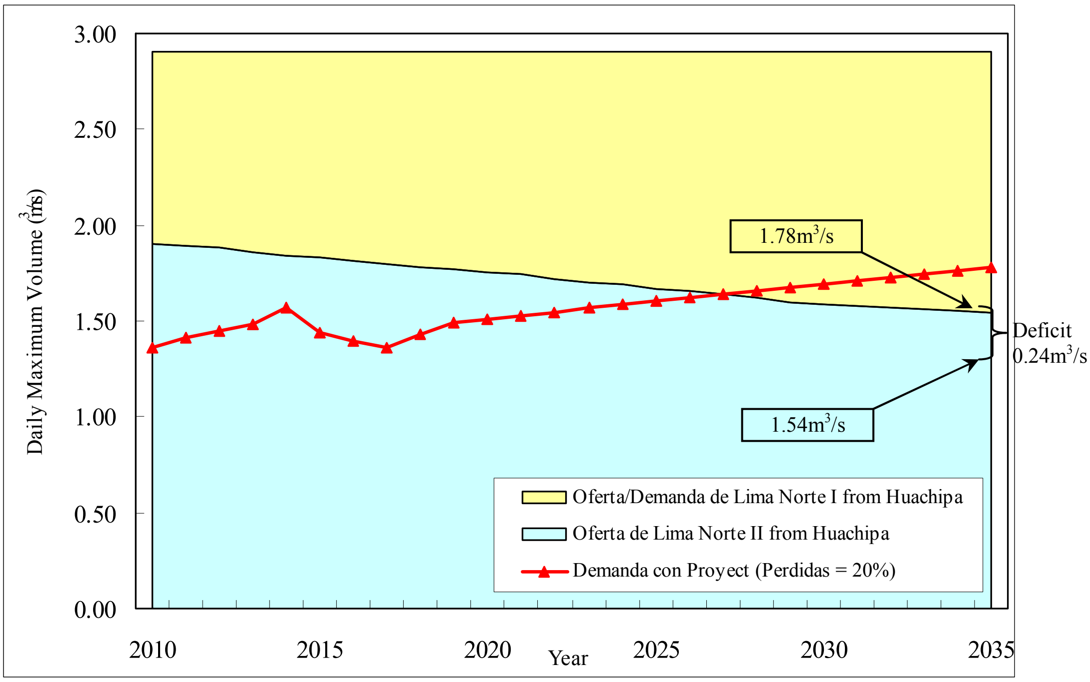
(1) Water Requirement

1) Methodology

Supply-Demand analysis of water requirement can be found by comparing water production with the water demand in the Area of Influence. After determining the demand and balance, water will be supplied from other WTP to the Area of Influence.

2) Requirement Deficit in the Current Plan

As shown in the following figure, demand in the Area of Influence will exceed supply starting in 2027, and the deficit will be $0.24m^3/s$ in 2035.



Source: JICA Study Team

Figure 3.3.1-1: Supply–Demand Analysis on Water Production

3) Water Distribution Proposed to Solve the Deficit

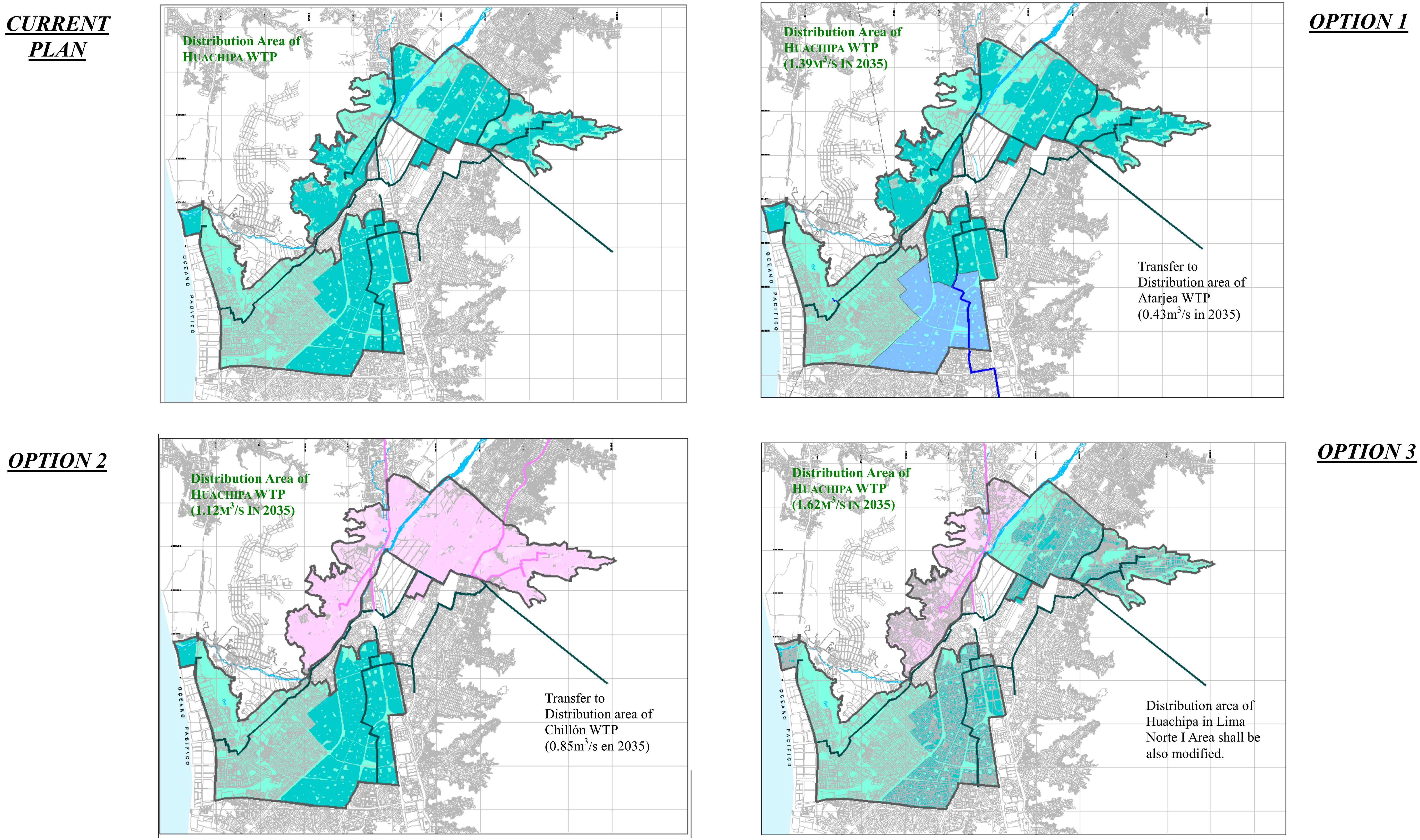
As explained above, water supply deficit from the Huachipa WTP to the Area of Influence will be $0.24m^3/s$ in 2035. There are three options for modifying the distribution area so as to avoid the deficit; these options are explained below:

Option-1: Separate Sectors 83A, 83B, 84B, 212A, 212B, and 213 (total water demand is $0.4m^3/s$ in 2035) and transfer them to the La Atarjea WTP distribution area.

Option-2: Separate northern part of the "Los Olivos" area and the "Collique" area (total water demand is about $0.7m^3/s$ in 2035), and transfer them to the Chillón WTP distribution area.

Option-3: Re-arrange the distribution area of Huachipa WTP not locally (in the Study Area) but comprehensively including the surrounding area of the current distribution area.

The figure 3.3.1-2 illustrates the options above:



Source: JICA Study Team

Figure 3.3.1-2: Alternatives for Water Distribution Area of Huachipa WTP

Among the alternatives above, Option-1 will be preferable for the following reasons:

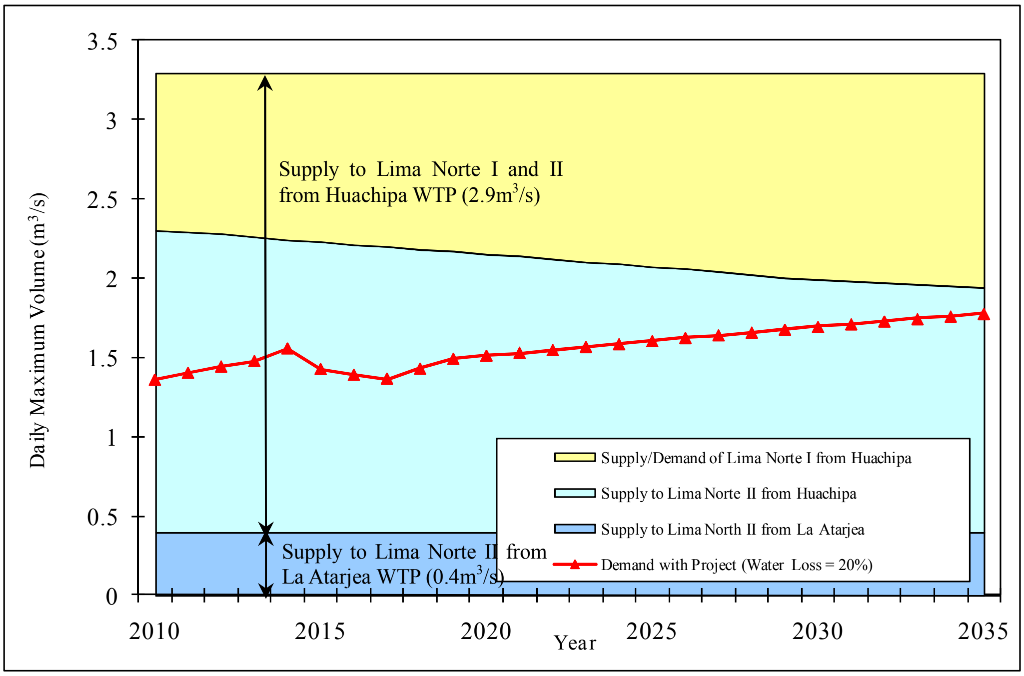
- Production of the Chillón WTP is expected to increase by the construction of reservoirs and an additional plant. However, it is still not clear that when the projects will be carried out, as project schedule is not yet finalized.
- If the additional project for the Chillón WTP is delayed or is not executed, the WTP will not be able to send water to the Area of Influence. Also this WTP has limited scope for surplus water production because of the low river flow and the increasing water demand in its own distribution area.
- The La Atarjea WTP has a capacity to produce 17.5m^3/s of water. The expected supply needed to meet the demand in the Area of Influence (0.4m^3/s) is only a very small part of its total production. The Study can conclude that the La Atarjea WTP has more possibility than the Chillón WTP to supply water to the Area of Influence in the future.
- As stated in the previous section, this issue should be studied comprehensively and in detail in another study to be carried out by SEDAPAL. The actual distribution plan to the Area of Influence shall be modified after the study.

The following table and figure show the results of the supply-demand analysis of Option-1, under the assumption that the La Atarjea WTP would supply 0.4m^3/s to the Study Area:

Table 3.3.1-1: Supply after Modification of Distribution Area

Year		Demand (m^3/s)	Supply (m^3/s)					Deficit (m^3/s)
			Huachipa WPP			Atarjea WPP	Total Supply to Lima North II	
		Demand of Lima North II	Supply to Lima North	Supply to Lima North I	Supply to Lima North II	Supply to Lima North II		
-	2007							
-	2008							
Base	2009	1.31	2.90	1.00	1.90	0.00	1.90	-
-5	2010	1.36	2.90	1.00	1.90	0.40	2.30	0.94
-4	2011	1.40	2.90	1.01	1.89	0.40	2.29	0.89
-3	2012	1.44	2.90	1.02	1.88	0.40	2.28	0.84
-2	2013	1.48	2.90	1.04	1.86	0.40	2.26	0.78
-1	2014	1.56	2.90	1.06	1.84	0.40	2.24	0.68
0	2015	1.43	2.90	1.07	1.83	0.40	2.23	0.80
1	2016	1.39	2.90	1.09	1.81	0.40	2.21	0.82
2	2017	1.36	2.90	1.10	1.80	0.40	2.20	0.84
3	2018	1.43	2.90	1.12	1.78	0.40	2.18	0.75
4	2019	1.49	2.90	1.13	1.77	0.40	2.17	0.68
5	2020	1.51	2.90	1.15	1.75	0.40	2.15	0.64
6	2021	1.53	2.90	1.16	1.74	0.40	2.14	0.61
7	2022	1.55	2.90	1.18	1.72	0.40	2.12	0.57
8	2023	1.57	2.90	1.20	1.70	0.40	2.10	0.53
9	2024	1.58	2.90	1.21	1.69	0.40	2.09	0.51
10	2025	1.60	2.90	1.23	1.67	0.40	2.07	0.47
11	2026	1.62	2.90	1.24	1.66	0.40	2.06	0.44
12	2027	1.64	2.90	1.26	1.64	0.40	2.04	0.40
13	2028	1.66	2.90	1.28	1.62	0.40	2.02	0.36
14	2029	1.68	2.90	1.30	1.60	0.40	2.00	0.32
15	2030	1.69	2.90	1.31	1.59	0.40	1.99	0.30
16	2031	1.71	2.90	1.32	1.58	0.40	1.98	0.27
17	2032	1.73	2.90	1.33	1.57	0.40	1.97	0.24
18	2033	1.75	2.90	1.34	1.56	0.40	1.96	0.21
19	2034	1.76	2.90	1.35	1.55	0.40	1.95	0.19
20	2035	1.78	2.90	1.36	1.54	0.40	1.94	0.16

Source: JICA Study Team



Source: JICA Study Team

Figure 3.3.1-3: Result of Supply-Demand Analysis after Modification of Distribution Area (Option-1)

(2) Reservoir Storage

The supply-demand analysis of reservoir storage can be found by comparing reservoir capacity and required volume of storage for each sub-sector in the final year of the design period, which is 2035. The target area of the analysis is the Area of Influence. Table 3.3.1-2 shows the result of the analysis.

As shown in the table, reservoirs' capacities are not enough in seven sub-sectors. Solutions of the deficit of the capacities is studied in Section 3.4.4.

Table 3.3.1-2: Supply-Demand Analysis for Reservoir Storage

Subsector	Reservoir	Balance Oferta-demanda en 2035			Evaluation
		Demand (m^3)	Supply (m^3)	Balance (m^3)	
83A-1	Villa Sol R-1	516	1,300	784	OK
83A-2	Villa del Norte R-1	910	1,800	890	OK
83B-1	Parque del Naranja R-1	465	1,400	935	OK
83B-2	Cueto Fernandini R-1	1,370	1,500	130	OK
84A-1	Olivos de Pro R-1	962	1,500	538	OK
84A-2	Programa Confraternidad R-2	664	1,600	936	OK
84B-1	Programa Confraternidad R-1	863	1,600	737	OK
84B-2	Comite Aposte	413	500	87	OK
85A	Puerta de Pro R-1	728	1,100	372	OK
85B-1	Rio Santa R-1	536	570	34	OK
85B-2	Pro	2,055	1,400	-655	NG
85B-3	Santa Luisa R-1	301	500	199	OK
85C	Pro	638	500	-138	NG
212A-1	Virgin de las Nieves R-4	839	1,500	661	OK
212A-2	Virgin del Rosario R-1	534	1,200	666	OK
212B-1	Rosario del Norte R-3	427	1,200	773	OK
212B-2	Jazmines de Naranja R-2	383	1,200	817	OK
213-1	Vipol Naranjal R-1	783	1,900	1,117	OK
213-2	Cerro eo Choclo R-2	62	100	38	OK
213-3	Cerro eo Choclo R-1	75	100	25	OK
259	Márquez R-522	744	1,200	456	OK
346-1	El Manantial R-1, R-2	234	2,200	1,966	OK
346-2	El Pinar R-1	592	1,200	608	OK
347-1	San Felipe R-1	550	670	120	OK
347-2	LA Alborada R-2, R-1	540	2,400	1,860	OK
348A	Collique R-1	352	1,100	748	OK
348B-1	Collique R-2	624	1,500	876	OK
348B-2	RE-01	103	100	-3	NG
349A-1	Collique R-3	608	1,100	492	OK
349A-2	Nueva Esperanza R-1	205	400	195	OK
349A-3	Collique R-4	354	1,000	646	OK
349B-1	Collique R-5	309	800	491	OK
349B-2	Collique R-6	375	800	425	OK
349B-3	Collique R-7, R-8	283	650	367	OK
350-1	Santa Isabel R-1	1,411	1,400	-11	NG
350-2	Santa Isabel R-2	1,408	1,500	92	OK
351-1	Los Angeles R-1	355	400	45	OK
351-2	Los Angeles R-2, R-3	255	250	-5	NG
351-3	Los Angeles R-4	83	100	17	OK
361	La Canpitania Parma	1,085	1,000	-85	OK
368A-1	RPA-6	970	2,000	1,030	OK
368A-2	RPA-1	199	500	301	OK
368B	RPA	1,300	2,650	1,350	OK
369A	RPA-7 La Ensenada	989	3,000	2,011	OK
369B	Laderas del Chillon	1,256	1,050	-206	NG
370	Shangrila R-1 CR-128	725	1,000	275	OK

Source: JICA Study Team

(3) Primary and Secondary Networks

At primary network level, the commissioning of the Huachipa Water Treatment Plant, the Northern Branch, and the Compensation reservoirs will require the construction of an interconnection Huachipa – Comas / Los Olivos matriz

Table 3.3.1-3: Supply-Demand Balance of Main Networks

Year	Demand (l/s)					Supply	Balance (l/s)				
	Los Olivos	Comas	San Martin	Puente Piedra	TOTAL	(l/s)	Los Olivos	Comas	San Martin	Puente Piedra	TOTAL
2009	650	465	40	149	1,305	0	650	465	40	149	1,305
2010	664	476	54	163	1,357	0	664	476	54	163	1,357
2011	674	483	67	178	1,401	0	674	483	67	178	1,401
2012	683	487	79	192	1,441	0	683	487	79	192	1,441
2013	690	489	90	208	1,477	0	690	489	90	208	1,477
2014	711	515	105	226	1,557	0	711	515	105	226	1,557
2015	652	453	111	212	1,427	0	652	453	111	212	1,427
2016	638	414	119	218	1,389	0	638	414	119	218	1,389
2017	626	384	128	226	1,364	0	626	384	128	226	1,364
2018	642	401	142	243	1,428	0	642	401	142	243	1,428
2019	657	417	156	260	1,491	0	657	417	156	260	1,491
2020	663	422	157	268	1,510	0	663	422	157	268	1,510
2021	669	427	158	276	1,530	0	669	427	158	276	1,530
2022	673	431	159	284	1,547	0	673	431	159	284	1,547
2023	679	436	160	292	1,566	0	679	436	160	292	1,566
2024	684	440	161	300	1,585	0	684	440	161	300	1,585
2025	690	445	161	308	1,604	0	690	445	161	308	1,604
2026	696	449	162	316	1,624	0	696	449	162	316	1,624
2027	702	453	163	323	1,642	0	702	453	163	323	1,642
2028	707	457	164	330	1,659	0	707	457	164	330	1,659
2029	714	461	165	337	1,677	0	714	461	165	337	1,677
2030	721	465	166	343	1,695	0	721	465	166	343	1,695
2031	728	469	166	349	1,712	0	728	469	166	349	1,712
2032	734	474	167	354	1,729	0	734	474	167	354	1,729
2033	740	477	168	360	1,745	0	740	477	168	360	1,745
2034	747	481	169	364	1,762	0	747	481	169	364	1,762
2035	754	485	170	369	1,777	0	754	485	170	369	1,777

Source: JICA Study Team

The supply-demand analysis of primary and secondary networks is presented as hydraulic calculations and designs as explained in 3.4.5 and 3.4.7.

Table 3.3.1-4: Supply-Demand Balance in Secondary Networks (Km)

Sector	Demand	Supply	Balance
83 A	34.12	15.41	18.71
83 B	49.28	19.07	30.21
84 A	60.90	49.27	11.63
84 B	45.78	33.02	12.76
85 A	18.89	13.59	5.30
85 B	26.81	15.21	11.60
85 C	18.64	6.48	12.16
212 A	53.39	47.06	6.33
212 B	29.11	26.55	2.56
213	41.09	32.77	8.32
259	16.06	12.19	3.87
345	13.58	13.37	0.21
346	17.49	14.72	2.77
347	53.09	47.89	5.20
348 A	8.10	5.85	2.25
348 B	22.04	16.62	5.42
349 A	31.47	17.46	14.01
349 B	28.33	14.84	13.49
350	78.17	21.32	56.85
351	7.07	6.08	0.99
368 A	29.13	26.81	2.32
369 A	26.77	25.21	1.56
Total	**709.31**	**480.79**	**228.52**

Source: JICA Study Team

Table 3.3.1-5: Supply-Demand Balance in Gravity Pressure Lines per Sectors (QMD) (l/s)

SECTOR		83A			83B			84A			84B			85A			85B			85C			212A			212B			213		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance
	2009	70	0	-70	90	0	-90	73	0	-73	55	0	-55	43	0	-43	126	0	-126	118	0	-118	68	0	-68	36	0	-36	52	58	5
-5	2010	72	0	-72	93	0	-93	75	0	-75	56	0	-56	43	0	-43	126	0	-126	119	0	-119	69	0	-69	37	0	-37	54	58	4
-4	2011	74	0	-74	95	0	-95	76	0	-76	57	0	-57	43	0	-43	127	0	-127	119	0	-119	71	0	-71	38	0	-38	55	58	2
-3	2012	75	0	-75	97	0	-97	78	0	-78	59	0	-59	44	0	-44	126	0	-126	119	0	-119	71	0	-71	39	0	-39	57	58	1
-2	2013	76	0	-76	99	0	-99	79	0	-79	60	0	-60	44	0	-44	125	0	-125	119	0	-119	72	0	-72	40	0	-40	58	58	0
-1	2014	79	0	-79	103	0	-103	82	0	-82	61	0	-61	45	0	-45	128	0	-128	123	0	-123	74	0	-74	41	0	-41	60	58	-2
0	2015	71	0	-71	92	0	-92	81	0	-81	61	0	-61	40	0	-40	113	0	-113	108	0	-108	70	0	-70	39	0	-39	51	58	6
1	2016	71	0	-71	92	0	-92	81	0	-81	62	0	-62	38	0	-38	108	0	-108	104	0	-104	70	0	-70	39	0	-39	45	58	12
2	2017	70	0	-70	92	0	-92	82	0	-82	63	0	-63	36	0	-36	105	0	-105	100	0	-100	69	0	-69	38	0	-38	41	58	17
3	2018	72	0	-72	95	0	-95	84	0	-84	64	0	-64	37	0	-37	108	0	-108	104	0	-104	70	0	-70	39	0	-39	42	58	16
4	2019	74	0	-74	97	0	-97	85	0	-85	66	0	-66	38	0	-38	110	0	-110	106	0	-106	71	0	-71	40	0	-40	43	58	14
5	2020	75	0	-75	98	0	-98	86	0	-86	66	0	-66	38	0	-38	113	0	-113	109	0	-109	72	0	-72	40	0	-40	44	58	14
6	2021	75	0	-75	98	0	-98	86	0	-86	66	0	-66	38	0	-38	116	0	-116	112	0	-112	72	0	-72	40	0	-40	44	58	14
7	2022	75	0	-75	99	0	-99	87	0	-87	67	0	-67	38	0	-38	118	0	-118	113	0	-113	72	0	-72	40	0	-40	44	58	14
8	2023	76	0	-76	99	0	-99	87	0	-87	67	0	-67	38	0	-38	121	0	-121	116	0	-116	73	0	-73	41	0	-41	44	58	14
9	2024	76	0	-76	100	0	-100	88	0	-88	67	0	-67	39	0	-39	124	0	-124	119	0	-119	73	0	-73	41	0	-41	44	58	14
10	2025	76	0	-76	100	0	-100	88	0	-88	68	0	-68	39	0	-39	127	0	-127	122	0	-122	73	0	-73	41	0	-41	44	58	13
11	2026	77	0	-77	100	0	-100	88	0	-88	68	0	-68	39	0	-39	131	0	-131	125	0	-125	74	0	-74	41	0	-41	45	58	13
12	2027	77	0	-77	101	0	-101	89	0	-89	68	0	-68	39	0	-39	134	0	-134	128	0	-128	74	0	-74	41	0	-41	45	58	13
13	2028	77	0	-77	101	0	-101	89	0	-89	69	0	-69	39	0	-39	137	0	-137	131	0	-131	74	0	-74	41	0	-41	45	58	13
14	2029	78	0	-78	102	0	-102	89	0	-89	69	0	-69	39	0	-39	141	0	-141	134	0	-134	75	0	-75	42	0	-42	45	58	13
15	2030	78	0	-78	102	0	-102	90	0	-90	69	0	-69	40	0	-40	145	0	-145	138	0	-138	75	0	-75	42	0	-42	45	58	12
16	2031	78	0	-78	103	0	-103	90	0	-90	70	0	-70	40	0	-40	149	0	-149	141	0	-141	75	0	-75	42	0	-42	46	58	12
17	2032	79	0	-79	103	0	-103	91	0	-91	70	0	-70	40	0	-40	153	0	-153	145	0	-145	76	0	-76	42	0	-42	46	58	12
18	2033	79	0	-79	104	0	-104	91	0	-91	70	0	-70	41	0	-41	157	0	-157	148	0	-148	76	0	-76	42	0	-42	46	58	12
19	2034	80	0	-80	104	0	-104	91	0	-91	70	0	-70	41	0	-41	161	0	-161	152	0	-152	76	0	-76	43	0	-43	46	58	12
20	2035	80	0	-80	104	0	-104	92	0	-92	71	0	-71	41	0	-41	165	0	-165	156	0	-156	77	0	-77	43	0	-43	46	58	11

SECTOR		259			345			346			347			348A			348B			349A			349B			350			351			368/369		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Deficit	Demand	Supply	Balance
	2009	40	0	-40	9	36	27	39	58	19	57	58	1	20	0	20	48	0	48	65	0	65	51	0	51	160	117	-43	16	36	20	127	243	116
-5	2010	41	0	-41	12	36	24	39	58	19	58	58	0	21	0	21	47	0	47	66	0	66	52	0	52	164	117	-47	18	36	18	137	243	106
-4	2011	42	0	-42	14	36	22	38	58	20	58	58	0	20	0	20	46	0	46	66	0	66	52	0	52	166	117	-49	20	36	16	147	243	96
-3	2012	44	0	-44	16	36	20	37	58	20	58	58	-1	20	0	20	44	0	44	65	0	65	52	0	52	168	117	-52	22	36	14	158	243	85
-2	2013	44	0	-44	18	36	18	37	58	21	59	58	-1	19	0	19	43	0	43	64	0	64	51	0	51	170	117	-54	24	36	12	169	243	74
-1	2014	47	0	-47	21	36	15	37	58	21	61	58	-3	21	0	21	45	0	45	68	0	68	55	0	55	177	117	-61	26	36	10	181	243	62
0	2015	41	0	-41	19	36	17	32	58	25	54	58	4	18	0	18	39	0	39	60	0	60	48	0	48	153	117	-36	24	36	12	167	243	76
1	2016	37	0	-37	18	36	18	31	58	27	52	58	6	16	0	16	35	0	35	54	0	54	44	0	44	137	117	-20	22	36	14	166	243	77
2	2017	34	0	-34	18	36	18	29	58	29	51	58	7	15	0	15	32	0	32	50	0	50	40	0	40	124	117	-7	21	36	15	166	243	77
3	2018	35	0	-35	19	36	17	29	58	29	52	58	5	16	0	16	33	0	33	53	0	53	43	0	43	128	117	-11	22	36	14	177	243	66
4	2019	37	0	-37	21	36	15	29	58	28	54	58	4	17	0	17	34	0	34	56	0	56	45	0	45	132	117	-15	24	36	12	188	243	55
5	2020	37	0	-37	21	36	15	30	58	28	54	58	3	17	0	17	34	0	34	56	0	56	45	0	45	134	117	-18	24	36	12	194	243	49
6	2021	38	0	-38	21	36	15	30	58	28	55	58	3	17	0	17	35	0	35	56	0	56	45	0	45	137	117	-20	25	36	11	199	243	44
7	2022	38	0	-38	21	36	15	30	58	28	55	58	3	17	0	17	35	0	35	57	0	57	46	0	46	139	117	-22	26	36	10	205	243	38
8	2023	38	0	-38	22	36	14	30	58	28	55	58	2	17	0	17	35	0	35	57	0	57	46	0	46	141	117	-24	26	36	10	211	243	32
9	2024	39	0	-39	22	36	14	31	58	27	56	58	2	17	0	17	35	0	35	57	0	57	46	0	46	143	117	-26	27	36	9	217	243	26
10	2025	39	0	-39	22	36	14	31	58	27	56	58	2	17	0	17	36	0	36	58	0	58	46	0	46	145	117	-29	28	36	9	222	243	21
11	2026	39	0	-39	22	36	14	31	58	27	56	58	1	17	0	17	36	0	36	58	0	58	47	0	47	147	117	-31	28	36	8	228	243	15
12	2027	39	0	-39	22	36	14	31	58	27	57	58	1	17	0	17	36	0	36	58	0	58	47	0	47	149	117	-33	29	36	7	233	243	10
13	2028	40	0	-40	22	36	14	31	58	27	57	58	1	17	0	17	36	0	36	59	0	59	47	0	47	151	117	-34	29	36	7	238	243	5
14	2029	40	0	-40	22	36	14	31	58	26	57	58	0	18	0	18	36	0	36	59	0	59	47	0	47	153	117	-36	30	36	6	243	243	0
15	2030	40	0	-40	23	36	13	32	58	26	58	58	0	18	0	18	37	0	37	60	0	60	48	0	48	155	117	-38	30	36	6	248	243	-5
16	2031	41	0	-41	23	36	13	32	58	26	58	58	0	18	0	18	37	0	37	60	0	60	48	0	48	156	117	-40	31	36	5	252	243	-9
17	2032	41	0	-41	23	36	13	32	58	26	58	58	-1	18	0	18	37	0	37	60	0	60	48	0	48	158	117	-42	31	36	5	255	243	-12
18	2033	41	0	-41	23	36	13	32	58	26	59	58	-1	18	0	18	37	0	37	61	0	61	49	0	49	160	117	-43	32	36	4	259	243	-16
19	2034	41	0	-41	23	36	13	32	58	25	59	58	-1	18	0	18	38	0	38	61	0	61	49	0	49	162	117	-46	32	36	4	263	243	-20
20	2035	42	0	-42	23	36	13	33	58	25	60	58	-2	18	0	18	38	0	38	61	0	61	49	0	49	164	117	-47	33	36	3	266	243	-23

Source: JICA Study Team

Table 3.3.1-6: Supply-Demand Balance in Inlet to Sectors Pipes per Sub-Sector (QMH) (l/s)

SECTOR		83A						83B						84A						84B						85A			85B		
SUB SECTOR		83A-1			83A-2			83B-1			83B-2			84A-1			84A-2			84B-1			84B-2			85A			85B-1		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance
	2009	37.23	0.00	-37.23	59.84	0.00	-59.84	26.93	0.00	-26.93	97.38	0.00	-97.38	59.55	0.00	-59.55	41.36	0.00	-41.36	53.73	0.00	-53.73	22.10	0.00	-22.10	59.02	0.00	-59.02	44.23	0.00	-44.23
-5	2010	38.01	0.00	-38.01	61.83	0.00	-61.83	28.16	0.00	-28.16	100.06	0.00	-100.06	61.33	0.00	-61.33	42.35	0.00	-42.35	55.00	0.00	-55.00	22.85	0.00	-22.85	59.85	0.00	-59.85	43.66	0.00	-43.66
-4	2011	38.46	0.00	-38.46	63.37	0.00	-63.37	29.40	0.00	-29.40	101.95	0.00	-101.95	62.69	0.00	-62.69	43.07	0.00	-43.07	55.92	0.00	-55.92	23.52	0.00	-23.52	59.93	0.00	-59.93	43.30	0.00	-43.30
-3	2012	38.94	0.00	-38.94	65.22	0.00	-65.22	30.57	0.00	-30.57	103.96	0.00	-103.96	63.98	0.00	-63.98	43.79	0.00	-43.79	56.82	0.00	-56.82	24.17	0.00	-24.17	60.66	0.00	-60.66	42.69	0.00	-42.69
-2	2013	39.35	0.00	-39.35	66.55	0.00	-66.55	31.67	0.00	-31.67	105.41	0.00	-105.41	65.45	0.00	-65.45	44.48	0.00	-44.48	57.64	0.00	-57.64	24.77	0.00	-24.77	60.99	0.00	-60.99	41.77	0.00	-41.77
-1	2014	40.28	0.00	-40.28	69.21	0.00	-69.21	33.04	0.00	-33.04	108.97	0.00	-108.97	67.24	0.00	-67.24	45.62	0.00	-45.62	59.32	0.00	-59.32	25.70	0.00	-25.70	62.60	0.00	-62.60	42.49	0.00	-42.49
0	2015	35.64	0.00	-35.64	62.22	0.00	-62.22	29.81	0.00	-29.81	97.46	0.00	-97.46	66.73	0.00	-66.73	45.19	0.00	-45.19	58.97	0.00	-58.97	25.72	0.00	-25.72	54.78	0.00	-54.78	37.06	0.00	-37.06
1	2016	35.24	0.00	-35.24	62.41	0.00	-62.41	30.00	0.00	-30.00	97.20	0.00	-97.20	67.27	0.00	-67.27	45.47	0.00	-45.47	59.57	0.00	-59.57	26.13	0.00	-26.13	52.14	0.00	-52.14	34.95	0.00	-34.95
2	2017	34.77	0.00	-34.77	62.54	0.00	-62.54	30.14	0.00	-30.14	96.91	0.00	-96.91	67.76	0.00	-67.76	45.72	0.00	-45.72	60.10	0.00	-60.10	26.54	0.00	-26.54	50.01	0.00	-50.01	33.28	0.00	-33.28
3	2018	35.44	0.00	-35.44	64.62	0.00	-64.62	31.22	0.00	-31.22	99.86	0.00	-99.86	69.25	0.00	-69.25	46.66	0.00	-46.66	61.51	0.00	-61.51	27.34	0.00	-27.34	51.08	0.00	-51.08	33.58	0.00	-33.58
4	2019	36.03	0.00	-36.03	66.64	0.00	-66.64	32.27	0.00	-32.27	102.59	0.00	-102.59	70.72	0.00	-70.72	47.60	0.00	-47.60	62.95	0.00	-62.95	28.12	0.00	-28.12	52.01	0.00	-52.01	33.88	0.00	-33.88
5	2020	36.19	0.00	-36.19	66.97	0.00	-66.97	32.43	0.00	-32.43	103.06	0.00	-103.06	71.05	0.00	-71.05	47.82	0.00	-47.82	63.25	0.00	-63.25	28.26	0.00	-28.26	52.22	0.00	-52.22	34.32	0.00	-34.32
6	2021	36.36	0.00	-36.36	67.26	0.00	-67.26	32.56	0.00	-32.56	103.51	0.00	-103.51	71.36	0.00	-71.36	48.03	0.00	-48.03	63.54	0.00	-63.54	28.40	0.00	-28.40	52.63	0.00	-52.63	34.71	0.00	-34.71
7	2022	36.52	0.00	-36.52	67.58	0.00	-67.58	32.76	0.00	-32.76	103.95	0.00	-103.95	71.69	0.00	-71.69	48.24	0.00	-48.24	63.82	0.00	-63.82	28.53	0.00	-28.53	52.81	0.00	-52.81	34.93	0.00	-34.93
8	2023	36.67	0.00	-36.67	67.91	0.00	-67.91	32.91	0.00	-32.91	104.39	0.00	-104.39	72.00	0.00	-72.00	48.66	0.00	-48.66	64.12	0.00	-64.12	28.64	0.00	-28.64	53.16	0.00	-53.16	35.61	0.00	-35.61
9	2024	36.82	0.00	-36.82	68.19	0.00	-68.19	33.05	0.00	-33.05	104.85	0.00	-104.85	72.32	0.00	-72.32	48.87	0.00	-48.87	64.40	0.00	-64.40	28.78	0.00	-28.78	53.35	0.00	-53.35	35.98	0.00	-35.98
10	2025	36.99	0.00	-36.99	68.72	0.00	-68.72	33.21	0.00	-33.21	105.29	0.00	-105.29	72.63	0.00	-72.63	49.06	0.00	-49.06	64.68	0.00	-64.68	28.91	0.00	-28.91	53.54	0.00	-53.54	36.21	0.00	-36.21
11	2026	37.18	0.00	-37.18	69.02	0.00	-69.02	33.37	0.00	-33.37	105.78	0.00	-105.78	72.94	0.00	-72.94	49.27	0.00	-49.27	64.98	0.00	-64.98	29.04	0.00	-29.04	53.72	0.00	-53.72	36.80	0.00	-36.80
12	2027	37.35	0.00	-37.35	69.32	0.00	-69.32	33.49	0.00	-33.49	106.21	0.00	-106.21	73.28	0.00	-73.28	49.50	0.00	-49.50	65.27	0.00	-65.27	29.18	0.00	-29.18	54.29	0.00	-54.29	37.20	0.00	-37.20
13	2028	37.49	0.00	-37.49	69.60	0.00	-69.60	33.64	0.00	-33.64	106.65	0.00	-106.65	73.59	0.00	-73.59	49.72	0.00	-49.72	65.55	0.00	-65.55	29.32	0.00	-29.32	54.48	0.00	-54.48	37.43	0.00	-37.43
14	2029	37.66	0.00	-37.66	69.92	0.00	-69.92	33.78	0.00	-33.78	107.12	0.00	-107.12	73.89	0.00	-73.89	49.93	0.00	-49.93	65.82	0.00	-65.82	29.43	0.00	-29.43	54.66	0.00	-54.66	37.81	0.00	-37.81
15	2030	37.80	0.00	-37.80	70.20	0.00	-70.20	33.92	0.00	-33.92	107.54	0.00	-107.54	74.21	0.00	-74.21	50.14	0.00	-50.14	66.11	0.00	-66.11	29.56	0.00	-29.56	55.01	0.00	-55.01	38.40	0.00	-38.40
16	2031	38.20	0.00	-38.20	70.48	0.00	-70.48	34.05	0.00	-34.05	108.22	0.00	-108.22	74.71	0.00	-74.71	50.35	0.00	-50.35	66.60	0.00	-66.60	29.69	0.00	-29.69	55.43	0.00	-55.43	38.79	0.00	-38.79
17	2032	38.37	0.00	-38.37	70.79	0.00	-70.79	34.21	0.00	-34.21	108.70	0.00	-108.70	75.01	0.00	-75.01	50.56	0.00	-50.56	66.89	0.00	-66.89	29.83	0.00	-29.83	55.82	0.00	-55.82	39.18	0.00	-39.18
18	2033	38.52	0.00	-38.52	71.09	0.00	-71.09	34.34	0.00	-34.34	109.13	0.00	-109.13	75.34	0.00	-75.34	50.77	0.00	-50.77	67.18	0.00	-67.18	29.96	0.00	-29.96	56.17	0.00	-56.17	39.77	0.00	-39.77
19	2034	38.72	0.00	-38.72	71.36	0.00	-71.36	34.48	0.00	-34.48	109.54	0.00	-109.54	75.66	0.00	-75.66	50.98	0.00	-50.98	67.46	0.00	-67.46	30.08	0.00	-30.08	56.36	0.00	-56.36	40.17	0.00	-40.17
20	2035	38.86	0.00	-38.86	71.66	0.00	-71.66	34.61	0.00	-34.61	110.01	0.00	-110.01	75.97	0.00	-75.97	51.20	0.00	-51.20	67.74	0.00	-67.74	30.21	0.00	-30.21	56.54	0.00	-56.54	40.54	0.00	-40.54

SECTOR		85B						85C			212A						212B						213									259		
SUB SECTOR		85B-2			85B-3			85C			212A-1			212A-2			212B-1			212B-2			213-1			213-2			213-3			259		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Deficit	Demand	Supply	Balance
	2009	112.14	0.00	-112.14	18.40	0.00	-18.40	51.36	0.00	-51.36	58.68	0.00	-58.68	35.65	0.00	-35.65	27.50	0.00	-27.50	22.91	0.00	-22.91	68.48	0.00	-68.48	1.41	0.00	-1.41	2.77	0.00	-2.77	54.97	0.00	-54.97
-5	2010	112.98	0.00	-112.98	18.27	0.00	-18.27	51.72	0.00	-51.72	59.80	0.00	-59.80	36.32	0.00	-36.32	28.10	0.00	-28.10	23.61	0.00	-23.61	70.64	0.00	-70.64	1.44	0.00	-1.44	2.82	0.00	-2.82	57.29	0.00	-57.29
-4	2011	113.56	0.00	-113.56	18.61	0.00	-18.61	51.64	0.00	-51.64	60.72	0.00	-60.72	36.92	0.00	-36.92	28.65	0.00	-28.65	24.22	0.00	-24.22	72.47	0.00	-72.47	1.45	0.00	-1.45	2.88	0.00	-2.88	58.76	0.00	-58.76
-3	2012	113.17	0.00	-113.17	18.24	0.00	-18.24	51.92	0.00	-51.92	61.37	0.00	-61.37	37.36	0.00	-37.36	29.03	0.00	-29.03	24.81	0.00	-24.81	74.04	0.00	-74.04	1.46	0.00	-1.46	2.90	0.00	-2.90	60.29	0.00	-60.29
-2	2013	112.93	0.00	-112.93	17.99	0.00	-17.99	52.10	0.00	-52.10	62.03	0.00	-62.03	37.85	0.00	-37.85	29.46	0.00	-29.46	25.29	0.00	-25.29	75.46	0.00	-75.46	1.46	0.00	-1.46	2.92	0.00	-2.92	61.43	0.00	-61.43
-1	2014	116.76	0.00	-116.76	18.53	0.00	-18.53	53.46	0.00	-53.46	63.53	0.00	-63.53	38.69	0.00	-38.69	30.24	0.00	-30.24	26.07	0.00	-26.07	78.22	0.00	-78.22	1.48	0.00	-1.48	2.96	0.00	-2.96	64.67	0.00	-64.67
0	2015	103.19	0.00	-103.19	16.37	0.00	-16.37	46.73	0.00	-46.73	60.62	0.00	-60.62	36.96	0.00	-36.96	28.87	0.00	-28.87	25.02	0.00	-25.02	67.37	0.00	-67.37	1.25	0.00	-1.25	2.49	0.00	-2.49	56.61	0.00	-56.61
1	2016	99.13	0.00	-99.13	15.96	0.00	-15.96	44.67	0.00	-44.67	60.05	0.00	-60.05	36.49	0.00	-36.49	28.54	0.00	-28.54	24.89	0.00	-24.89	59.62	0.00	-59.62	1.07	0.00	-1.07	2.16	0.00	-2.16	50.92	0.00	-50.92
2	2017	96.03	0.00	-96.03	15.39	0.00	-15.39	42.65	0.00	-42.65	59.26	0.00	-59.26	36.06	0.00	-36.06	28.24	0.00	-28.24	24.69	0.00	-24.69	53.74	0.00	-53.74	0.95	0.00	-0.95	1.90	0.00	-1.90	46.66	0.00	-46.66
3	2018	99.78	0.00	-99.78	15.80	0.00	-15.80	43.59	0.00	-43.59	60.37	0.00	-60.37	36.75	0.00	-36.75	28.77	0.00	-28.77	25.27	0.00	-25.27	55.56	0.00	-55.56	0.95	0.00	-0.95	1.91	0.00	-1.91	48.80	0.00	-48.80
4	2019	102.42	0.00	-102.42	16.24	0.00	-16.24	44.78	0.00	-44.78	61.42	0.00	-61.42	37.38	0.00	-37.38	29.28	0.00	-29.28	25.80	0.00	-25.80	57.07	0.00	-57.07	0.96	0.00	-0.96	1.93	0.00	-1.93	51.35	0.00	-51.35
5	2020	105.86	0.00	-105.86	16.44	0.00	-16.44	44.97	0.00	-44.97	61.71	0.00	-61.71	37.60	0.00	-37.60	29.47	0.00	-29.47	25.93	0.00	-25.93	57.35	0.00	-57.35	0.96	0.00	-0.96	1.94	0.00	-1.94	51.74	0.00	-51.74
6	2021	109.51	0.00	-109.51	16.63	0.00	-16.63	45.13	0.00	-45.13	61.99	0.00	-61.99	37.77	0.00	-37.77	29.60	0.00	-29.60	26.10	0.00	-26.10	57.61	0.00	-57.61	0.98	0.00	-0.98	1.94	0.00	-1.94	52.14	0.00	-52.14
7	2022	111.83	0.00	-111.83	16.82	0.00	-16.82	45.28	0.00	-45.28	62.23	0.00	-62.23	37.93	0.00	-37.93	29.73	0.00	-29.73	26.20	0.00	-26.20	57.85	0.00	-57.85	0.98	0.00	-0.98	1.95	0.00	-1.95	52.53	0.00	-52.53
8	2023	115.27	0.00	-115.27	17.23	0.00	-17.23	45.85	0.00	-45.85	62.51	0.00	-62.51	38.11	0.00	-38.11	29.83	0.00	-29.83	26.33	0.00	-26.33	58.10	0.00	-58.10	0.98	0.00	-0.98	1.96	0.00	-1.96	52.93	0.00	-52.93
9	2024	118.70	0.00	-118.70	17.59	0.00	-17.59	46.00	0.00	-46.00	62.79	0.00	-62.79	38.30	0.00	-38.30	29.97	0.00	-29.97	26.43	0.00	-26.43	58.34	0.00	-58.34	0.99	0.00	-0.99	1.96	0.00	-1.96	53.34	0.00	-53.34
10	2025	122.35	0.00	-122.35	17.79	0.00	-17.79	46.16	0.00	-46.16	63.03	0.00	-63.03	38.47	0.00	-38.47	30.11	0.00	-30.11	26.54	0.00	-26.54	58.58	0.00	-58.58	0.99	0.00	-0.99	1.98	0.00	-1.98	53.75	0.00	-53.75
11	2026	126.90	0.00	-126.90	17.99	0.00	-17.99	46.55	0.00	-46.55	63.33	0.00	-63.33	38.64	0.00	-38.64	30.26	0.00	-30.26	26.65	0.00	-26.65	58.82	0.00	-58.82	0.99	0.00	-0.99	1.98	0.00	-1.98	54.13	0.00	-54.13
12	2027	130.33	0.00	-130.33	18.35	0.00	-18.35	46.88	0.00	-46.88	63.59	0.00	-63.59	38.81	0.00	-38.81	30.37	0.00	-30.37	26.81	0.00	-26.81	59.05	0.00	-59.05	1.00	0.00	-1.00	1.99	0.00	-1.99	54.55	0.00	-54.55
13	2028	133.77	0.00	-133.77	18.55	0.00	-18.55	47.04	0.00	-47.04	63.87	0.00	-63.87	39.01	0.00	-39.01	30.49	0.00	-30.49	26.92	0.00	-26.92	59.31	0.00	-59.31	1.00	0.00	-1.00	2.00	0.00	-2.00	54.95	0.00	-54.95
14	2029	138.53	0.00	-138.53	18.90	0.00	-18.90	47.21	0.00	-47.21	64.13	0.00	-64.13	39.18	0.00	-39.18	30.61	0.00	-30.61	27.03	0.00	-27.03	59.60	0.00	-59.60	1.00	0.00	-1.00	2.00	0.00	-2.00	55.36	0.00	-55.36
15	2030	143.08	0.00	-143.08	19.32	0.00	-19.32	47.82	0.00	-47.82	64.44	0.00	-64.44	39.34	0.00	-39.34	30.77	0.00	-30.77	27.14	0.00	-27.14	59.83	0.00	-59.83	1.01	0.00	-1.01	2.01	0.00	-2.01	55.76	0.00	-55.76
16	2031	147.63	0.00	-147.63	19.67	0.00	-19.67	47.99	0.00	-47.99	64.68	0.00	-64.68	39.64	0.00	-39.64	30.91	0.00	-30.91	27.26	0.00	-27.26	60.08	0.00	-60.08	1.01	0.00	-1.01	2.03	0.00	-2.03	56.18	0.00	-56.18
17	2032	152.18	0.00	-152.18	20.04	0.00	-20.04	48.15	0.00	-48.15	64.92	0.00	-64.92	39.84	0.00	-39.84	31.03	0.00	-31.03	27.37	0.00	-27.37	60.31	0.00	-60.31	1.01	0.00	-1.01	2.03	0.00	-2.03	56.59	0.00	-56.59
18	2033	156.72	0.00	-156.72	20.23	0.00	-20.23	48.48	0.00	-48.48	65.22	0.00	-65.22	40.03	0.00	-40.03	31.15	0.00	-31.15	27.49	0.00	-27.49	60.58	0.00	-60.58	1.03	0.00	-1.03	2.04	0.00	-2.04	57.02	0.00	-57.02
19	2034	161.48	0.00	-161.48	20.60	0.00	-20.60	48.87	0.00	-48.87	65.48	0.00	-65.48	40.19	0.00	-40.19	31.28	0.00	-31.28	27.65	0.00	-27.65	60.82	0.00	-60.82	1.03	0.00	-1.03	2.05	0.00	-2.05	57.43	0.00	-57.43
20	2035	167.12	0.00	-167.12	20.95	0.00	-20.95	49.03	0.00	-49.03	65.76	0.00	-65.76	40.35	0.00	-40.35	31.43	0.00	-31.43	27.76	0.00	-27.76	61.05	0.00	-61.05	1.03	0.00	-1.03	2.05	0.00	-2.05	57.84	0.00	-57.84

SECTOR		345			346			347						348A			348B						349A								
SUB SECTOR		345			346			347-1			347-2			348A			348B-1			348B-2			349A-1			349A-2			349A-3		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance
	2009	12.66	0.00	-12.66	54.33	0.00	-54.33	43.16	0.00	-43.16	35.60	0.00	-35.60	27.98	0.00	-27.98	61.70	0.00	-61.70	4.24	0.00	-4.24	52.51	0.00	-52.51	10.75	0.00	-10.75	27.10	0.00	-27.10
-5	2010	16.52	0.00	-16.52	53.71	0.00	-53.71	43.17	0.00	-43.17	36.59	0.00	-36.59	28.43	0.00	-28.43	60.76	0.00	-60.76	4.41	0.00	-4.41	52.65	0.00	-52.65	11.30	0.00	-11.30	27.34	0.00	-27.34
-4	2011	19.44	0.00	-19.44	52.93	0.00	-52.93	42.93	0.00	-42.93	37.49	0.00	-37.49	28.17	0.00	-28.17	58.99	0.00	-58.99	4.57	0.00	-4.57	52.28	0.00	-52.28	11.74	0.00	-11.74	27.31	0.00	-27.31
-3	2012	22.37	0.00	-22.37	51.90	0.00	-51.90	42.59	0.00	-42.59	38.27	0.00	-38.27	27.66	0.00	-27.66	56.86	0.00	-56.86	4.73	0.00	-4.73	51.41	0.00	-51.41	11.99	0.00	-11.99	26.87	0.00	-26.87
-2	2013	25.37	0.00	-25.37	51.00	0.00	-51.00	42.12	0.00	-42.12	38.97	0.00	-38.97	26.85	0.00	-26.85	54.20	0.00	-54.20	4.87	0.00	-4.87	50.15	0.00	-50.15	12.04	0.00	-12.04	26.23	0.00	-26.23
-1	2014	28.74	0.00	-28.74	51.61	0.00	-51.61	43.49	0.00	-43.49	40.66	0.00	-40.66	28.69	0.00	-28.69	56.70	0.00	-56.70	5.13	0.00	-5.13	52.99	0.00	-52.99	13.14	0.00	-13.14	27.96	0.00	-27.96
0	2015	26.82	0.00	-26.82	44.87	0.00	-44.87	38.41	0.00	-38.41	36.31	0.00	-36.31	25.20	0.00	-25.20	49.35	0.00	-49.35	4.48	0.00	-4.48	46.54	0.00	-46.54	11.86	0.00	-11.86	24.73	0.00	-24.73
1	2016	25.47	0.00	-25.47	42.34	0.00	-42.34	37.07	0.00	-37.07	35.28	0.00	-35.28	22.71	0.00	-22.71	44.10	0.00	-44.10	4.01	0.00	-4.01	41.95	0.00	-41.95	10.95	0.00	-10.95	22.48	0.00	-22.48
2	2017	24.49	0.00	-24.49	40.10	0.00	-40.10	35.75	0.00	-35.75	34.36	0.00	-34.36	20.89	0.00	-20.89	40.18	0.00	-40.18	3.67	0.00	-3.67	38.51	0.00	-38.51	10.29	0.00	-10.29	20.76	0.00	-20.76
3	2018	26.72	0.00	-26.72	40.49	0.00	-40.49	36.76	0.00	-36.76	35.75	0.00	-35.75	21.87	0.00	-21.87	41.76	0.00	-41.76	3.83	0.00	-3.83	40.43	0.00	-40.43	10.99	0.00	-10.99	22.00	0.00	-22.00
4	2019	28.97	0.00	-28.97	40.83	0.00	-40.83	37.76	0.00	-37.76	37.04	0.00	-37.04	22.88	0.00	-22.88	43.36	0.00	-43.36	3.99	0.00	-3.99	42.26	0.00	-42.26	11.70	0.00	-11.70	23.10	0.00	-23.10
5	2020	29.16	0.00	-29.16	41.09	0.00	-41.09	38.00	0.00	-38.00	37.28	0.00	-37.28	23.01	0.00	-23.01	43.65	0.00	-43.65	4.02	0.00	-4.02	42.63	0.00	-42.63	11.77	0.00	-11.77	23.25	0.00	-23.25
6	2021	29.33	0.00	-29.33	41.34	0.00	-41.34	38.25	0.00	-38.25	37.52	0.00	-37.52	23.13	0.00	-23.13	43.92	0.00	-43.92	4.04	0.00	-4.04	42.89	0.00	-42.89	11.85	0.00	-11.85	23.39	0.00	-23.39
7	2022	29.50	0.00	-29.50	41.59	0.00	-41.59	38.48	0.00	-38.48	37.76	0.00	-37.76	23.26	0.00	-23.26	44.18	0.00	-44.18	4.07	0.00	-4.07	43.14	0.00	-43.14	11.91	0.00	-11.91	23.54	0.00	-23.54
8	2023	29.92	0.00	-29.92	41.84	0.00	-41.84	38.72	0.00	-38.72	37.98	0.00	-37.98	23.39	0.00	-23.39	44.46	0.00	-44.46	4.09	0.00	-4.09	43.40	0.00	-43.40	11.99	0.00	-11.99	23.67	0.00	-23.67
9	2024	30.09	0.00	-30.09	42.23	0.00	-42.23	38.93	0.00	-38.93	38.21	0.00	-38.21	23.53	0.00	-23.53	44.76	0.00	-44.76	4.11	0.00	-4.11	43.65	0.00	-43.65	12.06	0.00	-12.06	23.82	0.00	-23.82
10	2025	30.26	0.00	-30.26	42.50	0.00	-42.50	39.17	0.00	-39.17	38.45	0.00	-38.45	23.65	0.00	-23.65	45.03	0.00	-45.03	4.14	0.00	-4.14	43.90	0.00	-43.90	12.13	0.00	-12.13	23.96	0.00	-23.96
11	2026	30.44	0.00	-30.44	42.80	0.00	-42.80	39.42	0.00	-39.42	38.68	0.00	-38.68	23.78	0.00	-23.78	45.29	0.00	-45.29	4.17	0.00	-4.17	44.15	0.00	-44.15	12.19	0.00	-12.19	24.10	0.00	-24.10
12	2027	30.61	0.00	-30.61	43.01	0.00	-43.01	39.66	0.00	-39.66	38.94	0.00	-38.94	23.91	0.00	-23.91	45.55	0.00	-45.55	4.20	0.00	-4.20	44.40	0.00	-44.40	12.26	0.00	-12.26	24.24	0.00	-24.24
13	2028	30.80	0.00	-30.80	43.25	0.00	-43.25	39.88	0.00	-39.88	39.15	0.00	-39.15	24.22	0.00	-24.22	45.81	0.00	-45.81	4.22	0.00	-4.22	44.66	0.00	-44.66	12.34	0.00	-12.34	24.38	0.00	-24.38
14	2029	30.97	0.00	-30.97	43.50	0.00	-43.50	40.13	0.00	-40.13	39.41	0.00	-39.41	24.36	0.00	-24.36	46.08	0.00	-46.08	4.24	0.00	-4.24	44.91	0.00	-44.91	12.42	0.00	-12.42	24.52	0.00	-24.52
15	2030	31.42	0.00	-31.42	43.88	0.00	-43.88	40.35	0.00	-40.35	39.62	0.00	-39.62	24.50	0.00	-24.50	46.54	0.00	-46.54	4.26	0.00	-4.26	45.16	0.00	-45.16	12.59	0.00	-12.59	24.66	0.00	-24.66
16	2031	31.58	0.00	-31.58	44.13	0.00	-44.13	40.59	0.00	-40.59	39.85	0.00	-39.85	24.62	0.00	-24.62	46.80	0.00	-46.80	4.29	0.00	-4.29	45.54	0.00	-45.54	12.66	0.00	-12.66	24.80	0.00	-24.80
17	2032	31.76	0.00	-31.76	44.40	0.00	-44.40	40.82	0.00	-40.82	40.09	0.00	-40.09	24.75	0.00	-24.75	47.06	0.00	-47.06	4.32	0.00	-4.32	45.77	0.00	-45.77	12.73	0.00	-12.73	24.94	0.00	-24.94
18	2033	31.92	0.00	-31.92	44.64	0.00	-44.64	41.16	0.00	-41.16	40.31	0.00	-40.31	24.87	0.00	-24.87	47.32	0.00	-47.32	4.35	0.00	-4.35	46.02	0.00	-46.02	12.81	0.00	-12.81	25.09	0.00	-25.09
19	2034	32.09	0.00	-32.09	44.87	0.00	-44.87	41.41	0.00	-41.41	40.57	0.00	-40.57	25.00	0.00	-25.00	47.59	0.00	-47.59	4.36	0.00	-4.36	46.28	0.00	-46.28	12.87	0.00	-12.87	25.22	0.00	-25.22
20	2035	32.26	0.00	-32.26	45.13	0.00	-45.13	41.63	0.00	-41.63	40.80	0.00	-40.80	25.14	0.00	-25.14	47.85	0.00	-47.85	4.39	0.00	-4.39	46.54	0.00	-46.54	12.94	0.00	-12.94	25.36	0.00	-25.36

SECTOR		349B									350						351									368A						369A		
SUB SECTOR		349B-1			349B-2			349B-3			350-1			350-2			351-1			351-2			351-3			368A1			368A-2			369A		
YEAR		Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Balance	Demand	Supply	Deficit	Demand	Supply	Balance
	2009	24.26	0.00	-24.26	23.76	0.00	-23.76	22.05	0.00	-22.05	116.51	0.00	-116.51	104.97	0.00	-104.97	13.28	0.00	-13.28	7.85	0.00	-7.85	1.65	0.00	-1.65	30.52	0.00	-30.52	5.00	0.00	-5.00	41.56	0.00	-41.56
-5	2010	24.38	0.00	-24.38	24.83	0.00	-24.83	22.17	0.00	-22.17	118.32	0.00	-118.32	108.13	0.00	-108.13	14.64	0.00	-14.64	8.84	0.00	-8.84	1.77	0.00	-1.77	33.50	0.00	-33.50	5.54	0.00	-5.54	43.83	0.00	-43.83
-4	2011	24.16	0.00	-24.16	25.69	0.00	-25.69	22.01	0.00	-22.01	119.15	0.00	-119.15	110.66	0.00	-110.66	16.02	0.00	-16.02	9.90	0.00	-9.90	1.92	0.00	-1.92	36.64	0.00	-36.64	6.11	0.00	-6.11	46.39	0.00	-46.39
-3	2012	23.92	0.00	-23.92	26.21	0.00	-26.21	21.78	0.00	-21.78	119.94	0.00	-119.94	113.35	0.00	-113.35	17.44	0.00	-17.44	10.97	0.00	-10.97	2.05	0.00	-2.05	39.86	0.00	-39.86	6.72	0.00	-6.72	48.58	0.00	-48.58
-2	2013	23.39	0.00	-23.39	26.37	0.00	-26.37	21.39	0.00	-21.39	120.35	0.00	-120.35	115.63	0.00	-115.63	18.88	0.00	-18.88	12.11	0.00	-12.11	2.19	0.00	-2.19	43.17	0.00	-43.17	7.33	0.00	-7.33	51.02	0.00	-51.02
-1	2014	24.67	0.00	-24.67	28.46	0.00	-28.46	22.47	0.00	-22.47	124.44	0.00	-124.44	120.83	0.00	-120.83	20.57	0.00	-20.57	13.33	0.00	-13.33	2.34	0.00	-2.34	47.11	0.00	-47.11	8.00	0.00	-8.00	54.55	0.00	-54.55
0	2015	21.64	0.00	-21.64	25.50	0.00	-25.50	19.65	0.00	-19.65	107.07	0.00	-107.07	104.85	0.00	-104.85	18.59	0.00	-18.59	12.13	0.00	-12.13	2.08	0.00	-2.08	43.82	0.00	-43.82	7.44	0.00	-7.44	49.83	0.00	-49.83
1	2016	19.49	0.00	-19.49	23.39	0.00	-23.39	17.77	0.00	-17.77	94.67	0.00	-94.67	94.67	0.00	-94.67	17.19	0.00	-17.19	11.31	0.00	-11.31	1.90	0.00	-1.90	44.19	0.00	-44.19	7.52	0.00	-7.52	49.61	0.00	-49.61
2	2017	17.88	0.00	-17.88	21.94	0.00	-21.94	16.24	0.00	-16.24	85.33	0.00	-85.33	86.20	0.00	-86.20	16.18	0.00	-16.18	10.74	0.00	-10.74	1.76	0.00	-1.76	44.62	0.00	-44.62	7.60	0.00	-7.60	49.33	0.00	-49.33
3	2018	18.69	0.00	-18.69	23.30	0.00	-23.30	16.93	0.00	-16.93	87.68	0.00	-87.68	89.37	0.00	-89.37	17.35	0.00	-17.35	11.59	0.00	-11.59	1.87	0.00	-1.87	47.91	0.00	-47.91	8.17	0.00	-8.17	52.35	0.00	-52.35
4	2019	19.53	0.00	-19.53	24.67	0.00	-24.67	17.62	0.00	-17.62	90.15	0.00	-90.15	92.57	0.00	-92.57	18.53	0.00	-18.53	12.47	0.00	-12.47	1.96	0.00	-1.96	51.29	0.00	-51.29	8.76	0.00	-8.76	55.27	0.00	-55.27
5	2020	19.65	0.00	-19.65	24.83	0.00	-24.83	17.85	0.00	-17.85	91.75	0.00	-91.75	94.01	0.00	-94.01	19.03	0.00	-19.03	12.80	0.00	-12.80	2.02	0.00	-2.02	52.86	0.00	-52.86	9.02	0.00	-9.02	56.92	0.00	-56.92
6	2021	19.77	0.00	-19.77	24.97	0.00	-24.97	17.96	0.00	-17.96	94.17	0.00	-94.17	95.25	0.00	-95.25	19.49	0.00	-19.49	13.12	0.00	-13.12	2.07	0.00	-2.07	54.42	0.00	-54.42	9.30	0.00	-9.30	58.73	0.00	-58.73
7	2022	19.88	0.00	-19.88	25.12	0.00	-25.12	18.06	0.00	-18.06	95.67	0.00	-95.67	96.63	0.00	-96.63	19.97	0.00	-19.97	13.43	0.00	-13.43	2.13	0.00	-2.13	55.96	0.00	-55.96	9.56	0.00	-9.56	60.35	0.00	-60.35
8	2023	20.10	0.00	-20.10	25.27	0.00	-25.27	18.17	0.00	-18.17	97.04	0.00	-97.04	97.85	0.00	-97.85	20.44	0.00	-20.44	13.76	0.00	-13.76	2.18	0.00	-2.18	57.52	0.00	-57.52	9.82	0.00	-9.82	61.97	0.00	-61.97
9	2024	20.22	0.00	-20.22	25.41	0.00	-25.41	18.26	0.00	-18.26	98.54	0.00	-98.54	99.19	0.00	-99.19	20.92	0.00	-20.92	14.08	0.00	-14.08	2.22	0.00	-2.22	59.08	0.00	-59.08	10.09	0.00	-10.09	63.76	0.00	-63.76
10	2025	20.33	0.00	-20.33	25.56	0.00	-25.56	18.38	0.00	-18.38	100.06	0.00	-100.06	101.26	0.00	-101.26	21.41	0.00	-21.41	14.41	0.00	-14.41	2.28	0.00	-2.28	60.69	0.00	-60.69	10.35	0.00	-10.35	65.38	0.00	-65.38
11	2026	20.45	0.00	-20.45	25.70	0.00	-25.70	18.48	0.00	-18.48	101.55	0.00	-101.55	102.66	0.00	-102.66	21.87	0.00	-21.87	14.73	0.00	-14.73	2.33	0.00	-2.33	62.24	0.00	-62.24	10.62	0.00	-10.62	67.17	0.00	-67.17
12	2027	20.56	0.00	-20.56	25.84	0.00	-25.84	18.58	0.00	-18.58	102.83	0.00	-102.83	103.80	0.00	-103.80	22.34	0.00	-22.34	15.03	0.00	-15.03	2.37	0.00	-2.37	63.70	0.00	-63.70	10.87	0.00	-10.87	68.68	0.00	-68.68
13	2028	20.67	0.00	-20.67	26.00	0.00	-26.00	18.69	0.00	-18.69	104.27	0.00	-104.27	104.89	0.00	-104.89	22.78	0.00	-22.78	15.33	0.00	-15.33	2.42	0.00	-2.42	65.08	0.00	-65.08	11.11	0.00	-11.11	70.10	0.00	-70.10
14	2029	20.80	0.00	-20.80	26.14	0.00	-26.14	18.79	0.00	-18.79	105.60	0.00	-105.60	106.14	0.00	-106.14	23.24	0.00	-23.24	15.63	0.00	-15.63	2.46	0.00	-2.46	66.37	0.00	-66.37	11.32	0.00	-11.32	71.60	0.00	-71.60
15	2030	21.03	0.00	-21.03	26.38	0.00	-26.38	18.89	0.00	-18.89	106.77	0.00	-106.77	107.17	0.00	-107.17	23.64	0.00	-23.64	15.90	0.00	-15.90	2.52	0.00	-2.52	67.56	0.00	-67.56	11.54	0.00	-11.54	72.87	0.00	-72.87
16	2031	21.13	0.00	-21.13	26.54	0.00	-26.54	18.99	0.00	-18.99	108.07	0.00	-108.07	108.23	0.00	-108.23	24.04	0.00	-24.04	16.16	0.00	-16.16	2.56	0.00	-2.56	68.70	0.00	-68.70	11.72	0.00	-11.72	74.05	0.00	-74.05
17	2032	21.25	0.00	-21.25	26.69	0.00	-26.69	19.10	0.00	-19.10	109.14	0.00	-109.14	110.25	0.00	-110.25	24.42	0.00	-24.42	16.41	0.00	-16.41	2.60	0.00	-2.60	69.76	0.00	-69.76	11.91	0.00	-11.91	75.15	0.00	-75.15
18	2033	21.36	0.00	-21.36	26.82	0.00	-26.82	19.19	0.00	-19.19	110.34	0.00	-110.34	111.19	0.00	-111.19	24.77	0.00	-24.77	16.66	0.00	-16.66	2.63	0.00	-2.63	70.74	0.00	-70.74	12.08	0.00	-12.08	76.33	0.00	-76.33
19	2034	21.47	0.00	-21.47	26.97	0.00	-26.97	19.31	0.00	-19.31	112.45	0.00	-112.45	112.13	0.00	-112.13	25.10	0.00	-25.10	16.89	0.00	-16.89	2.67	0.00	-2.67	71.65	0.00	-71.65	12.23	0.00	-12.23	77.33	0.00	-77.33
20	2035	21.58	0.00	-21.58	27.11	0.00	-27.11	19.41	0.00	-19.41	113.40	0.00	-113.40	113.17	0.00	-113.17	25.44	0.00	-25.44	17.12	0.00	-17.12	2.71	0.00	-2.71	72.50	0.00	-72.50	12.38	0.00	-12.38	78.21	0.00	-78.21

Source: JICA Study Team

Table 3.3.1-7: Supply-Demand Balance in Water Connection per Sub-Sectors

SECTOR		83A						83B						84A						84B						85A		
SUB SECTOR		83A-1			83A-2			83B-1			83B-2			84A-1			84A-2			84B-1			84B-2			85A		
	AÑO	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance
	2009	1609	0	-1609	2487	0	-2487	1273	0	-1273	4068	0	-4068	4477	0	-4477	3109	0	-3109	4021	0	-4021	1669	0	-1669	2184	0	-2184
-5	2010	1657	0	-1657	2622	0	-2622	1345	0	-1345	4253	0	-4253	4638	0	-4638	3213	0	-3213	4172	0	-4172	1748	0	-1748	2262	0	-2262
-4	2011	1705	0	-1705	2754	0	-2754	1418	0	-1418	4433	0	-4433	4793	0	-4793	3313	0	-3313	4318	0	-4318	1824	0	-1824	2337	0	-2337
-3	2012	1750	0	-1750	2887	0	-2887	1489	0	-1489	4612	0	-4612	4944	0	-4944	3409	0	-3409	4461	0	-4461	1900	0	-1900	2410	0	-2410
-2	2013	1793	0	-1793	3019	0	-3019	1559	0	-1559	4786	0	-4786	5091	0	-5091	3504	0	-3504	4601	0	-4601	1974	0	-1974	2480	0	-2480
-1	2014	1836	0	-1836	3148	0	-3148	1629	0	-1629	4957	0	-4957	5234	0	-5234	3595	0	-3595	4737	0	-4737	2049	0	-2049	2549	0	-2549
0	2015	1876	0	-1876	3274	0	-3274	1698	0	-1698	5125	0	-5125	5372	0	-5372	3682	0	-3682	4868	0	-4868	2121	0	-2121	2616	0	-2616
1	2016	1916	0	-1916	3401	0	-3401	1767	0	-1767	5291	0	-5291	5507	0	-5507	3766	0	-3766	4998	0	-4998	2191	0	-2191	2681	0	-2681
2	2017	1953	0	-1953	3526	0	-3526	1834	0	-1834	5454	0	-5454	5639	0	-5639	3848	0	-3848	5124	0	-5124	2262	0	-2262	2745	0	-2745
3	2018	1991	0	-1991	3650	0	-3650	1902	0	-1902	5616	0	-5616	5767	0	-5767	3929	0	-3929	5246	0	-5246	2331	0	-2331	2808	0	-2808
4	2019	2026	0	-2026	3772	0	-3772	1968	0	-1968	5775	0	-5775	5893	0	-5893	4009	0	-4009	5369	0	-5369	2399	0	-2399	2868	0	-2868
5	2020	2035	0	-2035	3791	0	-3791	1978	0	-1978	5803	0	-5803	5921	0	-5921	4028	0	-4028	5395	0	-5395	2411	0	-2411	2882	0	-2882
6	2021	2045	0	-2045	3808	0	-3808	1986	0	-1986	5829	0	-5829	5948	0	-5948	4046	0	-4046	5420	0	-5420	2423	0	-2423	2897	0	-2897
7	2022	2054	0	-2054	3825	0	-3825	1996	0	-1996	5855	0	-5855	5976	0	-5976	4064	0	-4064	5444	0	-5444	2434	0	-2434	2909	0	-2909
8	2023	2063	0	-2063	3844	0	-3844	2005	0	-2005	5881	0	-5881	6002	0	-6002	4084	0	-4084	5470	0	-5470	2444	0	-2444	2923	0	-2923
9	2024	2072	0	-2072	3861	0	-3861	2014	0	-2014	5908	0	-5908	6030	0	-6030	4102	0	-4102	5494	0	-5494	2456	0	-2456	2936	0	-2936
10	2025	2082	0	-2082	3879	0	-3879	2023	0	-2023	5934	0	-5934	6056	0	-6056	4119	0	-4119	5518	0	-5518	2467	0	-2467	2949	0	-2949
11	2026	2092	0	-2092	3896	0	-3896	2033	0	-2033	5962	0	-5962	6083	0	-6083	4137	0	-4137	5544	0	-5544	2478	0	-2478	2961	0	-2961
12	2027	2102	0	-2102	3914	0	-3914	2041	0	-2041	5988	0	-5988	6111	0	-6111	4156	0	-4156	5569	0	-5569	2490	0	-2490	2977	0	-2977
13	2028	2110	0	-2110	3931	0	-3931	2050	0	-2050	6014	0	-6014	6138	0	-6138	4175	0	-4175	5593	0	-5593	2502	0	-2502	2990	0	-2990
14	2029	2120	0	-2120	3949	0	-3949	2059	0	-2059	6041	0	-6041	6164	0	-6164	4193	0	-4193	5616	0	-5616	2512	0	-2512	3002	0	-3002
15	2030	2128	0	-2128	3966	0	-3966	2068	0	-2068	6066	0	-6066	6191	0	-6191	4211	0	-4211	5641	0	-5641	2523	0	-2523	3016	0	-3016
16	2031	2138	0	-2138	3983	0	-3983	2076	0	-2076	6093	0	-6093	6218	0	-6218	4229	0	-4229	5667	0	-5667	2534	0	-2534	3030	0	-3030
17	2032	2148	0	-2148	4001	0	-4001	2086	0	-2086	6121	0	-6121	6244	0	-6244	4247	0	-4247	5692	0	-5692	2546	0	-2546	3043	0	-3043
18	2033	2157	0	-2157	4019	0	-4019	2094	0	-2094	6146	0	-6146	6272	0	-6272	4265	0	-4265	5717	0	-5717	2557	0	-2557	3057	0	-3057
19	2034	2168	0	-2168	4035	0	-4035	2103	0	-2103	6171	0	-6171	6299	0	-6299	4283	0	-4283	5741	0	-5741	2568	0	-2568	3070	0	-3070
20	2035	2176	0	-2176	4052	0	-4052	2111	0	-2111	6198	0	-6198	6326	0	-6326	4302	0	-4302	5765	0	-5765	2579	0	-2579	3082	0	-3082

SECTOR		85B									85C			212A						212B						213									259		
SUB SECTOR		85B-1			85B-2			85B-3			85C			212A-1			212A-2			212B-1			212B-2			213-1			213-2			213-3			259		
	AÑO	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Deficit	Demanda	Oferta	Balance
	2009	918	0	-918	894	0	-894	287	0	-287	1657	0	-1657	3344	0	-3344	2084	0	-2084	1612	0	-1612	1358	0	-1358	3003	0	-3003	68	0	-68	130	0	-130	2282	0	-2282
-5	2010	937	0	-937	926	0	-926	306	0	-306	1717	0	-1717	3465	0	-3465	2150	0	-2150	1672	0	-1672	1416	0	-1416	3154	0	-3154	70	0	-70	133	0	-133	2435	0	-2435
-4	2011	956	0	-956	959	0	-959	324	0	-324	1775	0	-1775	3578	0	-3578	2214	0	-2214	1729	0	-1729	1472	0	-1472	3303	0	-3303	71	0	-71	136	0	-136	2590	0	-2590
-3	2012	974	0	-974	990	0	-990	342	0	-342	1833	0	-1833	3684	0	-3684	2274	0	-2274	1781	0	-1781	1525	0	-1525	3444	0	-3444	72	0	-72	138	0	-138	2747	0	-2747
-2	2013	989	0	-989	1022	0	-1022	361	0	-361	1891	0	-1891	3788	0	-3788	2334	0	-2334	1833	0	-1833	1575	0	-1575	3582	0	-3582	73	0	-73	140	0	-140	2907	0	-2907
-1	2014	1003	0	-1003	1056	0	-1056	379	0	-379	1948	0	-1948	3883	0	-3883	2389	0	-2389	1882	0	-1882	1624	0	-1624	3717	0	-3717	74	0	-74	142	0	-142	3069	0	-3069
0	2015	1018	0	-1018	1089	0	-1089	398	0	-398	2003	0	-2003	3973	0	-3973	2446	0	-2446	1927	0	-1927	1672	0	-1672	3845	0	-3845	75	0	-75	143	0	-143	3232	0	-3232
1	2016	1031	0	-1031	1121	0	-1121	418	0	-418	2058	0	-2058	4061	0	-4061	2498	0	-2498	1971	0	-1971	1719	0	-1719	3973	0	-3973	75	0	-75	145	0	-145	3400	0	-3400
2	2017	1043	0	-1043	1155	0	-1155	437	0	-437	2111	0	-2111	4142	0	-4142	2549	0	-2549	2013	0	-2013	1762	0	-1762	4096	0	-4096	76	0	-76	146	0	-146	3568	0	-3568
3	2018	1054	0	-1054	1187	0	-1187	455	0	-455	2166	0	-2166	4222	0	-4222	2600	0	-2600	2053	0	-2053	1805	0	-1805	4218	0	-4218	76	0	-76	147	0	-147	3739	0	-3739
4	2019	1064	0	-1064	1219	0	-1219	475	0	-475	2220	0	-2220	4298	0	-4298	2647	0	-2647	2091	0	-2091	1845	0	-1845	4336	0	-4336	77	0	-77	148	0	-148	3915	0	-3915
5	2020	1071	0	-1071	1229	0	-1229	479	0	-479	2233	0	-2233	4319	0	-4319	2661	0	-2661	2103	0	-2103	1855	0	-1855	4358	0	-4358	77	0	-77	149	0	-149	3946	0	-3946
6	2021	1078	0	-1078	1240	0	-1240	482	0	-482	2244	0	-2244	4338	0	-4338	2674	0	-2674	2113	0	-2113	1865	0	-1865	4378	0	-4378	78	0	-78	149	0	-149	3978	0	-3978
7	2022	1083	0	-1083	1249	0	-1249	485	0	-485	2255	0	-2255	4356	0	-4356	2686	0	-2686	2122	0	-2122	1873	0	-1873	4397	0	-4397	78	0	-78	150	0	-150	4009	0	-4009
8	2023	1091	0	-1091	1259	0	-1259	489	0	-489	2270	0	-2270	4376	0	-4376	2699	0	-2699	2130	0	-2130	1882	0	-1882	4416	0	-4416	78	0	-78	151	0	-151	4041	0	-4041
9	2024	1096	0	-1096	1269	0	-1269	494	0	-494	2281	0	-2281	4395	0	-4395	2711	0	-2711	2140	0	-2140	1890	0	-1890	4435	0	-4435	79	0	-79	151	0	-151	4074	0	-4074
10	2025	1102	0	-1102	1280	0	-1280	497	0	-497	2292	0	-2292	4413	0	-4413	2724	0	-2724	2149	0	-2149	1898	0	-1898	4454	0	-4454	79	0	-79	152	0	-152	4107	0	-4107
11	2026	1109	0	-1109	1291	0	-1291	501	0	-501	2305	0	-2305	4433	0	-4433	2736	0	-2736	2160	0	-2160	1906	0	-1906	4473	0	-4473	79	0	-79	152	0	-152	4138	0	-4138
12	2027	1116	0	-1116	1301	0	-1301	505	0	-505	2318	0	-2318	4452	0	-4452	2749	0	-2749	2168	0	-2168	1916	0	-1916	4491	0	-4491	80	0	-80	153	0	-153	4171	0	-4171
13	2028	1122	0	-1122	1311	0	-1311	509	0	-509	2329	0	-2329	4471	0	-4471	2762	0	-2762	2177	0	-2177	1924	0	-1924	4511	0	-4511	80	0	-80	154	0	-154	4203	0	-4203
14	2029	1128	0	-1128	1323	0	-1323	513	0	-513	2341	0	-2341	4490	0	-4490	2774	0	-2774	2186	0	-2186	1932	0	-1932	4531	0	-4531	80	0	-80	154	0	-154	4236	0	-4236
15	2030	1135	0	-1135	1334	0	-1334	518	0	-518	2355	0	-2355	4511	0	-4511	2786	0	-2786	2196	0	-2196	1940	0	-1940	4549	0	-4549	81	0	-81	155	0	-155	4268	0	-4268
16	2031	1141	0	-1141	1345	0	-1345	522	0	-522	2367	0	-2367	4529	0	-4529	2799	0	-2799	2206	0	-2206	1949	0	-1949	4568	0	-4568	81	0	-81	156	0	-156	4302	0	-4302
17	2032	1148	0	-1148	1356	0	-1356	527	0	-527	2378	0	-2378	4547	0	-4547	2812	0	-2812	2215	0	-2215	1957	0	-1957	4586	0	-4586	81	0	-81	156	0	-156	4335	0	-4335
18	2033	1155	0	-1155	1367	0	-1367	530	0	-530	2391	0	-2391	4567	0	-4567	2826	0	-2826	2224	0	-2224	1966	0	-1966	4607	0	-4607	82	0	-82	157	0	-157	4369	0	-4369
19	2034	1162	0	-1162	1379	0	-1379	535	0	-535	2404	0	-2404	4586	0	-4586	2838	0	-2838	2234	0	-2234	1976	0	-1976	4626	0	-4626	82	0	-82	158	0	-158	4402	0	-4402
20	2035	1167	0	-1167	1389	0	-1389	539	0	-539	2415	0	-2415	4605	0	-4605	2850	0	-2850	2243	0	-2243	1984	0	-1984	4644	0	-4644	82	0	-82	158	0	-158	4435	0	-4435

SECTOR		345			346			347						348A			348B						349A					
SUB SECTOR		345			346			347-1			347-2			348A			348B-1			348B-2			349A-1			349A-2		
	AÑO	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance
	2009	415	0	-415	2605	0	-2605	2050	0	-2050	1795	0	-1795	841	0	-841	2034	0	-2034	178	0	-178	1749	0	-1749	340	0	-340
-5	2010	554	0	-554	2641	0	-2641	2126	0	-2126	1888	0	-1888	911	0	-911	2150	0	-2150	189	0	-189	1879	0	-1879	388	0	-388
-4	2011	694	0	-694	2678	0	-2678	2204	0	-2204	1983	0	-1983	981	0	-981	2265	0	-2265	200	0	-200	2010	0	-2010	437	0	-437
-3	2012	838	0	-838	2712	0	-2712	2280	0	-2280	2079	0	-2079	1052	0	-1052	2381	0	-2381	211	0	-211	2143	0	-2143	487	0	-487
-2	2013	984	0	-984	2746	0	-2746	2358	0	-2358	2173	0	-2173	1124	0	-1124	2499	0	-2499	222	0	-222	2275	0	-2275	537	0	-537
-1	2014	1131	0	-1131	2780	0	-2780	2436	0	-2436	2269	0	-2269	1197	0	-1197	2617	0	-2617	234	0	-234	2410	0	-2410	589	0	-589
0	2015	1281	0	-1281	2812	0	-2812	2512	0	-2512	2366	0	-2366	1270	0	-1270	2735	0	-2735	245	0	-245	2546	0	-2546	640	0	-640
1	2016	1432	0	-1432	2844	0	-2844	2592	0	-2592	2465	0	-2465	1343	0	-1343	2854	0	-2854	256	0	-256	2683	0	-2683	692	0	-692
2	2017	1586	0	-1586	2875	0	-2875	2668	0	-2668	2562	0	-2562	1419	0	-1419	2974	0	-2974	268	0	-268	2821	0	-2821	745	0	-745
3	2018	1741	0	-1741	2904	0	-2904	2745	0	-2745	2660	0	-2660	1493	0	-1493	3093	0	-3093	279	0	-279	2960	0	-2960	798	0	-798
4	2019	1898	0	-1898	2930	0	-2930	2822	0	-2822	2758	0	-2758	1569	0	-1569	3213	0	-3213	291	0	-291	3099	0	-3099	851	0	-851
5	2020	1911	0	-1911	2949	0	-2949	2840	0	-2840	2776	0	-2776	1579	0	-1579	3235	0	-3235	293	0	-293	3120	0	-3120	856	0	-856
6	2021	1924	0	-1924	2968	0	-2968	2859	0	-2859	2794	0	-2794	1588	0	-1588	3255	0	-3255	295	0	-295	3140	0	-3140	862	0	-862
7	2022	1936	0	-1936	2987	0	-2987	2876	0	-2876	2812	0	-2812	1598	0	-1598	3275	0	-3275	297	0	-297	3159	0	-3159	867	0	-867
8	2023	1949	0	-1949	3005	0	-3005	2895	0	-2895	2829	0	-2829	1608	0	-1608	3296	0	-3296	298	0	-298	3179	0	-3179	873	0	-873
9	2024	1961	0	-1961	3025	0	-3025	2911	0	-2911	2846	0	-2846	1618	0	-1618	3318	0	-3318	300	0	-300	3198	0	-3198	878	0	-878
10	2025	1973	0	-1973	3045	0	-3045	2929	0	-2929	2864	0	-2864	1627	0	-1627	3338	0	-3338	302	0	-302	3217	0	-3217	883	0	-883
11	2026	1985	0	-1985	3067	0	-3067	2948	0	-2948	2881	0	-2881	1637	0	-1637	3358	0	-3358	304	0	-304	3236	0	-3236	888	0	-888
12	2027	1997	0	-1997	3083	0	-3083	2966	0	-2966	2901	0	-2901	1647	0	-1647	3377	0	-3377	306	0	-306	3255	0	-3255	893	0	-893
13	2028	2010	0	-2010	3101	0	-3101	2983	0	-2983	2917	0	-2917	1657	0	-1657	3397	0	-3397	308	0	-308	3275	0	-3275	899	0	-899
14	2029	2022	0	-2022	3120	0	-3120	3002	0	-3002	2936	0	-2936	1667	0	-1667	3417	0	-3417	309	0	-309	3294	0	-3294	905	0	-905
15	2030	2035	0	-2035	3138	0	-3138	3019	0	-3019	2952	0	-2952	1678	0	-1678	3438	0	-3438	311	0	-311	3313	0	-3313	911	0	-911
16	2031	2046	0	-2046	3157	0	-3157	3037	0	-3037	2969	0	-2969	1687	0	-1687	3458	0	-3458	313	0	-313	3334	0	-3334	916	0	-916
17	2032	2059	0	-2059	3177	0	-3177	3055	0	-3055	2987	0	-2987	1697	0	-1697	3477	0	-3477	315	0	-315	3352	0	-3352	921	0	-921
18	2033	2070	0	-2070	3195	0	-3195	3073	0	-3073	3004	0	-3004	1706	0	-1706	3497	0	-3497	317	0	-317	3371	0	-3371	927	0	-927
19	2034	2083	0	-2083	3212	0	-3212	3092	0	-3092	3023	0	-3023	1716	0	-1716	3517	0	-3517	318	0	-318	3391	0	-3391	932	0	-932
20	2035	2095	0	-2095	3232	0	-3232	3109	0	-3109	3040	0	-3040	1726	0	-1726	3537	0	-3537	320	0	-320	3410	0	-3410	937	0	-937

SECTOR		349A			349B									350						351									368A						369A		
SUB SECTOR		349A-3			349B-1			349B-2			349B-3			350-1			350-2			351-1			351-2			351-3			368A1			368A-2			369A		
	AÑO	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Balance	Demanda	Oferta	Deficit	Demanda	Oferta	Balance
	2009	894	0	-894	784	0	-784	764	0	-764	747	0	-747	3839	0	-3839	3448	0	-3448	598	0	-598	361	0	-361	76	0	-76	1761	0	-1761	297	0	-297	2179	0	-2179
-5	2010	973	0	-973	844	0	-844	859	0	-859	796	0	-796	3998	0	-3998	3638	0	-3638	663	0	-663	407	0	-407	82	0	-82	1954	0	-1954	330	0	-330	2363	0	-2363
-4	2011	1052	0	-1052	903	0	-903	954	0	-954	846	0	-846	4154	0	-4154	3829	0	-3829	732	0	-732	456	0	-456	89	0	-89	2158	0	-2158	365	0	-365	2556	0	-2556
-3	2012	1133	0	-1133	964	0	-964	1052	0	-1052	897	0	-897	4314	0	-4314	4025	0	-4025	803	0	-803	506	0	-506	95	0	-95	2370	0	-2370	402	0	-402	2753	0	-2753
-2	2013	1214	0	-1214	1025	0	-1025	1150	0	-1150	948	0	-948	4472	0	-4472	4223	0	-4223	876	0	-876	559	0	-559	102	0	-102	2592	0	-2592	440	0	-440	2958	0	-2958
-1	2014	1296	0	-1296	1086	0	-1086	1248	0	-1248	999	0	-999	4629	0	-4629	4421	0	-4421	955	0	-955	615	0	-615	109	0	-109	2825	0	-2825	480	0	-480	3170	0	-3170
0	2015	1378	0	-1378	1148	0	-1148	1349	0	-1349	1051	0	-1051	4786	0	-4786	4621	0	-4621	1034	0	-1034	672	0	-672	116	0	-116	3066	0	-3066	521	0	-521	3386	0	-3386
1	2016	1463	0	-1463	1210	0	-1210	1450	0	-1450	1105	0	-1105	4942	0	-4942	4824	0	-4824	1116	0	-1116	731	0	-731	124	0	-124	3313	0	-3313	564	0	-564	3608	0	-3608
2	2017	1546	0	-1546	1273	0	-1273	1554	0	-1554	1158	0	-1158	5097	0	-5097	5028	0	-5028	1201	0	-1201	793	0	-793	131	0	-131	3569	0	-3569	608	0	-608	3835	0	-3835
3	2018	1633	0	-1633	1335	0	-1335	1657	0	-1657	1210	0	-1210	5251	0	-5251	5231	0	-5231	1288	0	-1288	856	0	-856	139	0	-139	3833	0	-3833	654	0	-654	4066	0	-4066
4	2019	1717	0	-1717	1399	0	-1399	1760	0	-1760	1262	0	-1262	5404	0	-5404	5436	0	-5436	1376	0	-1376	921	0	-921	146	0	-146	4104	0	-4104	701	0	-701	4301	0	-4301
5	2020	1728	0	-1728	1408	0	-1408	1772	0	-1772	1272	0	-1272	5498	0	-5498	5518	0	-5518	1413	0	-1413	945	0	-945	150	0	-150	4230	0	-4230	722	0	-722	4434	0	-4434
6	2021	1739	0	-1739	1417	0	-1417	1783	0	-1783	1280	0	-1280	5590	0	-5590	5596	0	-5596	1447	0	-1447	969	0	-969	154	0	-154	4355	0	-4355	744	0	-744	4566	0	-4566
7	2022	1750	0	-1750	1425	0	-1425	1794	0	-1794	1288	0	-1288	5679	0	-5679	5674	0	-5674	1483	0	-1483	992	0	-992	159	0	-159	4479	0	-4479	765	0	-765	4696	0	-4696
8	2023	1760	0	-1760	1435	0	-1435	1805	0	-1805	1296	0	-1296	5768	0	-5768	5752	0	-5752	1518	0	-1518	1016	0	-1016	163	0	-163	4604	0	-4604	786	0	-786	4826	0	-4826
9	2024	1772	0	-1772	1444	0	-1444	1816	0	-1816	1303	0	-1303	5857	0	-5857	5828	0	-5828	1554	0	-1554	1040	0	-1040	166	0	-166	4729	0	-4729	807	0	-807	4958	0	-4958
10	2025	1782	0	-1782	1452	0	-1452	1827	0	-1827	1312	0	-1312	5946	0	-5946	5905	0	-5905	1590	0	-1590	1064	0	-1064	170	0	-170	4854	0	-4854	828	0	-828	5088	0	-5088
11	2026	1793	0	-1793	1461	0	-1461	1838	0	-1838	1319	0	-1319	6034	0	-6034	5983	0	-5983	1625	0	-1625	1088	0	-1088	174	0	-174	4979	0	-4979	850	0	-850	5220	0	-5220
12	2027	1804	0	-1804	1470	0	-1470	1848	0	-1848	1327	0	-1327	6119	0	-6119	6056	0	-6056	1660	0	-1660	1110	0	-1110	177	0	-177	5096	0	-5096	870	0	-870	5342	0	-5342
13	2028	1814	0	-1814	1478	0	-1478	1860	0	-1860	1335	0	-1335	6202	0	-6202	6126	0	-6126	1693	0	-1693	1132	0	-1132	181	0	-181	5206	0	-5206	889	0	-889	5456	0	-5456
14	2029	1825	0	-1825	1488	0	-1488	1871	0	-1871	1343	0	-1343	6280	0	-6280	6196	0	-6196	1725	0	-1725	1154	0	-1154	184	0	-184	5310	0	-5310	906	0	-906	5565	0	-5565
15	2030	1837	0	-1837	1498	0	-1498	1882	0	-1882	1350	0	-1350	6357	0	-6357	6262	0	-6262	1755	0	-1755	1174	0	-1174	188	0	-188	5406	0	-5406	923	0	-923	5667	0	-5667
16	2031	1847	0	-1847	1506	0	-1506	1894	0	-1894	1358	0	-1358	6431	0	-6431	6328	0	-6328	1785	0	-1785	1193	0	-1193	191	0	-191	5497	0	-5497	938	0	-938	5762	0	-5762
17	2032	1858	0	-1858	1515	0	-1515	1905	0	-1905	1366	0	-1366	6502	0	-6502	6392	0	-6392	1813	0	-1813	1212	0	-1212	194	0	-194	5582	0	-5582	953	0	-953	5850	0	-5850
18	2033	1869	0	-1869	1523	0	-1523	1915	0	-1915	1373	0	-1373	6571	0	-6571	6452	0	-6452	1839	0	-1839	1230	0	-1230	196	0	-196	5661	0	-5661	967	0	-967	5934	0	-5934
19	2034	1879	0	-1879	1532	0	-1532	1926	0	-1926	1382	0	-1382	6641	0	-6641	6512	0	-6512	1864	0	-1864	1247	0	-1247	199	0	-199	5734	0	-5734	979	0	-979	6012	0	-6012
20	2035	1890	0	-1890	1540	0	-1540	1937	0	-1937	1389	0	-1389	6704	0	-6704	6569	0	-6569	1889	0	-1889	1264	0	-1264	202	0	-202	5802	0	-5802	991	0	-991	6083	0	-6083

Source: JICA Study Team

3.3.2 Sewerage

The sewerage demand is shown in Table 3.1.3-4, and the supply is shown in Table 3.2.2-6. Table 3.3.2-1 shows the balance of supply and demand in terms of the length of pipe.

Table 3.3.2-1: Supply-Demand Balance for Sewerage in the Project Area

Drainage area	Demand of pipes (Km)	Supply of pipes in good condition (Km)	Balance (Km)
A16	7.52	7.52	
A18	11.53	11.53	
A19	5.73	5.73	
AD-0	1.70	1.70	
AD-01B	0.95	0.95	
AD-A1	30.31	20.84	9.47
AD-A2	24.16	21.22	2.94
AD-AG1	4.68	3.72	0.96
AD-AG2	29.91	6.04	23.87
AD-AG3	12.13	1.33	10.80
AD-AG4	26.44	14.39	12.05
ADC-1	10.08	8.57	1.51
ADC-2	13.52	11.50	2.02
ADC-3	4.97	4.22	0.75
ADC-4	6.91	5.87	1.04
ADC-5	13.70	11.65	2.05
ADC-6	11.38	9.67	1.71
AD-CA1	8.80	8.80	
AD-CA3	0.82	0.82	
AD-CH1	32.03	10.28	21.75
AD-CH2	12.58	6.57	6.01
AD-CH3	21.88	2.30	19.58
AD-CH4	30.87	30.87	
AD-CO1	20.84	2.85	17.99
AD-CO2	26.83	23.58	3.25
AD-M1	13.32	7.45	5.87
AD-N1	24.57	7.43	17.14
AD-N2	23.53	3.28	20.25
AD-P2	0.46	0.46	
AD-PL1	22.18	18.85	3.33
AD-PL2	22.59	19.57	3.02
AD-R1	14.81	2.32	12.49
AD-R2	17.36	2.57	14.79
AD-T1	14.54	4.57	9.97
AD-T2	6.61	6.26	0.35
AD-T3	0.04	0.03	0.01
AD-T4	12.54	6.35	6.19
AD-T5	10.06	5.03	5.03
AD-T6	2.61	1.31	1.30
PT1	22.99	22.99	
PT2	6.59	6.59	
PT3	13.00	13.00	
PT4	11.70	11.70	
PT5	8.78	8.78	
PT6	25.44	25.44	
PT7	7.54	7.54	
SA-57	0.03	0.03	
Total	651.56	414.07	237.49
Percentage	10%	63.55%	36.45%

Source: JICA Study Team

3.4 Technical Solutions Against the Problems

3.4.1 Consideration of Technical Solutions

(1) Problems in the Water Supply System

Problems in water supply system were identified in Section 2.5.14 through the diagnoses of the water supply system.

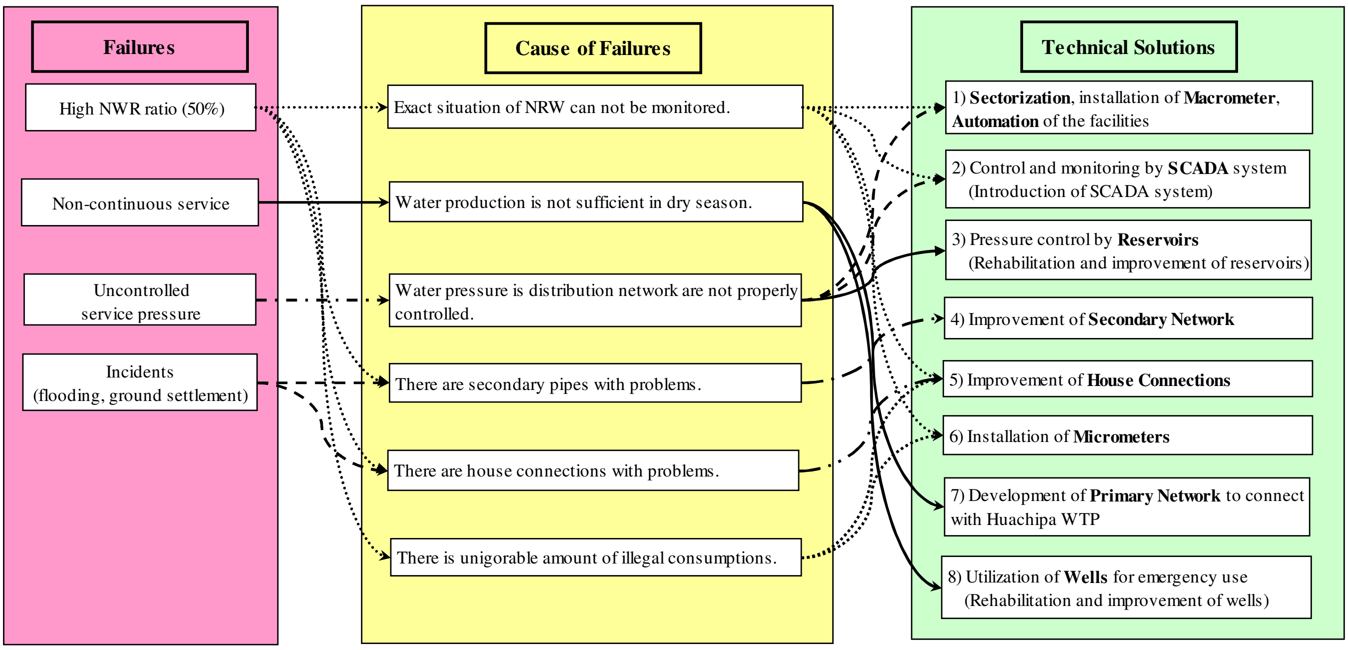
(2) Failures of the Existing Water Supply System and their Causes

Problems identified in Section 2.5.14 include two kinds of problems, which are i) failures of the existing water supply system and ii) causes of the failures. The "failures" mean the present conditions which do not comply with SEDAPAL's policy, or its required service level of water supply, or deteriorating people's living conditions.

Among the identified problems, the failures are high NRW ratio, discontinuous water supply service and improper service pressure, and frequent incidents caused by water supply pipes in the Study. Other identified problems are the causes of the failures above.

(3) Technical Solutions in the Project

Figure 3.4.1-1 presents the problems, in order of failures and causes, and technical solutions against the causes. The following sections related to water supply provide a study on the proposed technical solutions shown in the figure by which the Project will be formulated.



Source: JICA Study Team

Figure 3.4.1-1: Failures and Causes of the Water Supply System, and Technical Solutions to be Included in the Project

(4) Considerations for Technical Solutions

1) Necessity of the Considerations

Among the technical solutions shown in Figure 3.4.1-1, 1) *sectorization, installation of macrometer and automation*, 2) *control and monitoring by SCADA system*, 3) *pressure control by reservoirs*, 7) *development of primary network to connect with Huachipa WTP* and 8) *utilization of wells* are to be carried out completely in the Project, as they are minimum requirements for the Project to be able to improve the service level of the water supply. Moreover, 6) *installation of micrometer* is also one of the minimum requirements because it is a fundamental solution for SEDAPAL to know the exact situation of water distribution.

However, the remaining two solutions, which are 4) *improvement of secondary networks* and 5) *improvement of house connection*, are not the necessary technical solutions to be executed completely within the Project. Their required level of execution is a level which reduces the NRW ratio to the target value of 25% and eliminates the serious incidents which affect people's well-being.

Except for the two solutions of 7) *development of primary network* and 8) *utilization of wells*, all technical solutions contribute to the reduction of the NRW ratio, but they vary in reduction approach and extent. Before the study and design of the technical solutions, therefore, it is necessary to determine the execution levels of 4) *improvement of secondary networks* and 5) *improvement of house connection* needed to achieve the target 25% NRW ratio.

As for the elimination of serious incidents, they will be automatically prevented by the improvement of the secondary networks and house connections.

2) Methodology

The present condition of the NRW ratio was estimated in Section 2.5.10. In this consideration, the contribution of each technical solution in the NRW reduction is estimated first, and then alternatives execution levels will be prepared for 4) *improvement of secondary networks* and 5) *improvement of house connection*, to be included in the Project in order to achieve a 25% NRW ratio.

In the estimation of the contribution of each technical solution, the technical loss ratio is divided into three categories by location of the losses, such as distribution network, connection and others.

Among the prepared alternatives, the most suitable one in view of cost-efficiency is selected, and execution level for the technical solutions is determined.

3) Estimation of Water Loss on Secondary Networks and House Connections

Most of the technical loss is caused by secondary networks and house connections, and technical loss in reservoirs and others is minimal.

There is no data or investigation which identifies water loss in secondary networks and house connections separately in SEDAPAL. Here, in order to identify execution level of secondary networks and house connections, water loss on secondary networks and house connection are estimated separately, based on SEDAPAL's existing data.

Assuming the water loss is effluent from the orifice of pipes, theoretically, factors which determine water loss are i) number of orifices, ii) dimension of each orifice and iii) water pressure. The number of orifices and the dimension of each orifice affect the water loss proportionally. On the other hand, water pressure affects the water loss by one-half the square proportion, based on orifice theory.

The number of incidents can be used for the identification of number of orifices. According to SEDAPAL's data, about 90% of the total incidents are reported on house connections. From 2006 to 2009, 7,903 incidents are reported in house connections and 743 incidents are reported in secondary networks.

The size of the orifice is associated with the diameter of the pipes. House connections mainly have a diameter of 15mm, which is much smaller than that of secondary pipes. Pipes with diameters of 100mm and 110mm account for more than 60% of the total pipe length of secondary networks.

As for pressure, it is obviously higher in secondary networks than in house connections. According to the monitored pressure in the original sectors 83, 84, 85, 212 and 213, water pressure in secondary networks is about 25m at the entrance of the sectors. Although no data is available to identify the water pressure at connections, it will be around 10-15 m.c.a. on average, considering the service pressure at end users.

Factors which affect water loss and their relations to secondary networks and house connections are identified in Table 3.4.1-1. It is estimated that about 40% of the water loss is in secondary networks, and about 60% is in house connections.

Table 3.4.1-1: Estimation of Water Loss in Secondary Networks and House Connections

Code	Factors Related to Water Loss	Representing Data	Unit	Secondary Networks	House Connections
A	Number of Orifices	Number of Incidents	Nos	743*	7,903*
B	Dimension of Orifice	Mean Diameter	mm	110 (100-110)	15 (15-25)
C	Water Pressure at Orifice	Average Pressure	m.c.a.	15.0 (10-25)	12.5 (10-15)
Water Loss Index: I_{WL} (= A x B x $C^{1/2}$)				316,539	419,120
Ratio of I_{WL}				0.43 : 0.57	
Evaluation				About 40 % of water loss is in secondary networks.	

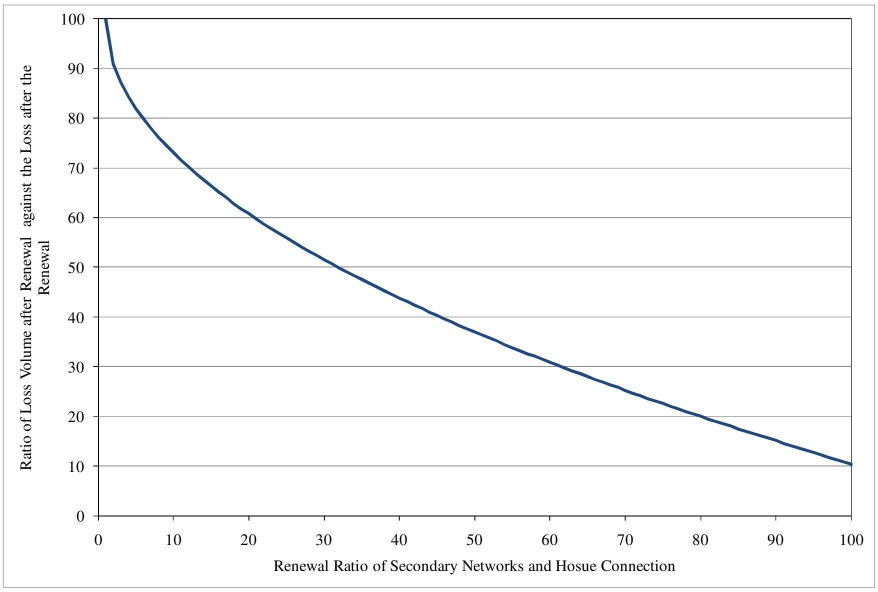
*: Data from 2006 to 2009
Source: JICA Study Team

4) Assumptions and Consideration of Alternatives

In the consideration, the following conditions are assumed:

- Based on the discussion given in Section 2.5.10, out of the NRW ratio of 50%, the technical loss is 40% and non technical loss is 10%.

- 40% of the technical loss arises from secondary networks, while 60% of technical loss comes from house connections.
- If secondary networks or house connections are totally renewed, the technical loss volume will be very low just immediately after the execution. However, reduction of the technical loss volume is assumed at 10% of the current volume, considering some future degradation of the renewed pipes.
- It is assumed that the renewed ratio and the reduction of technical loss volume are related as presented in Figure 3.4.1-2. The trend of NRW reduction in the figure is prepared considering that renewals of critical secondary pipes or house connections are prioritized.



Source: JICA Study Team

Figure 3.4.1-2: Reduction of Technical Loss Volume by Renewal of Secondary Networks or House Connections

- Illegal consumption will be lowered, corresponding to the execution level of improvement of house connections. For example, for 100% house connection replacement would reduce it to a much lower value compared to a case when 50% of the house connections are replaced.
- Volume of each category of NRW is presented by comparative volume and not percentage against revenue water, which is assumed to be "100" in all cases.

Based on the assumptions above, the NRW ratios after renewal of secondary networks and house connections are estimated in four cases, as shown in Table 3.4.1-1 and Figure 3.4.1-3.

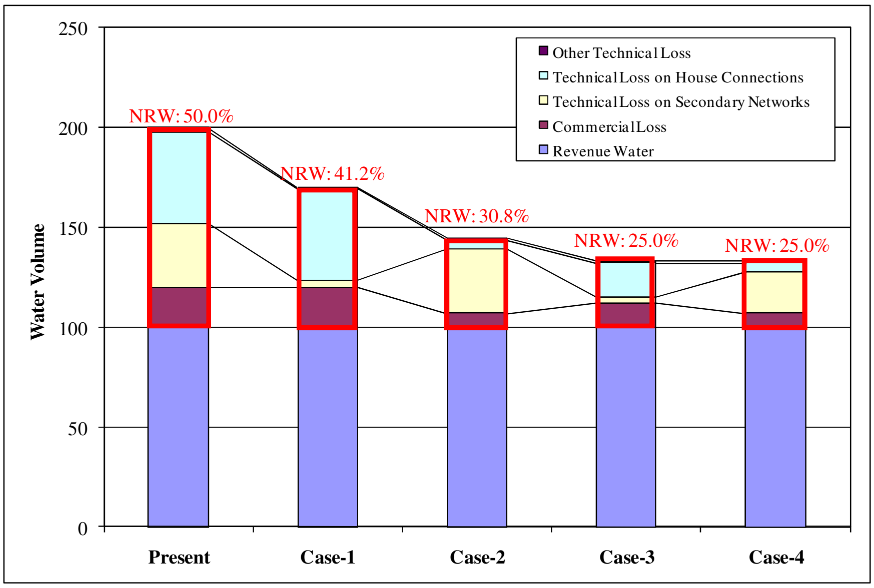
If all secondary pipes are renewed and no house connection is renewed, the NRW is expected to achieve to 41.2% (Case-1). If all house connections are renewed and no secondary pipe is renewed, the NRW is expected to achieve to 30.8% (Case-2). Both cases could not achieve to the target NRW ratio (25%). The case-3 is to renew all of secondary pipes and necessary number of house connections to achieve 25% of NRW ratio, and the case-4 is to renew all house connections and necessary length of secondary pipes to achieve 25% of NRW ratio. Furthermore, estimated results are summarized in Table 3.4.1-2.

As shown in the tables, Case-2 and Case-3 can be alternatives to achieve a 25% NRW ratio.

Table 3.4.1-2: Estimation of NRW Ratio after Projects

Items		Case-1	Case-2	Case-3	Case-4
Project	Renewal of Secondary Networks	100%	0%	100%	15%
	Renewal of House Connections	0%	100%	50%	100%
Expected NRW Ratio (after Project)		41.2%	30.8%	25.0%	25.0%

Source: JICA Study Team



Source: JICA Study Team

Figure 3.4.1-3: Reduction of NRW in the Four Cases

5) Determination of Execution Level of the Technical Solutions

The two alternatives are evaluated in Table 3.4.1-2. Construction costs in the table are approximate direct costs based on the unit prices calculated in the cost estimate of the Study. As shown in the tables, it is found that Alternative-2, in which 15% of the secondary networks and 100% of the house connections will be renewed, is more cost-effective than Alternative-1. Moreover, Alternative-2 has an advantage in that complete renewal of house connection can greatly reduce illegal consumption.

Table 3.4.1-3: Comparison of Alternatives of Execution Level of Technical Solutions

		Alternative-1 (Case-3)	**Alternative-2 (Case-4)**
Construction Item		100% of secondary pipes and 50% of house connections	15% of secondary pipes and 100% of house connections
Effect		NRW=25%	NRW=25%
Construction Cost	Secondary Networks	760,000m x 193 S/m = 146,680,000 S	114,000m x 193 S/m = 22,002,000 S
	House Connections	35,000nos x 716S/nos = 25,060,000 S	70,000nos x 716S/nos = 50,120,000 S
	Total*	**171,174,000 S**	**72,122,000 S**
Others		It will be difficult to identify which house connections will have priority for renewal.	Illegal connections can be found by complete renewal of house connections.
Evaluation		Fair	Good

*: Cost of items other than secondary networks and house connections are not included.
Source: JICA Study Team

As a result of the considerations, execution levels of the technical solutions are determined as follows;

- 1) *Sectorization, installation of macrometer and automation*, 2) *control and monitoring by SCADA system*, 3) *pressure control by reservoirs*, 6) *installation of micrometer*, 7) *development of primary network to connect with Huachipa WTP* and 8) *utilization of wells* shall be completely executed in the Project.
- In 4) *improvement of secondary networks*, at least 15% of all pipes shall be renewed. Priority of the pipes to be renewed shall be considered in selection of the 15%.
- In 5) *improvement of house connections*, 100% of the existing house connections shall be renewed, excluding those which have been installed recently.

Categrization of Distributed Water			Technical Solutions*1	Present		Case-1			Case-2			Case-3			Case-4		
						No renewal of house connections			No renewal of secondary networks			Complete renewal of secondary networks			Complete renewwal of house connections		
				NRW		Project*2	NRW		Project*2	NRW		Project*2	NRW		Project*2	NRW	
				%	m³		%	Volume*3		%	Volume*3		%	Volume*3		%	Volume*3
Revenued Water				**50.0**	100.0		**58.8**	100.0		**69.2**	100.0		**75.0**	100.0		**75.0**	100.0
Non-revenue Water	**Commercial Loss**	Legal Non-revenue Water	-	1.0	2.0		1.2	2.0		1.4	2.0		1.5	2.0		1.5	2.0
		Illegal Consumption	(5), (6)	8.0	16.0	–	9.4	16.0	√	2.1	3.0	Partly	6.0	8.0	√	2.3	3.0
		Meter Error and Others	(6)	1.0	2.0	√	1.2	2.0	√	1.4	2.0	√	1.5	2.0	√	1.5	2.0
		Sub-total		**10.0**	20.0		**11.8**	20.0		**4.8**	7.0		**9.0**	12.0		**5.3**	7.0
	Technical Loss	Secondary Network	(1), (2), (3)	16.0	32.0	√	1.9	3.2	-	22.1	32.0	√	2.4	3.2	√	15.5	20.7
			(4)			√			-			√			Partly		
		Connection	(5)	23.0	46.0	-	27.0	46.0	Partly	3.2	4.6	Partly	12.8	17.1	√	3.5	4.6
		Reservoirs and Others	(1), (2), (3)	1.0	2.0	√	0.6	1.0	√	0.7	1.0	√	0.8	1.0	√	0.8	1.0
		Sub-total		**40.0**	80.0		**29.5**	50.2		**26.0**	37.6		**16.0**	21.3		**19.7**	26.3
	NRW TOTAL			**50.0**	102.0		**41.2**	70.2		**30.8**	44.6		**25.0**	33.3		**25.0**	33.3
TOTAL				**100.0**	200.0		**100.0**	170.2		**100.0**	144.6		**100.0**	133.3		**100.0**	133.3
Percentage of NRW Volume after Renewal Against the Present NRW			Secondary Networks				10	%		100	%		10	%		65	%
			House Connections				100	%		10	%		37	%		10	%
Renewal Ratio			Secondary Networks				**100**	%		**0**	%		**100**	%		**15**	%
			House Connections				**0**	%		**100**	%		**49**	%		**100**	%
EVALUATION						**It is impossible to achieve the 25% of NRW** ratio without improvement of house connections.			**It is impossible to achieve the 25% of NRW** ratio without improvement of secondary networks.			Approximately more than **50% of house connections** are necessary to be renewed to achieve the 25% of NRW ratio.			Approximately **15% of secondary networks** are necessary to be renewed to achieve the 25% of NRW ratio.		

*1: 1) Sectorization, installation of Macrometer, Automation of the facilities
2) Control and monitoring by SCADA system (Introduction of SCADA system)
3) Pressure control by Reservoirs
4) Improvement of Secondary Networks
5) Improvement of House Connections
5) Installation of Micrometers

*2: √ : Carried out completely
Partly : Carried out partly

*3: Volume of revenue water is assumed to be "100".

Figure 3.4.1-4: Estimation of Effect of the Project

3.4.2 Conceptual Plan of Sectorization and Automation of Water Distribution System

(1) Purpose of Sectorization

Sectorization represents a shift in water distribution network management from a ramifying structure into an array of independently controlled sectors. It facilitates a) assessment of the current condition of water distribution, and b) control of water distribution in both normal and emergency conditions. Considering the problems which SEDAPAL is facing in the Study Area, the purpose and expected effects of sectorization can be summarized as follows:

i. Demand/Supply Control: Balance of water demand and supply will be monitored in each local area, which will help SEDAPAL to forecast future demand more accurately and to improve future development of water production;

ii. Loss Control: Water loss will be monitored effectively and precisely, which will help SEDAPAL to detect the causes of water loss and to plan corrective measures;

iii. Pressure Control: Water pressure can be controlled properly at each local area, which will enable continuous water supply in entire Project areas;

iv. Emergency Control: Independent sectors can be easily separated from the other sectors; any area that is affected by an incident can be confined to a local area; and

v. Maintenance Control: The independent sector can also be confined for the maintenance works.

(2) Existing Condition and Proposal of the *Perfil* for “Sector” and “Sub-sector”.

The Study area currently consists of 32 original sectors. In the *Perfil*, it was planned that some of the sectors to be further split up into two or three sectors, considering criteria based on size, land topography, area of influence of reservoirs, etc.; the total proposed number of the sectors was 41.

Twenty-two (22) out of the 41 sectors are the targets of the Project rehabilitation works. In the remaining 19 sectors, no rehabilitation was planned in the *Perfil* because i) 15 sectors do not have existing network or are being supplied water from wells, ii) 3 sectors (361, 368B and 369B) have networks which were recently established/rehabilitated, and iii) 1 sector (370) will be rehabilitated by other projects.

Furthermore, the concept of “sub-sector” was introduced in the *Perfil*, and the 22 sectors which have existing networks were divided into 46 sub-sectors. By this procedure, the total Study area was divided into 61 sub-sectors.

(3) Proposed Sector and Sub-sector in the Study

In the Study, the boundaries of sectors and sub-sectors have been reviewed and modified. The number of sectors has not changed from *Perfil*, but some of their boundaries have been modified. Regarding the sub-sectors, not only have their boundaries changed; in addition, the number of sub-sectors has increased to 63.

The number of sub-sectors under the sectors with existing network has also been increased to 48. Out of the 48 sub-sectors, 348B-4 does not have existing network, and 348A-2 has been recently rehabilitated.

Table 3.4.2-1 shows the list of sectors and sub-sectors proposed in the Study. It is noted that, among the 32 original sectors, 11 original sectors (83, 84, 85, 212, 213, 350, 345-346, 347-346, 361, 368, and 369) are physically defined and operating, and non-revenue water ratio values are obtained from 5 of them (83, 84, 85, 212, and 213).

The revision of boundaries of sectors and sub-sectors is explained in Section 3.4.3.

Table 3.4.2-1: Summary of Sectors and Sub-sectors in the Study

Discrict	Sector		Sub-sector	Scale of Sub-sectors			Reservoir	Remarks
	Original	The Study		Population (2007)	Conexion (2009)	Unit of Use (2009)		
Los Olivos	83	83A	83A-1	10,179	1,609	2,316	Villa Sol R-1	-
			83A-2	19,849	2,487	3,968	Villa del Norte R-1	-
		83B	83B-1	11,289	1,273	2,236	Parque del Naranjal R-1	-
			83B-2	29,135	4,068	5,933	Cueto Fernandini R-1	-
	84	84A	84A-1	24,627	4,477	4,963	Olivos de Pro R-1	-
			84A-2	16,849	3,109	3,527	Programa Confraternidad R-2	-
		84B	84B-1	23,931	4,021	4,858	Programa Confraternidad R-1	-
			84B-2	11,188	1,669	2,159	Comité Aposte, Patria Nueva	-
	85	85A	85A	13,072	2,184	2,746	Puerta de Pro R-1	-
		85B	85B-1	6,263	918	1,650	Rio Santa R-1	-
			85B-2	6,172	894	1,344	Pro	-
			85B-3	1,923	287	339	Santa Luisa R-1	-
		85C	85C	11,069	1,657	2,286	Pro	-
S.M.de Porres	212	212A	212A-1	17,951	3,344	3,936	Virgen de las Nieves R-4	-
			212A-2	11,766	2,084	2,571	Virgen del Rosario R-1	-
		212B	212B-1	9,870	1,612	2,179	Rosario del Norte R-3	-
			212B-2	8,515	1,358	1,800	Jazmines del Naranjal R-2	-
	213	213	213-1	17,480	3,003	3,382	Vipol Naranjal R-1 (CR-243)	-
			213-2	312	68	69	Cerro el Choclo R-2	-
			213-3	539	130	130	Cerro el Choclo R-1	-
	251	251	251	23,528	3	4	-	Without existing network
	252	252	252	9,316	2	2	-	Without existing network
	253	253	253	10,809	27	40	-	Without existing network
	254	254	254	12,782	4	4	-	Without existing network
	255	255	255	1,340	2	2	-	Without existing network
	256	256	256	16,162	15	163	-	Without existing network
Callao	257	257	257	1,706	4	4	-	Without existing network
	258	257	257	210	32	33	-	Without existing network
	259	259	259	16,397	2,282	2,404	Marquez R-522	-
Ventanilla	260	260	260	727	5	5	-	Without existing network
	261	261	261	3,370	5	10	-	Without existing network
	262	262	262	375	1	1	-	Without existing network
	263	263	263	309	1	1	-	Without existing network
	264	264	264	243	1	1	-	Without existing network
	265	265	265	147	1	1	-	Without existing network
	266	266	266	201	1	1	-	Without existing network
Comas	345	345	345	8,079	415	462	Alameda del Pinar R-1	-
	346	346	346-1	4,576	859	1,107	El Manantial R-1, R-2	-
			346-2	9,268	1,746	2,152	El Pinar R-1	-
	347	347	347-1	14,516	2,050	2,633	San Felipe R-1	-
			347-2	12,419	1,795	2,053	La Alborada R-2, R-1	-
	348	348A	348A	7,360	841	938	Collique R-1 (CR-93)	-
		348B	348B-1	15,627	2,034	2,306	Collique R-2	-
			348B-2	1,101	178	178	RE-01	-
	349	349A	349A-1	14,227	1,749	1,956	Collique R-3 (CR-95)	-
			349A-2	3,133	340	347	Nueva Esperanza R-1	-
			349A-3	7,539	894	964	Collique R-4 (CR-96)	-
		349B	349B-1	6,385	784	878	Collique R-5 (CR-97)	-
			349B-2	7,124	764	794	Collique R-6	-
			349B-3	4,862	747	758	Collique R-7, Collique R-8	-
			349B-4	2,257	2	2	-	Without existing network
Carabayllo	350	350	350-1	23,816	3,839	5,359	Santa Isabel R-1	-
			350-2	22,781	3,448	4,285	Santa Isabel R-2	-
	351	351	351-1	4,097	598	641	Los Angeles R-1	-
			351-2	2,400	361	362	Los Angeles R-2, R-3	-
			351-3	355	76	76	Los Angeles R-4	-
Puente Piedra	361	361	361	12,791	1,355	1,386	La Capitania Pampa Gallinazo RP-1	Recently established
	368	368A	368A-1	10,833	1,761	1,836	RPA-6	-
			368A-2	1,847	297	300	RPA-1	-
		368B	368B	14,778	2,928	2,946	RPA-2, 3, 4, 5, 16, 17	Recently established
	369	369A	369A	11,579	2,179	2,231	RPA-17 La Ensenada	-
		369B	369B	13,432	2,644	2,665	Laderas del Chillon R-1, R-2, R-3 RP-11, RP-12	Recently established
	370	370	370	5,616	251	288	Shangrila R-1, R-2	to be rehabilitated soon by other project
Total Number	32 (17)*	41(26)*	63 (47)*	592,399	77,573	94,971	61 (There are 4 other reservoirs in the Project Area for the total water supply system.)	-

Numbers in ( ) are numbers of former sectors, sectors and sub-sectors with existing network

Source: JICA Study Team

(4) Definition of "Sector" and "Sub-sector"

Reviewing the *Perfil* and other information obtained through the Study, "sector" and "sub-sector" are defined as follows:

Table 3.4.2-2: Definition of Sector and Sub-Sector

Category		Example	Definition
Sector	Original Sector	83, 85, 213	Established by SEDAPAL, which is the basic unit of administration and operation. (Ex. Monitoring of non-revenue water, cadastre)
	Proposed Sector in Perfil	83A, 83B, 85A, 85B, 85C, 213	Proposed in the Perfil based on the current original sector. Some of them are the original sectors and others are segments of the original sectors.
Sub-sector		83A-1, 83A-2, 83B-1, 83B-2, 85A, 85B-1, 85B-2, 85C, 213-1, 213-2, 213-3	Proposed in the Perfil in order to improve the function of the water supply system by dividing the sector into some segments. It will be the basic unit of operation and administration such as demand/supply control, pressure control, water leakage monitoring and its control.

Source: JICA Study Team

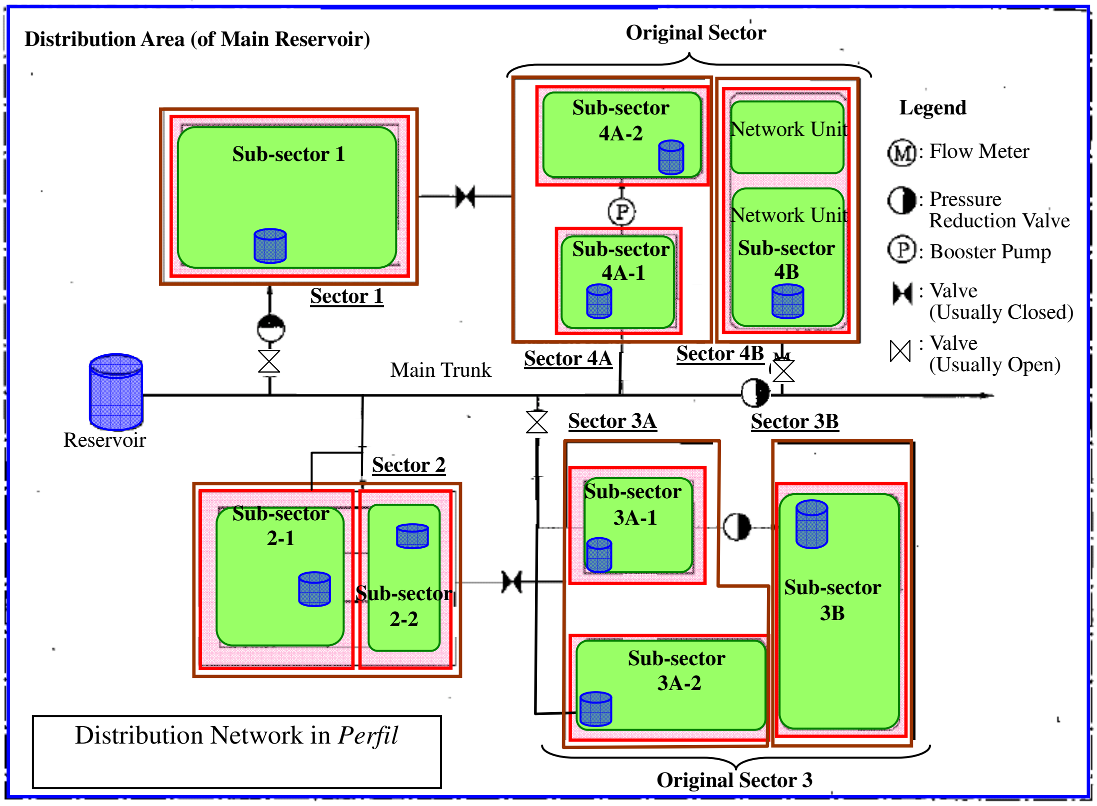
(5) Characteristics of the Proposed Distribution System (Comparison with Japan's Case)

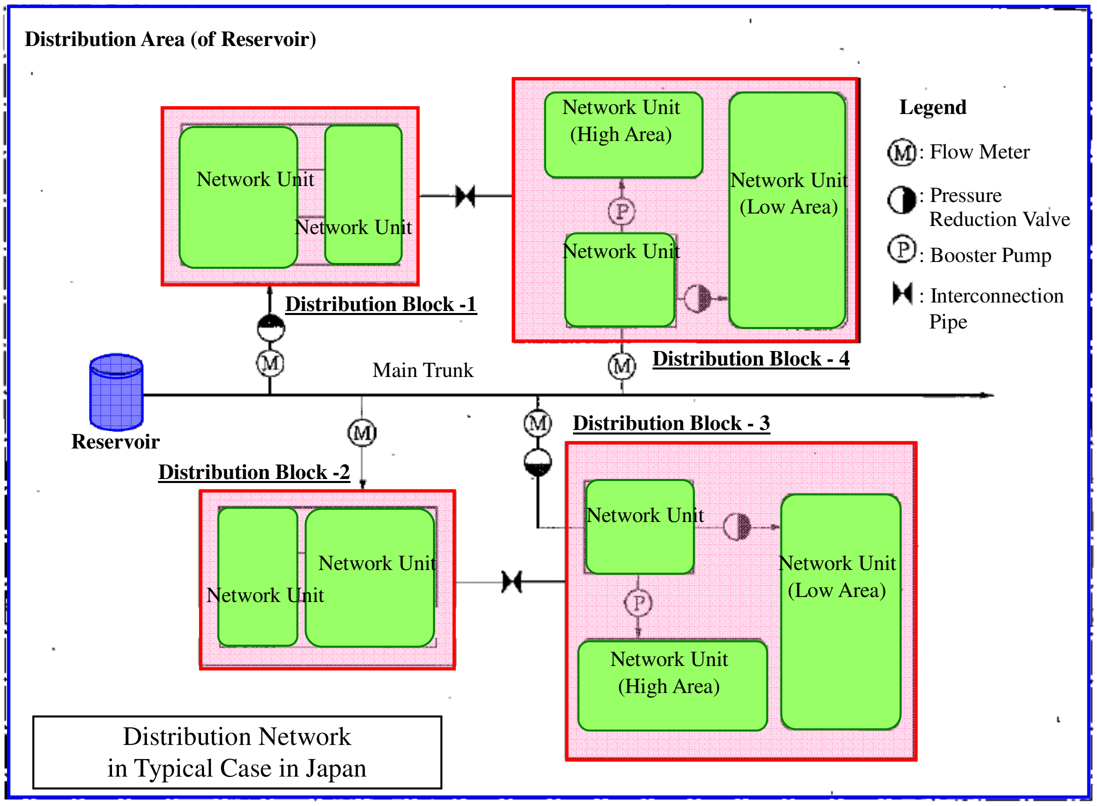
Water distribution systems in different regions have different characteristics because they have been developed to suit each area´s geographic, social, historical and technical conditions. It is, however, useful to compare a distribution system with that of other regions in order to confirm its characteristics, which can help assess how the system can be further developed.

The following figure illustrates the distribution system which was proposed in the *Perfil* and a distribution system which is typical in Japan. As shown in the figure, a significant characteristic of the distribution system is that each small distribution unit in the Study Area, which is a sub-sector in this case, has a reservoir. Moreover, it is noted that there are more layers, which are sector, sub-sector, and network unit, than in a typical Japanese case, where the sectors are divided into network units.

Table 3.4.2-3 explains the differences between the two distribution systems in view of functions that should be carried out by each layer of the system.

As presented in the table, it is suggested that the sectors would not have clear functions after the Project. Moreover, though it was not stipulated in the *Perfil*, it is recommended that a network is set up with the proper scale necessary to ensure fulfillment of the required functions of the distribution network.





Source: JICA Study Team

Figure 3.4.2-1: Structure of Distribution Network Proposed in the *Perfil* and in Typical Japanese Case

Table 3.4.2-3: Function of Sector and Sub-Sector Proposed in *Perfil* compared with Japanese Case

	Study Area				Japan's Typical Case		
	Distribution Area of (Main) Reservoir	**Sector**	**Sub-sector**	**Network Unit***	**Distribution Area of (Main) Reservoir**	**Distribution Block**	**Network Unit**
Scale	4,000m^3 of reservoir's capacity	10-14,000 connections in actual	Mostly 1,000-3,000 connections in Perfil	-	Various	Normally 5,000-10,000 persons	About 5km of pipe length
Demand/Supply Control	○		○		○		
Loss Control			○			○	
Pressure Control			○				○
Emergency Control			○				○
Maintenance Control			○	○			○
Characteristics of Water Distibution System in the Study Area	Because most of the sub-sectors have their own reservoirs, all operational and administrative functions are concentrated on the layer of sub-sector. It is not a problem, however, it will be necessary to consider meaning of "sector" and 2 to establish a distribution network which can formulate network units with a propor scale in each sub-sector.						

Source: JICA Study Team

(6) Proposal for Structure of Water Distribution Network

Based on the evaluations of the current water distribution network, and on that which was proposed in the *Perfil*, the formulation of the basic water distribution structures in the Study is proposed in the following manner:

i. <u>Clarification of the Position of "Sector"</u>: "Sector" is proposed to be defined as a segment of a distribution area of a main reservoir to which water is transmitted by a primary network pipe. Branches from main trunks (La Atarjea – Los Olivos main, Chillón – Los Olivos main, and Chillón - Comas main) to each sector shall be basically single lines. Motor valves (on/off) shall be installed at each branch from the main trunks, and they should be supervised/operated by SCADA.

ii. <u>Integration of Branches from Main Trunk</u>: Some branches planned in the *Perfil* from the main trunk to the sub-sectors shall be integrated if they are located close by. This will improve security of the main trunk and facilitate operation and maintenance work by reducing branches.

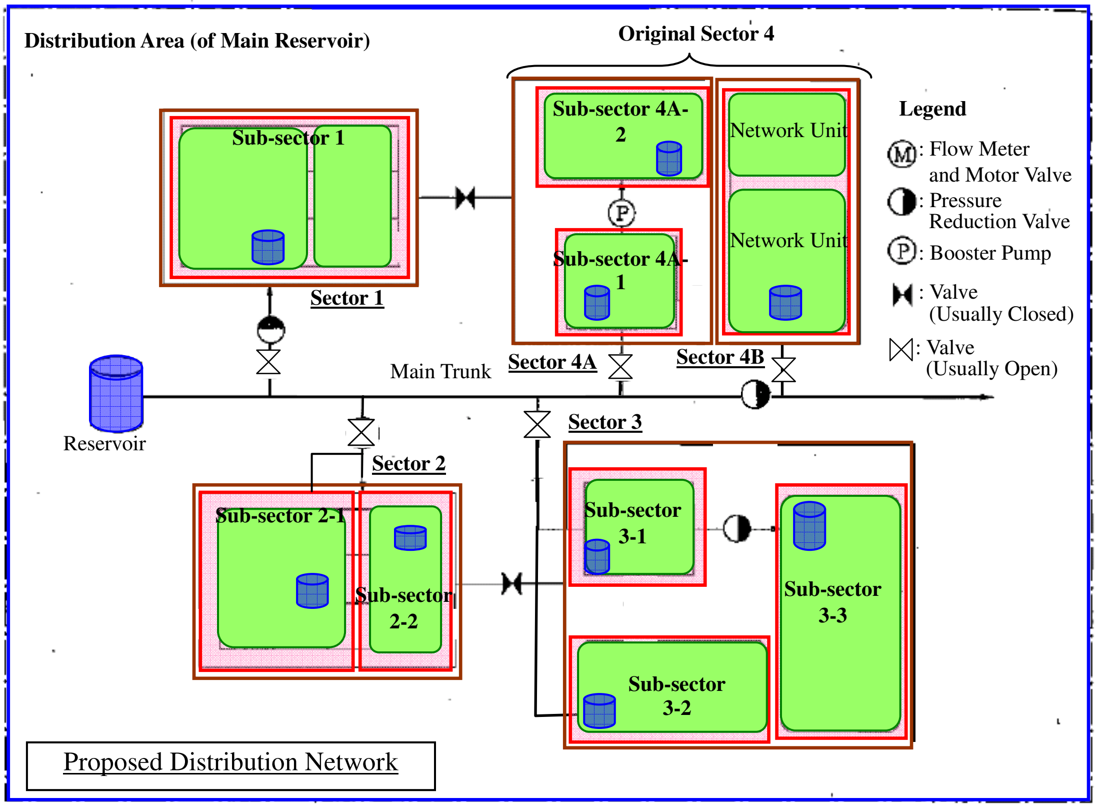
iii. <u>Installation of Pressure Reducing Valve</u>: A pressure reducing valve shall be installed in the main trunk or at the branch, if it is found to be necessary as a result of the hydraulic calculation, in order to avoid excessive pressure in the primary pipe.

iv. <u>Establishment of Sub-sector as a Basic Unit of Operation</u>: Secondary networks shall be rehabilitated so that they can form independent networks called "sub-sectors." All water shall be distributed to secondary networks of the sub-sector via reservoir in each sub-sector. It will regulate water pressure at households as well as in the secondary network.

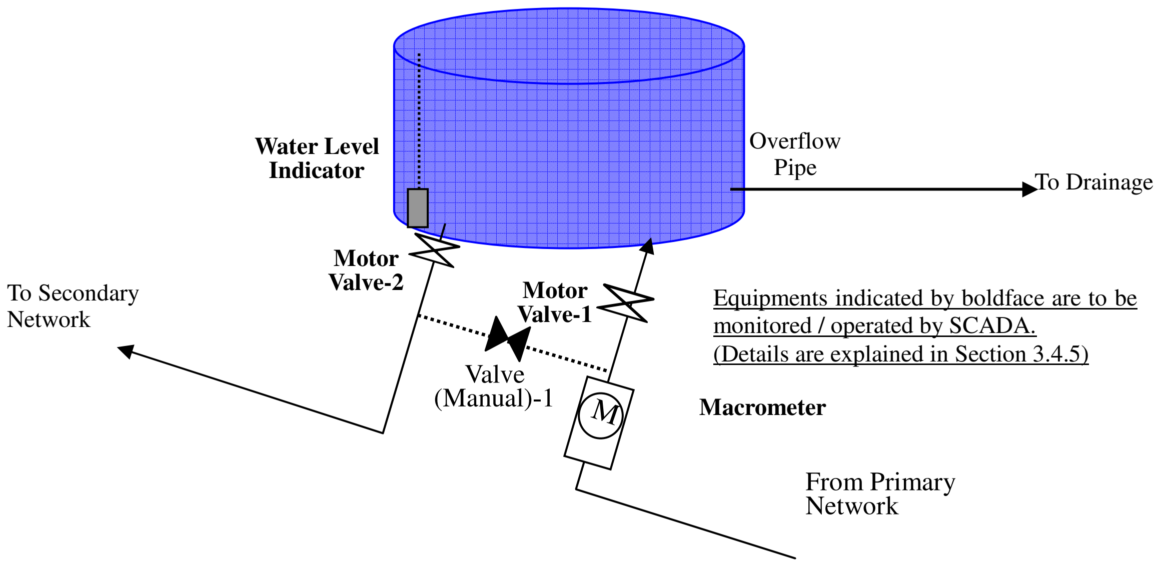
v. <u>Installation of Macrometer</u>: A flow meter, also called a macrometer, shall be installed at the entrance of the reservoirs. It will help SEDAPAL to assess water loss in each sub-sector. The macrometer is installed in a control pit, in which the macrometer, pressure meter, and pressure control valve are to be installed.

vi. Establishment of Network Unit in Sub-sector: In each sub-sector, the secondary network shall be designed so that the network will form network units whose total pipe lengths are approximately 5km. Interconnection between the network units shall be confined to one or two lines in principle. Valves at the interconnections are usually open, but they can separate the network unit from the secondary networks immediately in case of accident or maintenance work. It will help SEDAPAL easily confine the area of influence of accidents or maintenance.

Figure 3.4.2-2 illustrates the proposed structure of the water distribution network in the Study. Figure 3.4.2-3 presents network modifications based on the proposed network structure, using Sectors 83A, 83B, 84B, 212A, 212B and 213 as an example.

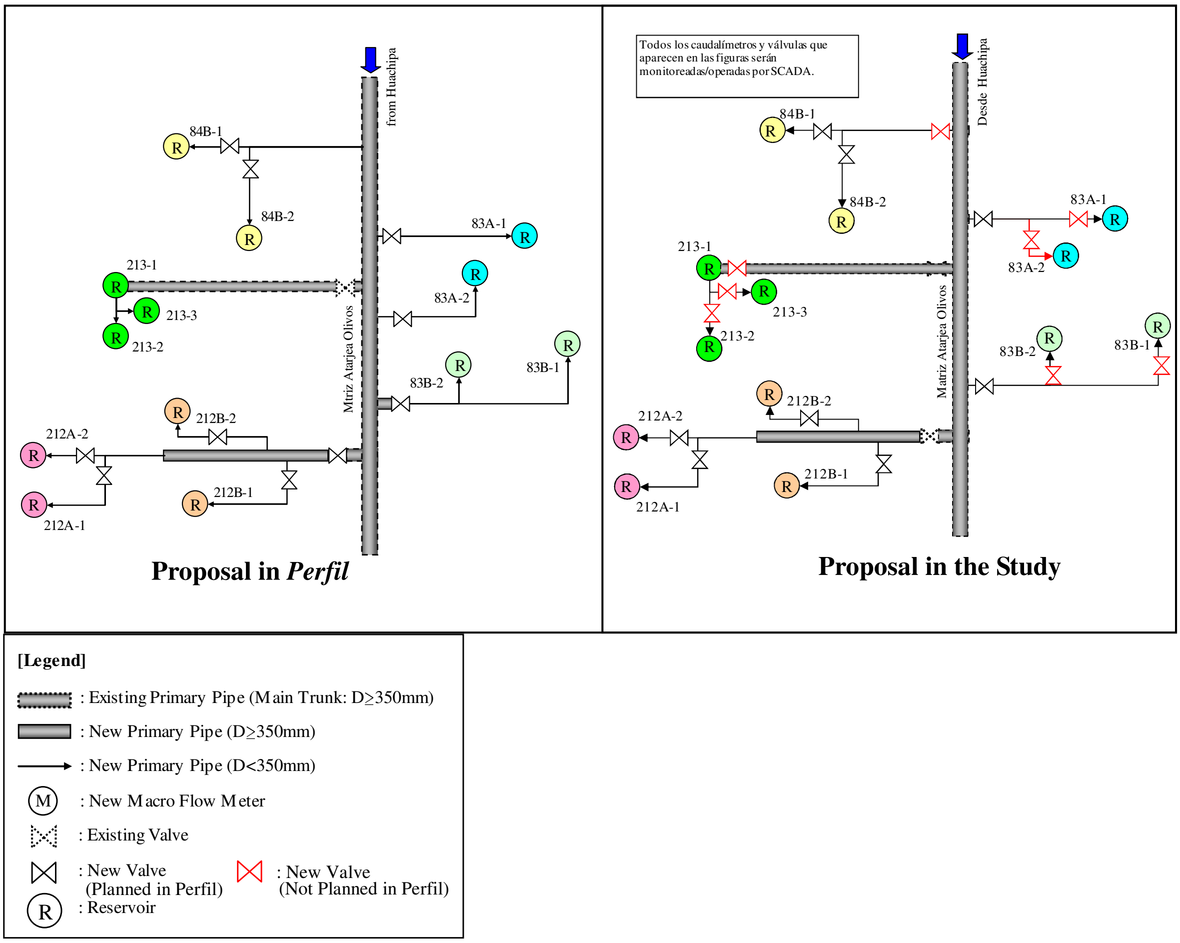


Source: JICA Study Team



Source: JICA Study Team

Figure 3.4.2-2: Proposed Structure of Water Distribution Network in the Study



Source: JICA Study Team

Figure 3.4.2-3: Modification of the Distribution Network in the Study

(7) Plan of Automation

In order to enhance the effects of sectorization by the Project and to achieve a water distribution system which can be operated and maintained efficiently, the distribution networks need to be automated. The basic concept of automation is explained below:

i. Operation of Primary Network: Motor valve (on/off), which will be installed at each branch from main trunk, should be supervised/ operated by SCADA system.

ii. Flow Monitoring to Sub-sectors: Water flow to each sub-sector shall be measured by a macrometer to be installed at the reservoir entrance, and the meter reading shall be transferred to the control center by the SCADA system.

iii. Flow Control to Reservoir: Water level of reservoirs in each sub-sector shall be monitored, and the motor valve at the reservoir entrance shall close automatically when the water level comes to high-water level (H.W.L.) and open when the water level lowers. In addition, motor valves at effluent pipes shall also be remote-controlled in order to close immediately in case of an accident.

iv. Flow and Pressure of Secondary Network: Flow to secondary networks will be monitored continuously by automatic calculation from measured inflow to the reservoir and its water level. Pressure to the network will be regulated by the reservoir. In case when water is distributed via the by-pass, the pressure will be controlled by the pressure control valve in the control pit.

3.4.3 Modification of Boundaries of Sectors and Sub-sectors

(1) Introduction

The Administration area of SEDAPAL is divided into sectors (here, they are called “original sectors”), which are the units of administration of SEDAPAL. The *Perfil* proposed to regulate the scale of sectors in the Study Area by dividing some large original sectors into sectors with moderate scales. In addition, the *Perfil* proposes dividing the sectors into sub-sectors, which will be the minimum units of operation in the water supply system.

In the Study, as explained in Section 3.4.2, the basic plan to regulate the scales of the sectors and to establish the sub-sectors is proposed. However, in the Study, boundaries of sectors and sub-sectors are further studied in detail and modified so that the construction and arrangement works for sectorization works could be simplified and the established sectors and sub-sectors would function more efficiently.

(2) Criteria for Determination of Boundaries

1) Sector Criteria

Boundaries of the sectors shall be determined based on the following criteria:

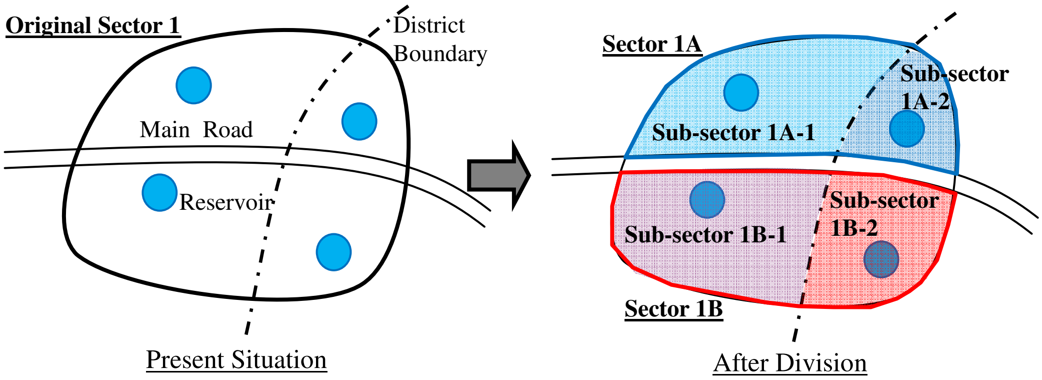
- In principle, boundaries of the original sectors shall be preserved.
- The boundaries should comply with the district boundaries or main roads as much as possible.
- The total number of the connections in a sector shall be less than 10,000.
- The boundaries shall be determined in such a way as to minimize cutting the existing networks. This implies that the boundaries are desirably on wide roads which have pipelines on both sides.

2) Sub-sector Criteria

Boundaries of the sub-sectors shall be determined based on the following criteria:

- Boundaries of the sub-sectors shall be determined so that each sub-sector has an existing reservoir to supply water to the sub-sector.
- The total number of connections in a sub-sector shall be less than 5,000. However, if there are no available reservoirs nearby to divide the area so that there are less than 5,000 connections, the sub-sector can include more than 5,000 connections.
- In the same way as with the sectors, the boundaries of the sub-sectors shall also be determined so that there is minimal cutting of existing networks.
- Geographic conditions, especially elevation, shall be considered so that high areas would be separated from the other surrounding areas in order to facilitate the pressure control.
- Areas with specific land use, which suggests that the trend of water use in the area is different, shall form independent sub-sectors.

The following figure is an image illustrating the division of the original sector and the boundaries of sub-sectors.



Source: JICA Study Team

Figure 3.4.3-1: Division of Sectors and Sub-sectors in the Study

(3) Modification of the Boundaries

Figure 3.4.3-2 presents the boundaries of sectors in the Study Area, which were proposed in the Perfil. Figure 3.4.3-3 and Figure 3.4.3-4 present the boundaries of the sub-sectors as well as those of the sectors with major modifications of the boundaries proposed in the Study.

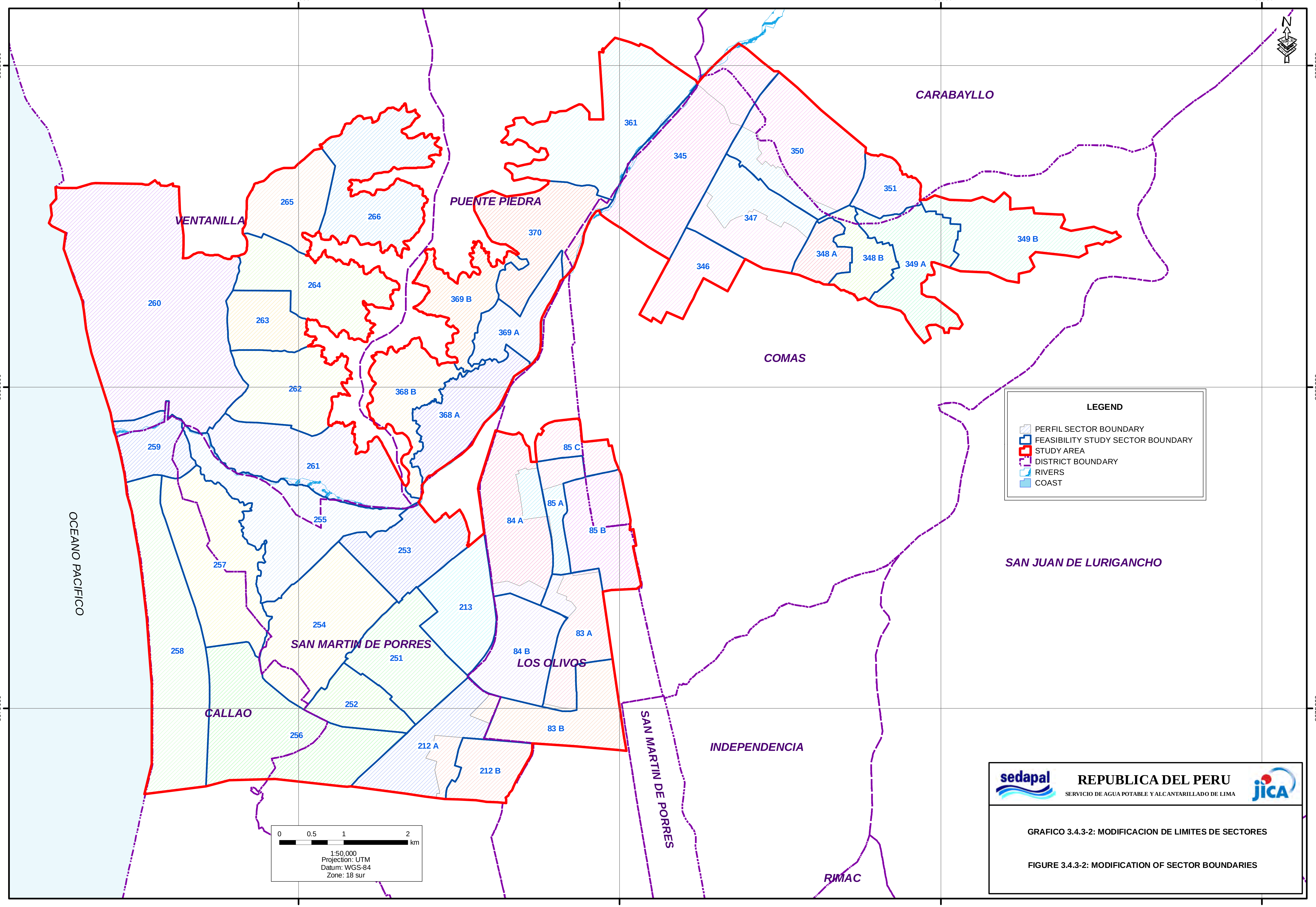


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GRAFICO 3.4.3-2: MODIFICACION DE LIMITES DE SECTORES

FIGURE 3.4.3-2: MODIFICATION OF SECTOR BOUNDARIES

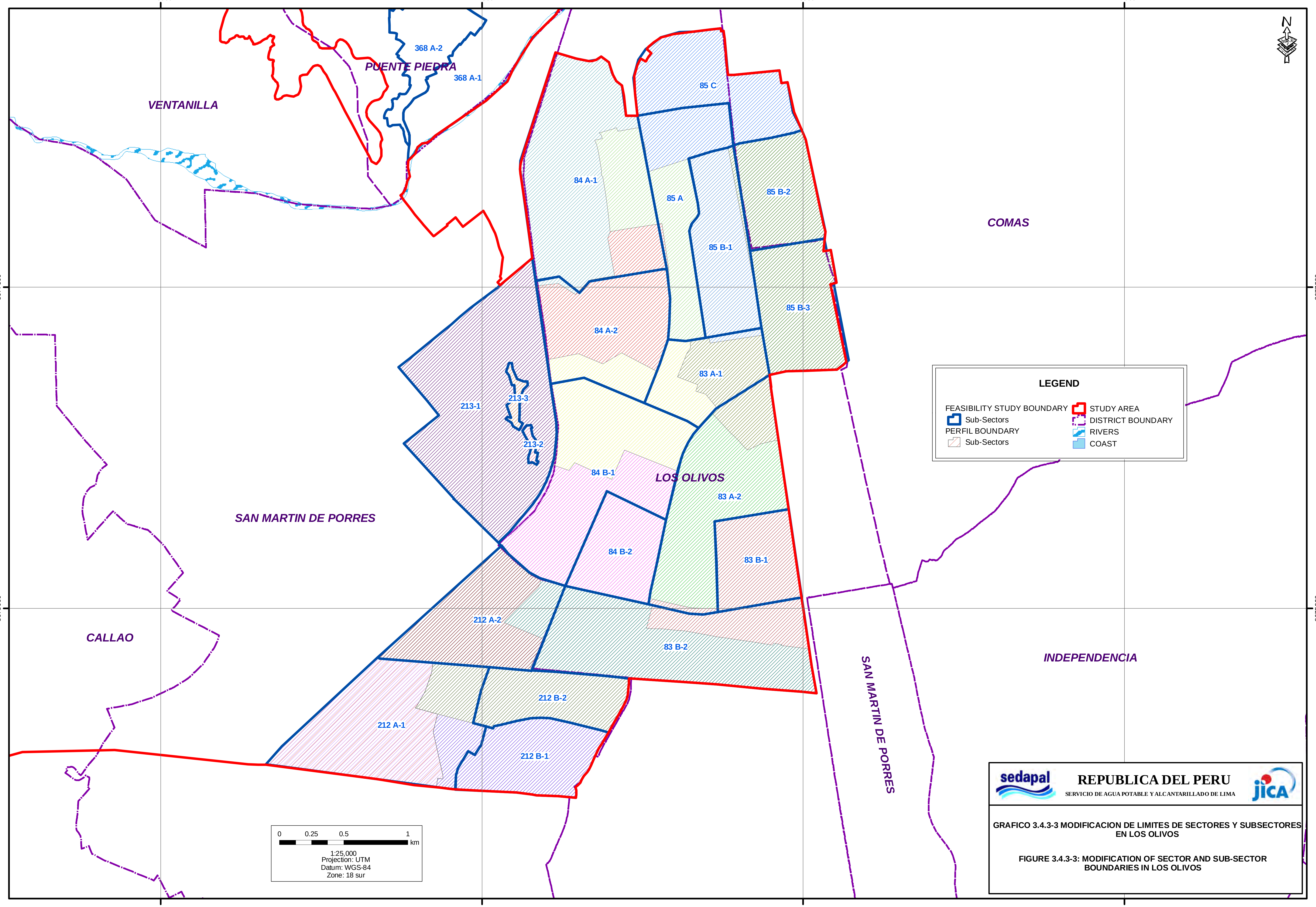

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GRAFICO 3.4.3-3 MODIFICACION DE LIMITES DE SECTORES Y SUBSECTORES EN LOS OLIVOS

FIGURE 3.4.3-3: MODIFICATION OF SECTOR AND SUB-SECTOR BOUNDARIES IN LOS OLIVOS

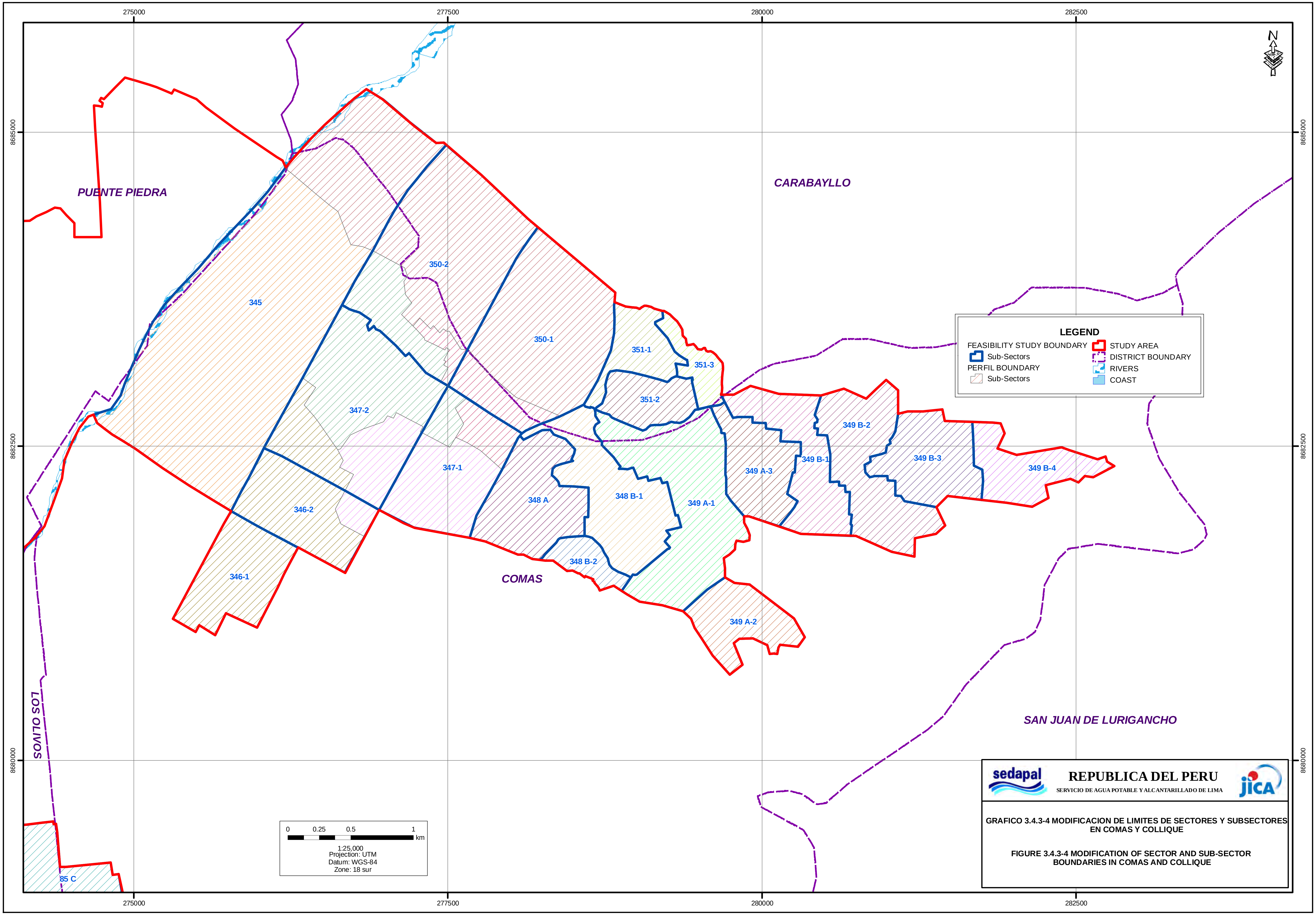


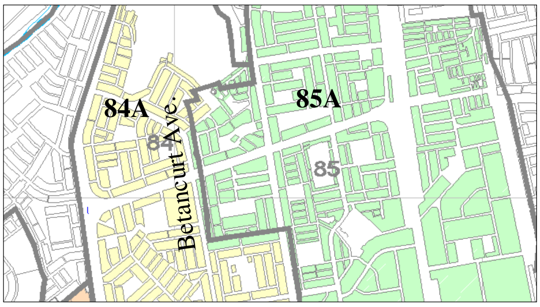
GRAFICO 3.4.3-4 MODIFICACION DE LIMITES DE SECTORES Y SUBSECTORES EN COMAS Y COLLIQUE

FIGURE 3.4.3-4 MODIFICATION OF SECTOR AND SUB-SECTOR BOUNDARIES IN COMAS AND COLLIQUE

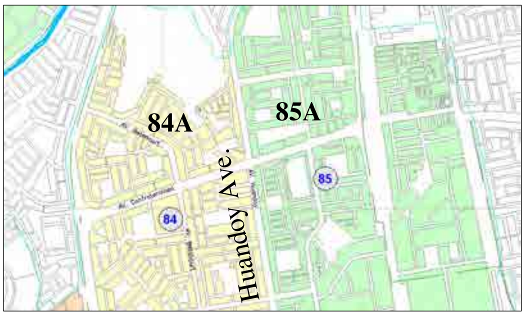
Among the modifications of the sector or sub-sector boundaries shown in the figures above, most of them are minor modifications with little effect on the scale of the sectors or sub-sectors. The modifications were made by adjusting the boundaries within the current limits of the secondary networks or along with the alignment of main roads. Other major modifications of boundaries are explained below;

1) Boundary between Sector 84A and 85A

The boundary has been arranged based on alignment with the main street and layout of existing pipelines. In the Study, the original plan in the *Perfil* was rearranged so that Huandoy Ave. would be the boundary of the sectors. The street is so wide that it can be an operational limit. Moreover, it has pipelines on the both sides, which avoids new installation of secondary pipes to separate the sectors.



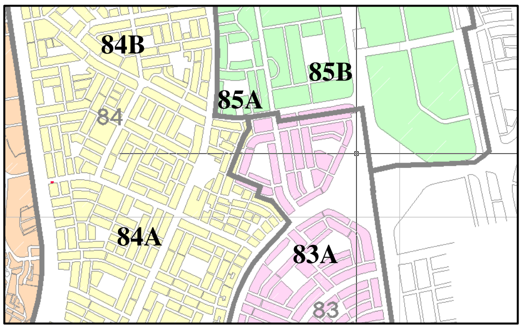
In the *Perfil*, sector 85 extends up to Betancurt Ave.



In the feasibility study, the sector boundary is set by Huandoy Ave.

2) Boundary among Sectors 83A, 84A, 85A and 85B

The boundary has been arranged based on the alignment with main streets and current operational conditions. In the Study, the original plan in the *Perfil* was rearranged so that Huandoy Ave., Universitaria Ave, Panamericana Ave, Central Ave, and De La Seguridad Social Ave would be the boundaries of sector 83A. The existing secondary network already formulates network units with this boundary (there is no flow crossing this modified boundary), which avoids any operational modification of the current secondary network and new installation of pipeline.



In the *Perfil*, streets that serve as the boundary for sectors are 17 and 50

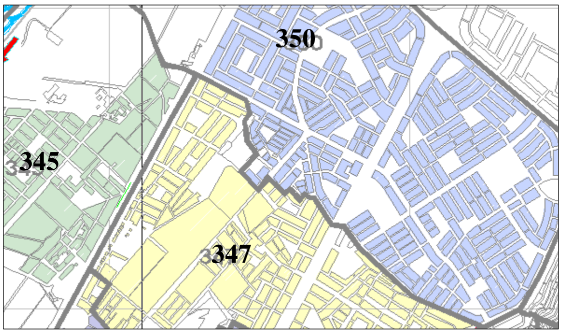
In the feasibility study, sector boundaries are made up by Huandoy Ave and De la Seguridad Social Ave.

3) Boundary among Sectors 345, 347 and 350 and Sub-sectors in Sector 350

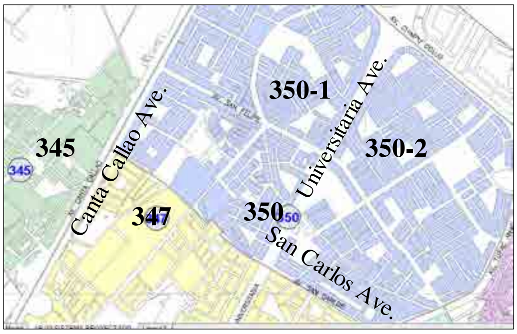
The boundary has been arranged based on alignment with main street and sub-sectors, , and are proposed based on the scale of the sector (one sub-sector should not include more than 5,000 connections in principle).

In the Study, the original area of the sector 350 has extended to the south so that the boundary would comply with a wider street (San Carlos Ave), and in addition, the western part of the sector has been transferred to sector 345 so that the boundary on the west side would comply with Canta Callao Ave. Boundaries of the sectors 345 and 347 have been also modified consequently.

Moreover, Sector 350 is proposed to be divided by Universitaria Ave into sub-sectors 350-1 and 350-2 because the sector had 7,287 connections in 2009.



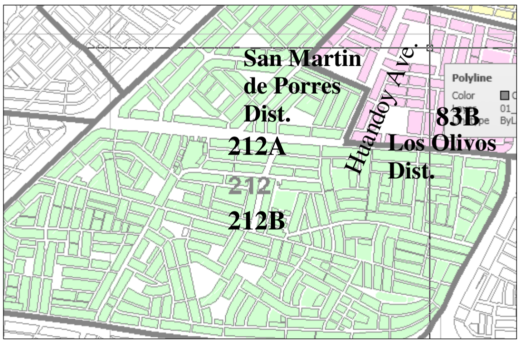
In the *Perfil*, boundaries are set by small streets



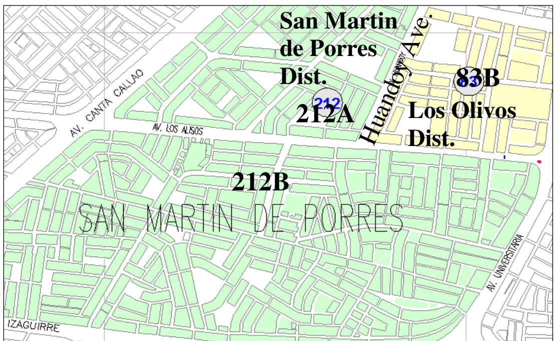
In the feasibility study, boundaries are the Canta Callao Ave and San Carlos Ave.

4) Boundaries between Sector 83B and 212A

The boundary has been arranged based on district boundary and alignment with the main street. In the Study, the boundary has been modified so that it complies with the district boundary between the Los Olivos district and the San Martín de Porres District. The modified boundary also coincides with Huandoy Ave, which has pipelines on both sides.



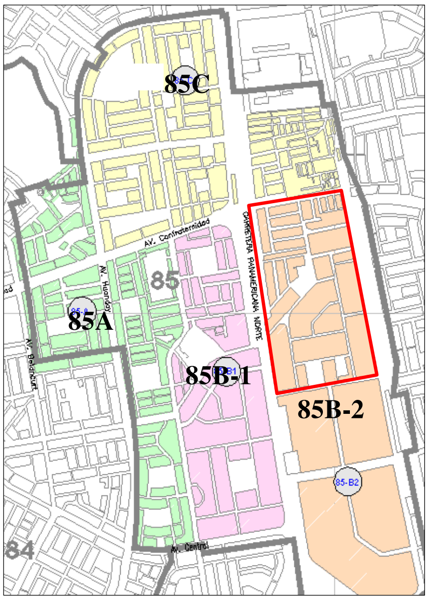
In the *Perfil*, the boundary just ran along 33 Street



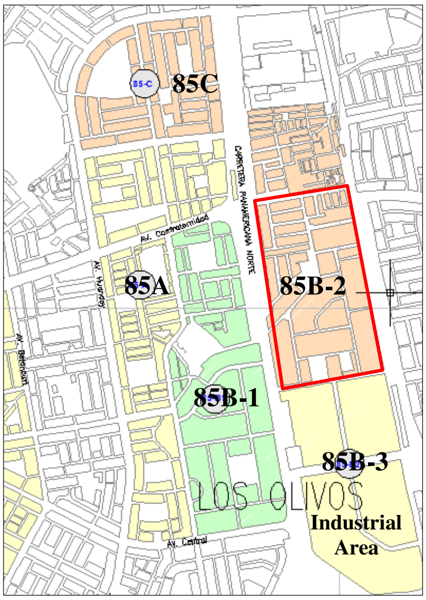
Ave. and the district boundary.

5) Boundaries of Sub-sectors in 85B

An additional sub-sector, which was not proposed in the *Perfil*, is proposed in the Study based on land use. An industrial area is separated from the sub-sector 85B-2. Water consumption in this area has quite different tendency than in other areas. Establishment of an independent sub-sector for this area will facilitate the operation of the water supply system, realize meaningful monitoring of actual water consumption, and improve accuracy of future demand forecast.



In the *Perfil*, the industrial area was not taken into account



In the feasibility study, the industrial area is considered as sub-sector 85-B2

3.4.4 Development of Primary Network

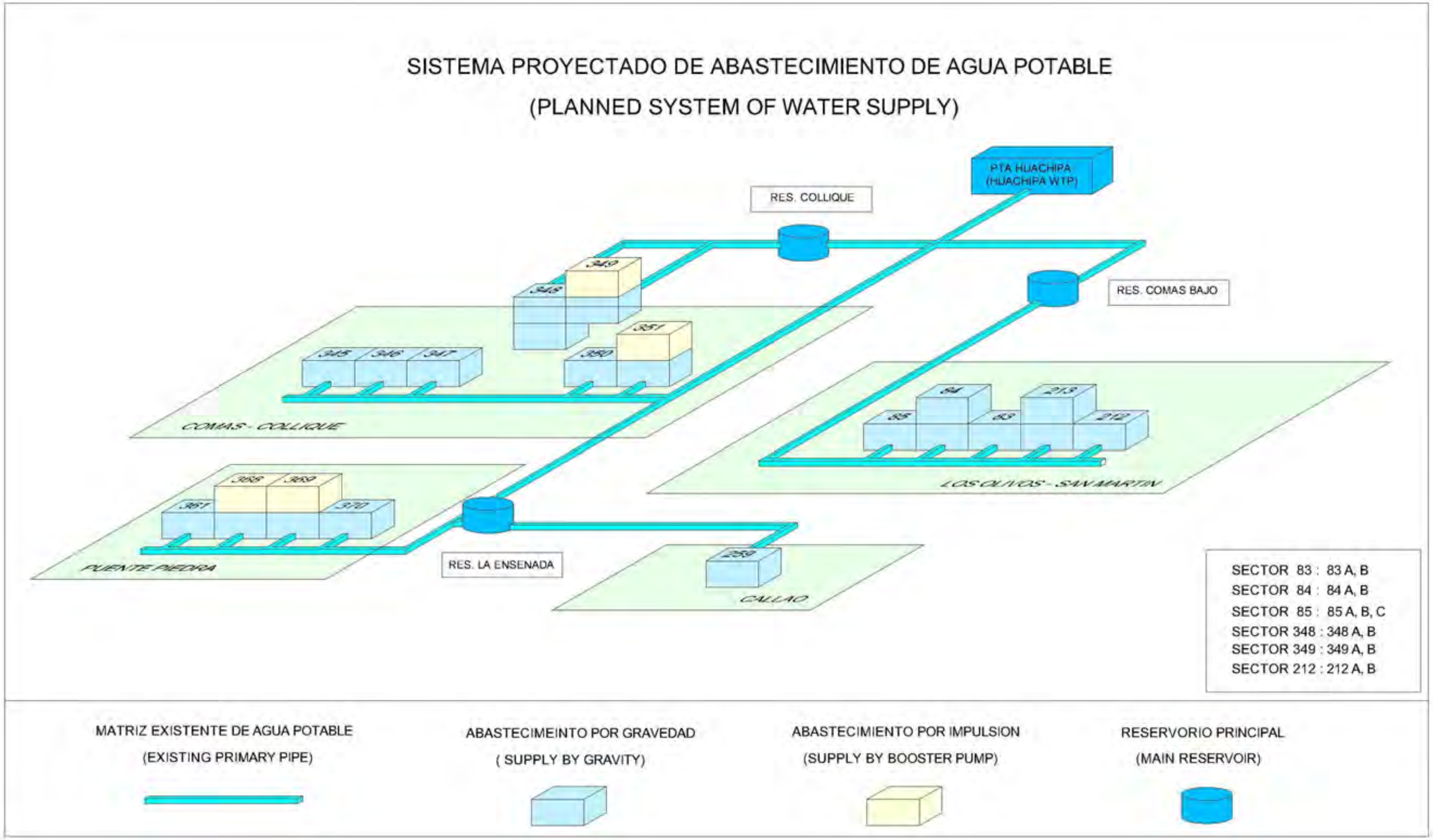
(1) Introduction

The primary network has a function to distribute water to sub-sectors, and it has to be planned in order to comply with the structure of the distribution network proposed in the previous sections. In this project formulation, primary pipes shall be designed so that the distribution area of the Huachipa WTP can receive water supply from the Huachipa WTP and thereby form the proposed sectors and sub-sectors. In order to happen this, the Consultant has performed or prepared the following: a scheme for the water supply system, a plan for primary pipe routing, a study on basic specifications of pipelines, hydraulic modeling and calculation, determination of pipe diameters, design of accessories and preparation of drawings.

(2) Scheme of Water Supply

In order that the Huachipa WTP can supply water to the Study Area in such a way that the proposed sub-sectors function as expected, a new water supply system scheme is proposed in the Study, as shown in Figure 3.4.4-1.

Planned primary pipes will receive water from the existing pipes or those currently being executed, and they will transmit water to the reservoir of each sub-sector. Also, primary pipes from wells (so called “pressure lines”) will send disinfected groundwater to the reservoirs.



Source: JICA Study Team

Figure 3.4.4-1: Proposed Scheme of the Water Supply System

(3) Route of Primary Network

Routes of primary pipes are basically planned in a way that pipe length from the branch and reservoir can be the shortest in order to save costs. Moreover, road width is also taken into account in order to facilitate the construction works because wider roads make it easier to find space for installation of the new primary pipes, and they also make construction easier.

(4) Hydraulic Modeling and Calculation

Based on the planned primary network, the hydraulic model for calculation by Water CAD is prepared.

The calculation is carried out following the National Sanitation Standard, which regulates the friction factor (C value), minimum diameter, velocity and service pressure. Each model is calculated in two cases; a case of minimum flow and a case of maximum flow, to assure that the hydraulic conditions satisfy the maximum pressure and minimum pressure.

Detailed information and explanations are given in Appendix B2.1.

(5) Determination of Pipe Diameter

Diameters of the primary pipes shall be determined based on the results of the hydraulic calculations.

(6) Basic Specifications of Primary Network

1) Soil Conditions

The soil mechanical survey in the Study found the following observations related to the design of the primary networks:

- It is estimated that 60% of the soil within the Study area has a strong presence of chemicals aggressive to the foundation soil and to the concrete and ductile iron pipes.
- The foundation soil for pipe support is not expected to suffer any serious problems due to the presence of the high water table, loose soils, or soils of very low bearing capacity. Hence, it requires no other treatment of the foundation prior to mechanical compaction, with the exception of those cases where material is anthropogenic and/or all the material down to the depth of influence will have to be removed.
- Minimum coverage should be 1.2 m and backfill should be properly compacted.

2) Pipe Material

SEDAPAL has recently applied Ductile Iron (DI) pipeline for their primary pipes. In the Project, DI is also used for the following reasons:

- Water pressures in the primary network tend to be high. DI has much higher endurance than PVC.
- A geotechnical survey found that the soils in a major part of the Study Area have strong chemical aggressiveness. Therefore, steel pipe should not be used because it is subject to corrosion.

3) Earth Cover

As recommended by the geotechnical survey result, earth cover is 1.2m in principle.

4) Protection of Pipes against Aggressive Soil

Though DI pipe has much better endurance against aggressive soil than steel pipe, the experiences of SEDAPAL have proven that DI pipe can still be affected by aggressive soils. Therefore, the use of PE protection to cover the DI pipes is required.

(7) Design of Accessories

1) Required Accessories

Accessories for primary networks are: control valves at the branches from the main trunks, pressure reduction valves, air valves and drain valves. Macrometers and control valves for sectorization are not included in the primary networks, but in the reservoirs.

2) Valve Pits for Pressure Reduction (Reuse of Existing Valve Pits)

Based on the result of the hydraulic calculation, 14 valves for pressure reduction are installed in the Project. Location of the valve pits are considered so that the existing valve pits, which are located at the entrances of the original sectors, can be reused. Existing valve pits to be reused will be rehabilitated and operated as pressure reducing valve pits. The macrometers will be removed in the rehabilitation work because macrometers will be installed in all sub-sectors.

Table 3.4.4-1 shows the rehabilitation and reuse plan for the existing valve pits in the Project. 5 valve pits will be newly constructed and 9 of the 11 existing valve pits will be rehabilitated and reused.

All pressure reduction valves shall be equipped with a by-pass and three sluice valves, 2 of them are installed upstream and downstream of the pressure reducing valve, and one of them is installed in the by-pass.

Table 3.4.4-1: Pressure Reduction Valves in the Study Area

No.	Covering Area (Sector)	Contents of Construction			
		New Installation	Rehabilitation*		
			Electro - mechanical	SCADA	Current Cover Area (Original Sector)
1	83A	√	-	-	83
	83B	√	-	-	
2	84A	-	√	-	84
	84B	√	-	-	
3	85A,85B	√	-	-	85
	85C	√	-	-	
4	212A, 212B	-	√	-	212
4	213	-	√	-	213
6	345, 346	-	√	√	345, 346
7	346, 347	-	√	√	346, 347
8	350	-	√	√	350
9	361	-	√	√	361
10	368A, 368B	-	√	√	368
11	369A, 369B	-	√	√	369
11	14	5	9	6	-

*: There are 11 existing valve pits. 9 of them are to be reused and the other 2 will be abandoned.
Source: JICA Study Team

3) Protection of Concrete Structure

According to the result of the geotechnical survey, concrete structures for accessories such as the pressure reduction valve pits shall be prepared with "Type V Cement," which has an anti-chemical strength.

(7) Construction Items and Quantities

Construction items and quantities for the primary network are listed in Table 3.4.4-2.

Table 3.4.4-2: Quantity of Construction Works in the Primary Network

Item		Units	Quantity	Remarks
Gravity Pipes (primary)	DN 700 mm	m	1,538.49	Pipes are DI because of its higher strength than PVC
	DN 450 mm	m	744.83	
	DN 400 mm	m	3,148.97	
	DN 350 mm	m	1,595.11	
	DN 300 mm	m	963.37	
	DN 250 mm	m	6,358.14	
	DN 200 mm	m	6,860.69	
	DN 150 mm	m	2,196.35	
	SUB TOTAL		**23,405.95**	
Pumping lines (from wells to reservoirs)	DN 150 mm.	m	5,338.05	
	DN 200 mm	m	8,042.23	
	DN 250 mm	m	2,823.64	
	DN 300 mm	m	937.49	
	SUB TOTAL		**17,141.41**	
TOTAL			**40,547.36**	
Valve pits (valves for sector)	DN 200-700 mm	Units	0	Valves for sectors are to be installed at the reservoirs
Valve pits (pressure reduction)	DN 300 mm	Units	14	3 sluice valves in each pit
Air valve	DN 50-150 mm	Units	40	
Purge valve	DN 100-150 mm	Units	25	

Source: JICA Study Team

3.4.5 Improvement of Reservoirs and Pumping Stations

(1) Introduction

Reservoirs have a function to receive water from the primary networks and store the water. They contribute to controlling water pressure in the following secondary networks, and they also contribute to maintain water supply in case of accidents.

Pumping stations are located beside the reservoirs or in the secondary networks which are to supply the high-elevation areas in the Study Area. They pump up the water from the reservoirs to the high-elevation areas in the distribution area of the reservoirs.

There are 63 existing reservoirs and 16 pumping stations located beside the reservoirs, and there are 2 independent pumping stations. (Apart from the 63 existing reservoirs, there are 2 reservoirs under construction.) Many of them have been rehabilitated or will be rehabilitated by SEDAPAL’s other projects to meet the required functions. Moreover, 1 pumping station (CR-243), which is located beside Vipol Naranjal R-2 (in Sector 213), will not be used after the Project because the Huachipa WTP can distribute the water to the area by gravity.

Therefore, possible target facilities of rehabilitation and upgrading works are the remaining 27 reservoirs, 3 pumping stations located beside the reservoirs and 1 independent pumping station. Among the 3 reservoirs with pumping stations, 2 reservoirs have been already rehabilitated, but the pumping stations still need to be rehabilitated.

In addition, among the reservoirs which have been already rehabilitated by other projects, 1 reservoir (RP-2, Cerro Oquendo) is planned to be connected with a well (No. 569), though the reservoir does not need any rehabilitation of either structure or electromechanical equipment.

In the Project, all reservoirs and pumping stations, even those which have been or are scheduled to be rehabilitated by other projects, shall be integrated to the SCADA system to be installed. However, construction works for SCADA are not included here, but in Chapter 3.4.9, “Installation of SCADA System”.

(2) Required Study and Analysis on for Improvement of Reservoir and Pumping Station

From the demand-supply analysis given in Section 3.3, it was found that some sub-sectors do not have enough reservoir storage capacity compared with the volume required by the National Standard. It is necessary to study the solution of this deficit.

As identified in the diagnosis of the reservoirs and pumping stations explained in Section 2.5.8, it is necessary to rehabilitate the structure and electromechanical equipment of the reservoirs, except those which have been or will be rehabilitated by other projects.

Apart from the rehabilitation work, many reservoirs do not have enough equipment, such as reservoir by-pass lines, flow meters, water level meters, and communication systems for SCADA, in order to secure proper operation or maintenance work. It is necessary to plan upgrading works of such reservoirs and pumping stations in order to improve their function.

(3) Solutions for the Deficit found by Demand – Supply Analysis

1) Result of the Analysis

In the demand – supply analysis of reservoir storage, 7 sub-sectors were found not to have reservoirs with enough capacity to comply with the National Sanitation Standard, which requires a total of 6-hours-volume of daily average demand and 50 m^3 for fire prevention.

Sub-sectors and reservoirs which do not satisfy the standard are shown in the following table.

Table 3.4.5-1: Sub-sectors Which Do Not Satisfy the National Standard for Reservoir Storage

Sub-sector	Required Volume (m^3)	Reservoir Capacity		Deficit (m^3)
		Volume (m^3)	Percentage against the Demand (%)	
85B-2*	2,055	1,400	68%	-655
85C*	638	500	78%	-138
348B-2	103	100	97%	-3
350-1	1,411	1,400	99%	-11
351-2	255	250	98%	-5
361	1,085	1,000	92%	-85
369B	1,256	1,050	84%	-206

*: The two reservoirs, sub-sectors 85B-2 and 85C, are exceptionally additionally supplied by a reservoir "Pro" with a capacity of 1,900m^3
Source: JICA Study Team

2) Methodology of Study for Solution

Even if a reservoir's capacity does not satisfy the required volume established by the National Sanitation Standard, it does not mean that the reservoir does not function in the distribution system. Moreover, the calculated requirement for the capacity is that in the target year of the Project (2035), so the capacity does not necessarily need to be enlarged immediately. In the Study, capacities of the reservoirs will be studied through the following evaluation, and the necessity of enlargement in the Project shall be determined:

- Evaluation of the immediacy to increase the capacities by comparing them with required demand in 2025
- Evaluation of the technical necessity of increase of the reservoirs' capacities by dynamic analysis of the storage

If the results of the evaluations suggest that the capacity of the reservoirs should be increased immediately for the reservoirs to play the expected roll, re-construction or additional construction of the reservoirs shall be considered.

3) Evaluation of the Immediacy to Increase the Capacities

The following table shows evaluations of the reservoirs' capacities based on the required capacities in 2035 and 2025:

Table 3.4.5-2: Evaluation of the Capacities of Reservoirs based on Demand in 2025

Sub-sector	Reservoir Volume (m^3)	Evaluation of the Capacity based on National Standard (2035)			Evaluation of the Capacity based on National Standard (2025)		
		Required Capacity (m^3)	Percentage against the Demand (%)	Deficit (m^3)	Required Capacity (m^3)	Percentage against the Demand (%)	Deficit (m^3)
85B-2*	1,400	2,055	68%	-655	1,518	92%	-118
85C*	500	638	78%	-138	602	83%	-102
85B-2 and 85C	1,900	2,693	71%	-793	2,120	90%	-220
348B-2	100	103	97%	-3	100	100%	0
350-1	1,400	1,411	99%	-11	1,251	112%	149
351-2	250	255	98%	-5	223	112%	27
361	1,000	1,085	92%	-85	916	109%	84
369B	1,050	1,256	84%	-206	1,058	99%	-8

*: Sub-sector 85B-2 and 85C are exceptionally supplied by a reservoir "Pro" with capacity of 1,900m^3
Source: JICA Study Team

As shown in the table above, sub-sectors 348B-2, 350-1, 351-2, 361 and 369B will still have enough capacities in 2025, which suggests that there is no immediate need to increase the capacity of the reservoirs.

Regarding 85B-2 and 85C, however, the reservoir's capacity cannot satisfy the requirement and, moreover, it is less than that in 2009 (2,062m^3) according the result of the demand analysis. Therefore, necessity of enlargement of the reservoir shall be determined after evaluating whether the reservoir can contribute to improvement of the water supply service with the current capacity, which is carried out in the following item.

4) Evaluation of the Necessity to increase the Capacities by Hydraulic Analysis

The most fundamental and important function of a reservoir is to regulate the water pressure in the subsequent secondary network by balancing inflow and outflow (consumption) of the sub-sector. As long as a reservoir can balance its inflow and outflow, even during peak time of water consumption, it can be concluded that enlarging the reservoir is not urgent in view of cost-efficiency.

The reservoir's capacity to balance the inflow and outflow can be evaluated by dynamic analyses of stored volume in the reservoir. In the Study, the analysis is carried out in the following manner:

- Evaluation will focus on the reservoirs' capacities based on hourly maximum consumption (how many times of the hourly maximum consumption the reservoirs store) and will identify the capacity needed to prevent the reservoirs from being empty even for 3 days, including a day of hourly maximum consumption.
- Storage of the reservoirs will be analyzed by the balance of assumed typical inflow and outflow of the reservoirs.
- Assumed typical outflows are the dynamic hourly consumptions prepared in Section 2.5.10 (See Figure 2.5.10-5) based on the actual consumption data of original sectors 83 and 84. In the typical flows, the water loss ratios are 20% and hourly peak factors are 1.85 and 1.81, respectively, which are equivalent to the peak factor of 1.8 to be applied to the design in the Study.
- As analyzed and concluded in Section 2.5.10, hourly peak factors of all sectors in the Study Area can be assumed as 1.8 regardless of their scales. Therefore, the assumed

dynamic hourly consumptions, whose hourly peak factors are close to 1.8, can be the typical models of the water consumptions of sub-sectors in the Study Area.

- Assumed inflows to the reservoirs are the daily maximum consumption (1.3 x Daily Average Consumption / 24) calculated based on the assumed typical consumptions throughout a year. This assumption complies with the National Sanitation Standard stating that design flow of the primary networks, which supply water to the reservoirs, shall be the hourly maximum consumption.
- Capacities of the reservoirs will be analyzed with four cases. Capacities in the first case are a six-hour-amount of the hourly maximum consumption, which is the capacity regulated in the National Sanitation Standard. The other cases are three-hour-amount, two-hour-amount and one-hour amounts of the hourly maximum consumption.

Assumed consumptions in the analysis are presented in Table 3.4.5-3, and results of the analysis are shown in Figure 3.4.5-1.

Table 3.4.5-3: Assumed Consumption in the Dynamic Analysis of the Reservoirs

Item	Unit	Sector 83	Sector 84
Daily Average Consumption	m^3/hour	432	428
Daily Maximum Consumption	m^3/hour	562	556
Hourly Maximum Consumption	m^3/hour	801	774
Daily Peak Factor	-	1.30	1.30
Hourly Peak Factor	-	1.85	1.81

Source: JICA Study Team

As shown in the figure, if the reservoirs' capacities are one-hour-amount of the hourly maximum consumptions (Case-4), the reservoirs will be empty at the peak time, which means that the reservoirs cannot regulate the pressure of the secondary networks. This situation can also allow sediments at the bottoms of the reservoirs to flow out to the networks, which can cause a problem with water quality.

If the capacities of the reservoirs are two-hour-amount of the hourly maximum consumptions, the reservoirs do not become empty in the analysis, but the minimum storage is only 20m^3 in the case of sector 84.

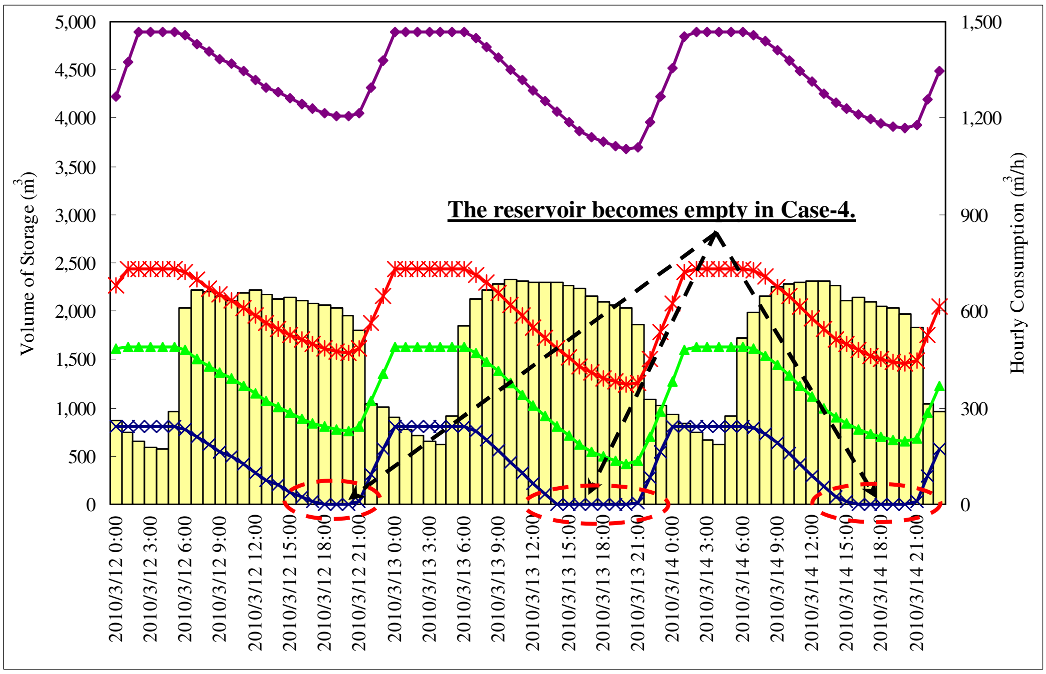
As a result of the dynamic analysis, it is concluded that for capacities of the reservoirs, a 3-hour-amount of the hourly consumptions is sufficient to fulfill the function to regulate the pressure. Table 3.4.5-4 summarizes the results of the evaluations of the capacities of the reservoirs to regulate the pressure.

Table 3.4.5-4: Evaluation of the Capacities of the Reservoirs to Regulate the Pressure

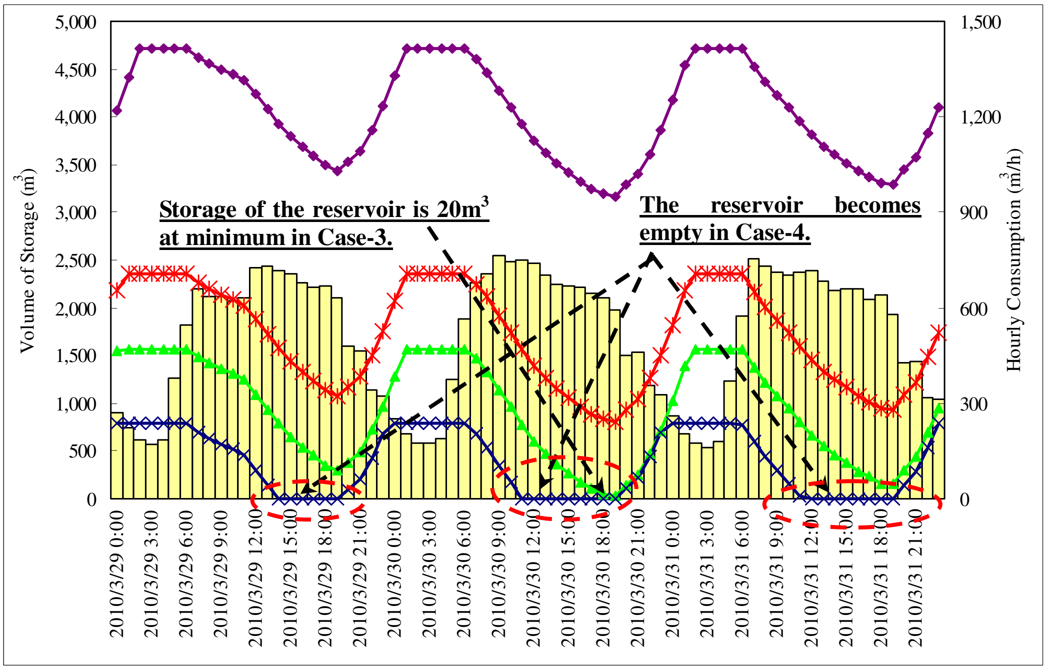
Sub-sector	Reservoir Volume (m^3)	Evaluation of the Capacity based on National Standard (2035)			Evaluation of the Function to Regulate the Pressure in the Secondary Network (2035)		
		Required Capacity (m^3)	Percentage against the Demand (%)	Deficit (m^3)	Hourly Maximum Consumption (HMC)	Capacity of the Reservoir based on HMC	Evaluation*
85B-2*	1,400	2,055	68%	-655	463	3.03	-
85C*	500	638	78%	-138	136	3.68	-
85B-2 and 85C	1,900	2,693	71%	-793	598	3.18	OK
348B-2	100	103	97%	-3	12	8.18	OK
350-1	1,400	1,411	99%	-11	314	4.46	OK
351-2	250	255	98%	-5	47	5.28	OK
361	1,000	1,085	92%	-85	239	4.19	OK
369B	1,050	1,256	84%	-206	278	3.77	OK

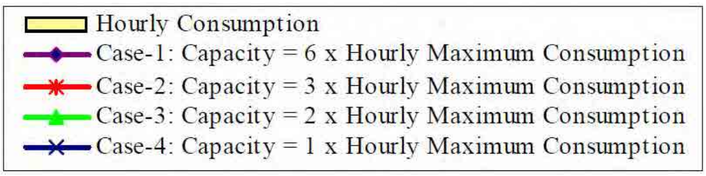
*: If the capacity of the reservoir based on the HMC is not less than 3 hours, evaluation is "OK".
Source: JICA Study Team

[Sector 83]



[Sector 84]





Source: JICA Study Team

Figure 3.4.5-1: Dynamic Analysis of Water Storage of the Reservoirs

5) Solutions of the Deficit of the Reservoirs' Capacities

Through the analyses above, it was found that the reservoirs will satisfy the National Sanitation Standard until 2025, except for the reservoir in sub-sectors 85B-2 and 85C. It was also found that the reservoir for the sub-sectors 85B-2 and 85C can function enough to regulate the pressure, though it does not satisfy the standard even in 2009.

As a conclusion, in view point of cost-efficiency, it is not necessary to increase the capacities of the reservoirs, and it is recommended that SEDAPAL consider the necessity and timing of the enlargement of the reservoirs observing their actual performance in the future.

(4) Rehabilitation, Upgrading and Renewal

1) Types of Construction Works for Improvement of Reservoirs and Pumping Stations

Improvement works of reservoirs and pumping stations include rehabilitation, upgrading and renewal of civil works and electromechanical works as shown below:

Table 3.4.5-5: Types of Construction Works of Reservoirs and Pumping Stations

<table>
<tr><th colspan="2">Category</th><th>Code</th><th>Item</th><th>Remarks</th></tr>
<tr><td>A</td><td>Civil Work
(Reservoir)</td><td>A-1</td><td>Rehabilitation of structure, interior water proof, exterior paint, or other accessories</td><td>Rehabilitation</td></tr>
<tr><td rowspan="4">B</td><td rowspan="4">Electromechanical Equipment
（Reservoir）</td><td>B-1</td><td>Adding new equipment, re-arrangement of pipe, or replacing equipment for enlarging capacity</td><td>Upgrading</td></tr>
<tr><td>B-2</td><td>Installation of equipment for connection with wells*1</td><td>Upgrading</td></tr>
<tr><td>B-3</td><td>Renewal of equipment</td><td>Renewal</td></tr>
<tr><td>B-4</td><td>Rehabilitation of existing equipment</td><td>Rehabilitation</td></tr>
<tr><td>C</td><td>Civil work and Electromechanical Equipment
(Pumping Station)</td><td>C</td><td>Rehabilitation of existing equipment and additional installation of necessary equipment</td><td>Rehabilitation and Upgrading</td></tr>
</table>

*1: Pipe and valves to receive water from wells
Source: JICA Study Team

In the construction works above, civil works for rehabilitation aim at recovering the original capacity to store water and secure quality of the reserved water.

Elecromechanical works are included in the Project not only to recover the original function but to improve the systems of the reservoirs so that they can achieve ideal operation and maintenance work. Upgrading of M&E work includes installation of equipment such as pipes, valves and other accessories for connection with existing wells at the reservoirs.

2) Rehabilitation of Civil Works

In the diagnoses of the structures of the reservoirs and pumping stations which were given in Section 2.5.8 and Appendix A4, the necessity and methodology of the rehabilitation were identified.

The Consultant carried out a structural survey on the possible target facilities of civil works, which are 27 reservoirs, 3 pumping stations beside the reservoirs and 1 independent pumping station. In the survey, no serious damage was observed which affects structural strength or endurance. However, it was found that rehabilitation works such as repair of cracks and exposed reinforcing steel, interior coating for water-resistance, and exterior painting were necessary for all 27 reservoirs. In addition, accessory items such as ladders or steps for maintenance works, pits for overflow and drainage, and fences for security needed to be rehabilitated.

As for pumping stations, minor repair works such as exterior works and painting are necessary.

The followings are the required activities included in rehabilitation of the reservoirs and pumping stations.

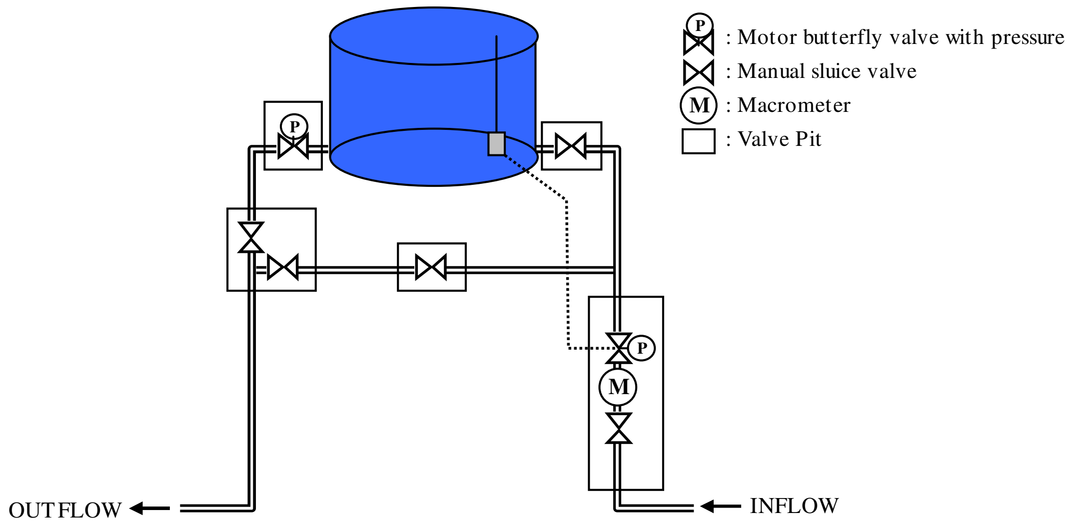
- Repair of cracks, repair of exposed reinforcement and chipped concrete, interior water proofing of the tank, reinstallation of ladders for maintenance, exterior painting of reservoirs, concrete pits for drain and overflow of the reservoirs and other accessories.
- Repair of cracks and painting of the pumping houses.
- Operational test of the reservoirs by filling the tanks with water (All reservoirs shall be checked.)
- Detailed structural survey such as laboratory test of concrete strength with sample cores, check of bar arrangement by ladder, geotechnical survey, modeling of the structures and structural calculation for the reservoirs (Target facilities can be selected based on their scale and age.)
- Strengthening of the structure if the structural calculation find the necessities

3) Electromechanical Equipment Required for the Reservoirs

Figure 3.4.5-2 illustrates the typical design of a reservoir. Upgrading works shall be carried out so that the reservoirs will comply with the system proposed in the typical design. Reservoir equipment is fabricated to meet the following requirements:

- Reservoir pipeline consists of inflow pipe, outflow pipe, by-pass, overflow pipe and drain pipe. The reservoirs to be connected with wells have another independent inflow pipe from the wells additionally.
- A flow meter shall be installed at inflow pipe from primary networks. The meter shall be equipped with a sluice valve at its upstream and a butterfly valve at its downstream. This flow meter works as the macrometer of the sub-sectors.
- The butterfly valve downstream of the macrometer shall be equipped with a pressure sensor. It has a function to control the inflow (volume and pressure) to the reservoir according to the pressure and water level of the reservoir.
- The butterfly valve also has a function to control distribution pressure when the water is supplied via by-pass.
- The inflow pipe should have two sluice valves between the by-pass and the tank in order for maintenance works.

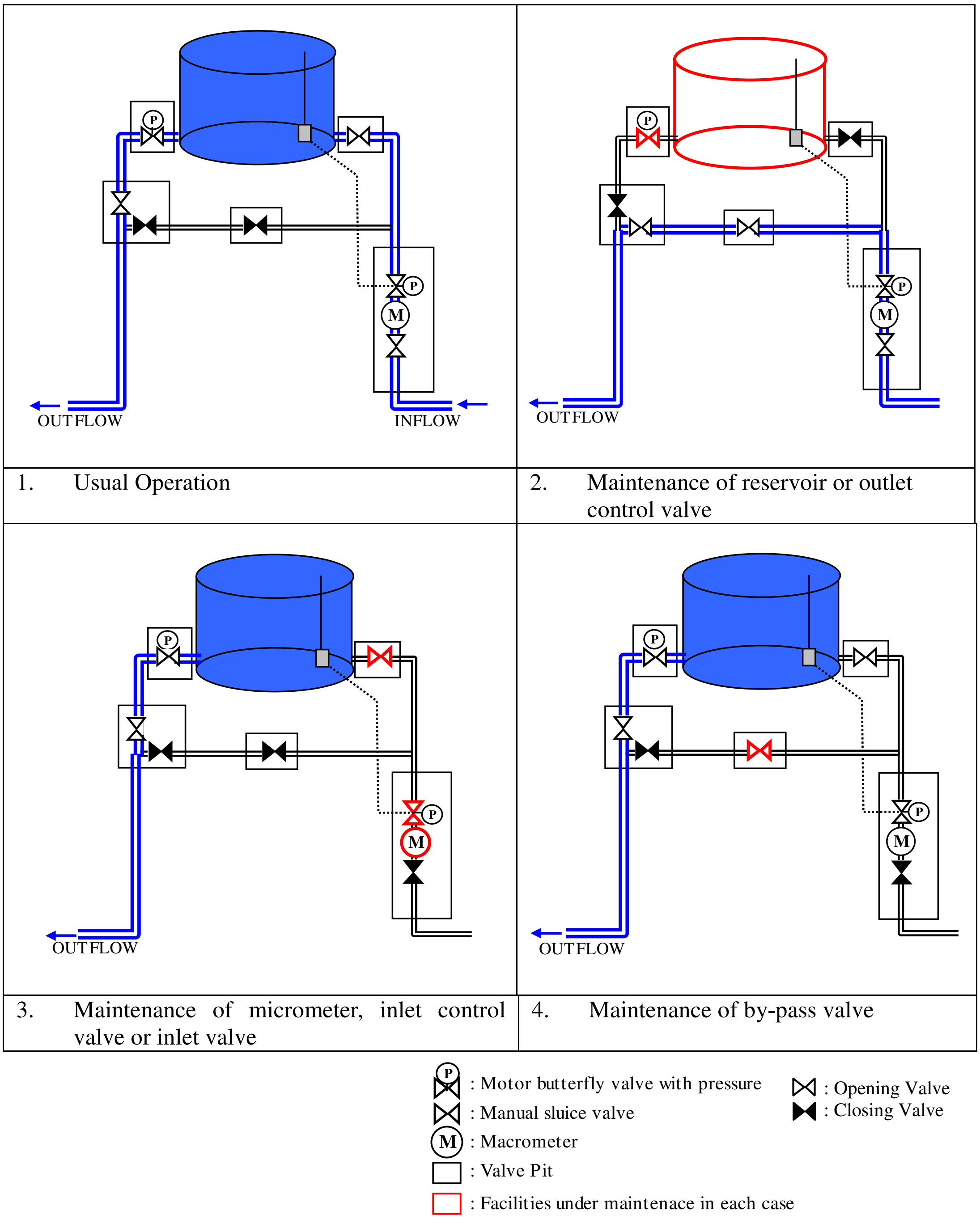
- The reservoirs shall be equipped with a water level meter.
- The outflow pipe shall have one butterfly valve with a pressure sensor to control the outflow of the reservoir.
- One manual sluice valve is installed in the outflow pipe between the butterfly valve and the by-pass in order for maintenance works.
- By pass shall have one main valve and another valve for maintenance works.
- The relief valve is installed before the flow meter to prevent water hammer. Plumbing from the relief valve shall be connected to the drain of the reservoir instead of the tank, which prevents the stored water from being contaminated by the water in the plumbing.
- No valve shall be installed in the inflow pipe from the wells because the inflow from the well is controlled at the wells.



Source: JICA Study Team

Figure 3.4.5-2: Typical Preliminary Design of Reservoir

Figure 3.4.5-6 presents operation plan of the reservoir which explains the necessity of the valves, and Table 3.4.5-6 shows the items and quantities of the equipment required for a reservoir.



Source: JICA Study Team

Figure 3.4.5-3: Reservoir Operation Plan

Table 3.4.5-6 Equipment Required in a Reservoir

No.	Equipment	Specifications	Q'ty (unit)
1	Flowmeter	Electromagnetic	1
2	Sluice Valve	Manual	5
3	Butterfly Valve	Motor control with pressure sensor (Operated by SCADA)	1
4	Butterfly Valve	Motor and hydraulic control with pressure sensor (Operated by SCADA)	1
5	Relief Valve	Hydraulic control	1
6	Water Depth Meter	-	1

Source: JICA Study Team

4) Rehabilitation, Upgrading and Renewal Works of Electromechanical Equipment

In the diagnoses of the existing electromechanical equipment given in Section 2.5.8 and Appendix A6, the necessity and methodology of rehabilitation were identified.

It is recommended that all equipment be renewed in the 16 reservoirs which are not in operation. As for the 10 operating reservoirs, there is no failure which can bring serious operational problems. However, some valves and control panels are not functioning and need to be rehabilitated or replaced.

Electromechanical equipment, such as electric or operation panels, in the 3 pumping stations beside the reservoirs (CR-95, CR-96 and CR-97) and the 1 independent pumping station (CR-76) also needs to be rehabilitated.

The current electromechanical equipment, especially the electric equipment, fails to comply with SEDAPAL's current specifications for its integration to the SCADA system. Therefore, the whole communications equipment and instrumentation must be replaced to meet SEDAPAL's current standards.

(5) Construction Items and Quantities of Reservoirs and Pumping Stations

Reservoirs and pumping stations are categorized by required types of construction in the Project. The numbers of the reservoirs and pumping stations by category are shown in Table 3.4.5-7 and the list of the reservoirs and pumping stations to be rehabilitated or upgraded is shown in Table 3.4.5-8. The locations of the reservoirs and pumping stations are illustrated in Figure 3.4.5-4.

Table 3.4.5-7: Quantity of Construction Works in the Reservoirs and Pumping Stations

Item							Unit	Quantity
Type	Construction Items*							
	Civil	Electromechanical						
	A	B-1	B-2	B-3	B-4	C		
I	√	√	√				Nos	11
II	√	√					Nos	5
III	√			√	√		Nos	9
IV	√			√	√	√	Nos	1
V			√				Nos	1
VI						√	Nos	4[*2]
Total	Reservoirs						Nos	27
	Pumping stations beside the reservoirs						Nos	3
	Independent Pumping station						Nos	1

A : Civil Work
B-1: Electromechanical works (Renewal of equipment)
B-2: Electromechanical works (for connection with wells)
B-3: Electromechanical works (Rehabilitation of existing equipment)
B-4: Electromechanical works (Additional equipment)
C: Civil work on pumping house and electromechanical works of pumping facilities (Rehabilitation and additional equipment)
*1: Including one reservoir to be re-constructed
*2: 3 pumping stations beside the reservoirs and 1 independent pumping station
Source: JICA Study Team

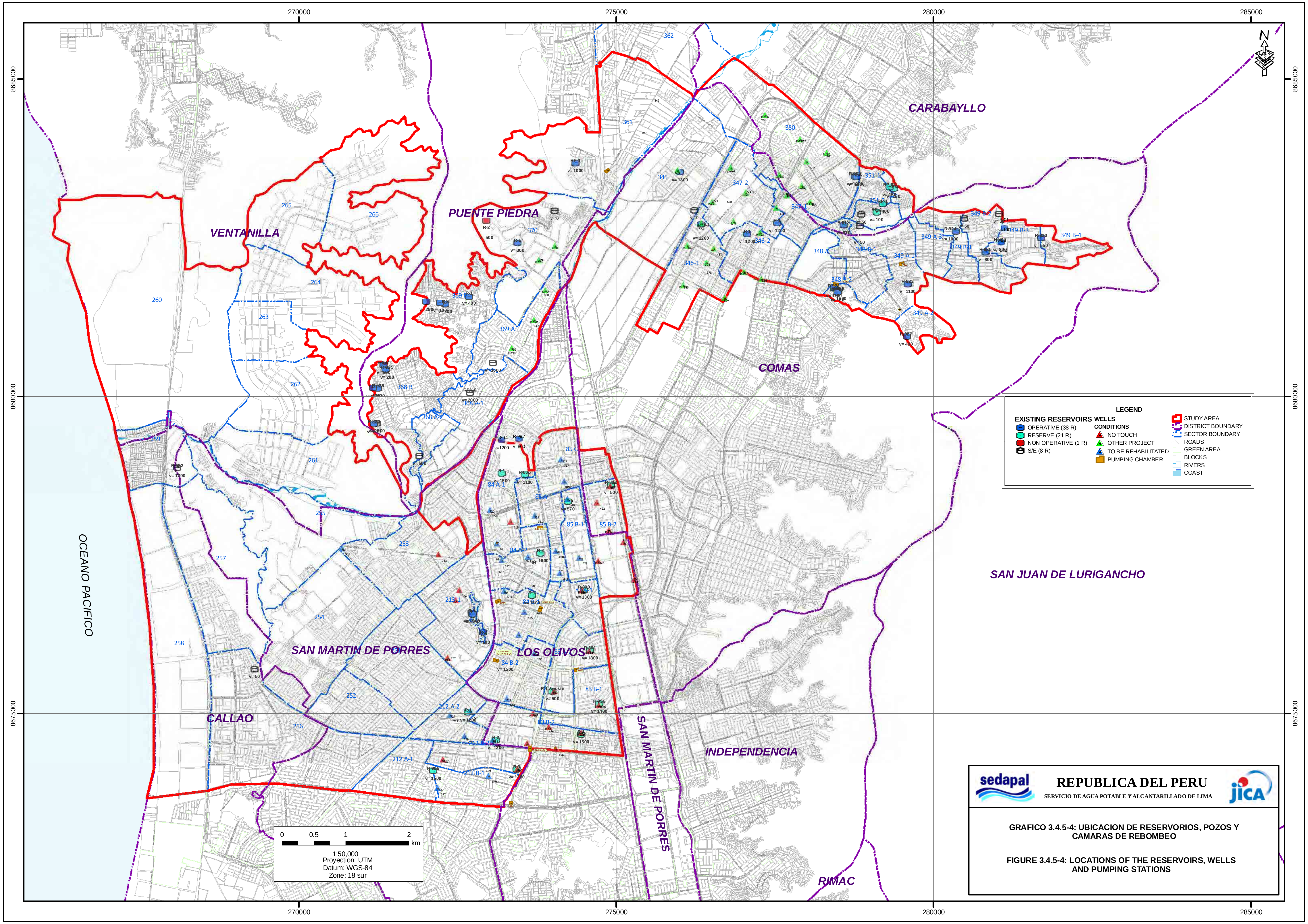
Table 3.4.5-8: List of the Reservoirs and Pumping Stations in the Project

Sub-Sector	Code/Name		Volume (m^3)	Current Condition	Project*	
					Type	Component*
83A-1	R-800	VILLA SOL R-1	1300	Non-operating	I	A, B-1, B-2
83A-2	R-801	VILLA DEL NORTE R-1	1800	Non-operating	II	A, B-1
83B-1	R-996	PARQUE DEL NARANJAL R-1	1400	Non-operating	II	A, B-1
83B-2	-	CUETO FERNANDINI R-1	1500	Non-operating	II	A, B-1
84A-1	-	OLIVOS DE PRO R-1	1500	Non-operating	I	A, B-1, B-2
84A-2	-	PROGRAMA CONFRATERNIDAD R-2	1600	Non-operating	I	A, B-1, B-2
84B-1	-	PROGRAMA CONFRATERNIDAD R-1	1600	Non-operating	I	A, B-1, B-2
84B-2	-	COMITÉ APOSTE	500	Non-operating	I	A, B-1, B-2
	-	PATRIA NUEVA R-1	70	Operating	III	A, B-3, B-4
85A	R-805	PUERTA DE PRO R-1	1100	Non-operating	I	A, B-1, B-2
85B-1	-	RIO SANTA R-1	570	Non-operating	I	A, B-1, B-2
85B-2, 85C	R-997	PRO	1900	Non-operating	II	A, B-1
85B-3	R-802	SANTA LUISA R-1	500	Non-operating	II	A, B-1
212A-1	R-986	VIRGEN DE LAS NIEVES R-4	1500	Non-operating	I	A, B-1, B-2
212A-2	-	VIRGEN DEL ROSARIO R-1	1200	Non-operating	I	A, B-1, B-2
212B-1	-	ROSARIO DEL NORTE R-3	1200	Non-operating	I	A, B-1, B-2
212B-2	-	JAZMINES DE NARANJAL R-2	1200	Non-operating	I	A, B-1, B-2
213-1	CR-243	VIPOL NARANJAL R-1	1900	Operating	III	A, B-3, B-4
213-2	-	CERRO EL CHOCLO R-2	100	Operating	III	A, B-3, B-4
213-3	-	CERRO EL CHOCLO R-1	100	Operating	III	A, B-3, B-4
259	R-522	MARQUEZ R-522	1200	Operating	III	A, B-3, B-4
349A-2	CR-76**	Cisterna	-	Operating	VI	C
	R-927	NVA. ESPERANZA R-1	400	Operating	III	A, B-3, B-4
349A-3	R-924	COLLIQUE R-4	1000	Operating	VI	C
349B-1	R-925	COLLIQUE R-5	800	Operating	VI	C
349B-2	R-926	COLLIQUE R-6	800	Operating	IV	A, B-3, B-4, C
349B-3	R-820	COLLIQUE R-7	550	Operating	III	A, B-3, B-4
351-2	RP-3	LOS ANGELES R-3	100	Operating	III	A, B-3, B-4
351-3	RP-4	LOS ANGELES R-4	100	Operating	III	A, B-3, B-4
-	RP-2	Cerro Oquendo	5000	Non-operating	V	B-2

* A : Civil Work
B-1: Electromechanical works (Renewal of equipment)
B-2: Electromechanical works (for connection with wells)
B-3: Electromechanical works (Rehabilitation of existing equipment)
B-4: Electromechanical works (Additional equipment)
C : Civil work on pumping house and electromechanical works of pumping facilities (Rehabilitation and additional equipment)

** Independent Pumping Station

Source: JICA Study Team



270000
275000
280000
285000
8685000
8680000
8675000
N
CARABAYLLO
PUENTE PIEDRA
VENTANILLA
COMAS
OCEANO PACIFICO
SAN JUAN DE LURIGANCHO
SAN MARTIN DE PORRES
LOS OLIVOS
CALLAO
INDEPENDENCIA
RIMAC
LEGEND
EXISTING RESERVOIRS
OPERATIVE (38 R)
RESERVE (21 R)
NON OPERATIVE (1 R)
S/E (8 R)
WELLS
CONDITIONS
NO TOUCH
OTHER PROJECT
TO BE REHABILITATED
PUMPING CHAMBER
STUDY AREA
DISTRICT BOUNDARY
SECTOR BOUNDARY
ROADS
GREEN AREA
BLOCKS
RIVERS
COAST
0 0.5 1 2 km
1:50,000
Proyection: UTM
Datum: WGS-84
Zone: 18 sur
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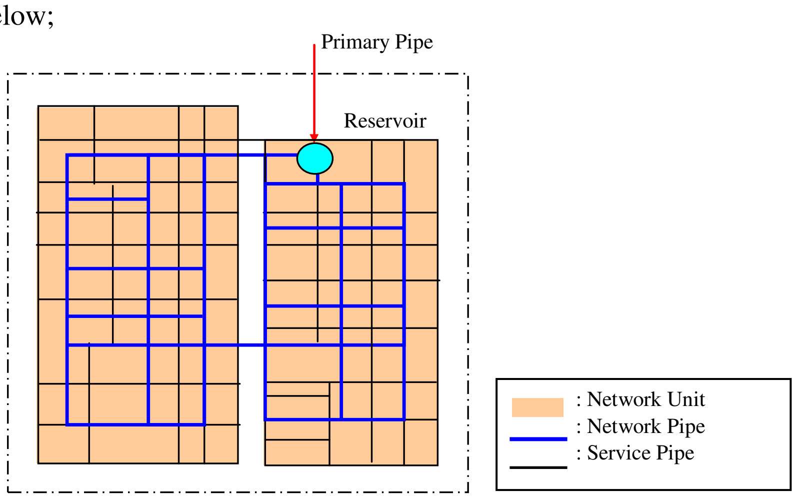
GRAFICO 3.4.5-4: UBICACION DE RESERVORIOS, POZOS Y CAMARAS DE REBOMBEO
FIGURE 3.4.5-4: LOCATIONS OF THE RESERVOIRS, WELLS AND PUMPING STATIONS

3.4.6 Improvement of Secondary Networks

(1) Introduction - Definition of Network Pipe and Service Pipe

Secondary network consists of secondary pipes and accessories such as shut valves, air valves, drain valves, etc. Their function is to distribute water from reservoirs in each sub-sector to the entire area of the sub-sector.

Secondary pipes can be categorized into two layers, which are network pipe and service pipe. Network pipes are the pipes which formulate a main circuit (network unit) in the secondary networks. If a sub-sector has a wide area or include areas with different elevations, the sub-sector shall have plural network units. Service pipes, on the other hand, are the pipes which distribute the water to all connections. The concept of network pipe and service pipe is illustrated below;



Source: JICA Study Team

Figure 3.4.6-1: Concept of Network Pipe and Service Pipe

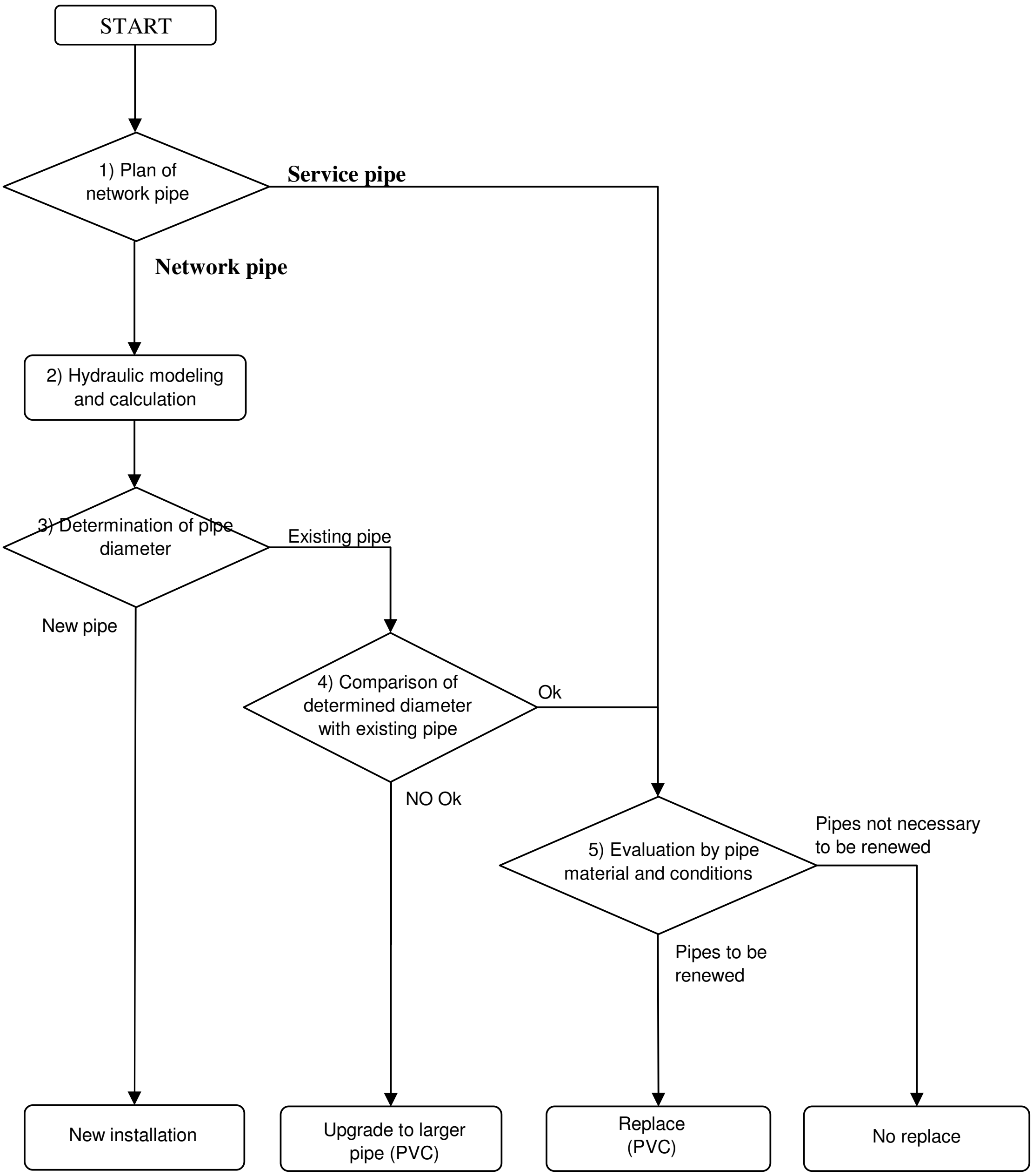
(2) Planning Methodology of Upgrading and Renewal

1) Target Sectors of the Plan

The plan of upgrading and renewal of secondary pipes shall be carried out for the all sectors in the Project Area except for sectors 361, 368B, 369B and 370. The sectors 361, 368B and 369B have new networks. Rehabilitation of the network in the sector 370 will be executed by another SEDAPAL project.

2) Procedure of the Plan

The construction work of the secondary networks in the Project includes upgrading and renewal. Upgrading work is to enhance the capacity of the pipes to meet the future water demand. Renewal is to replace the pipes having problems or pipes which can cause problems. Plans for upgrading and renewal are planned by a procedure which is shown in Figure 3.4.6-2.



Source: JICA Study Team

Figure 3.4-6-2: Procedure of Upgrading and Renewal Plan of Secondary Networks

As explained in the figure above, studies to be carried out are different between network pipes and service pipes. The procedure can be summarized as follows:

- Network pipes shall be newly planned so that they can form a desirable network to distribute the water efficiently.
- Diameters of the network pipes shall be determined by hydraulic modeling and calculation.
- Existing network pipes with sufficient capacities are evaluated according to their materials. AC pipe shall be renewed to PVC pipe.

- Service pipes to be renewed are identified and evaluated by pipe materials and identified conditions.

(3) Plan of Upgrading and Renewal

Each step included in the procedure of upgrading and renewal plan of secondary networks, which was presented by the figure above, is explained below:

1) Plan for Network Pipes

Network pipes shall be newly planned so that they can form a desirable network to distribute the water efficiently. Therefore, some of them can be new pipes, although the existing pipes shall be utilized as much as possible.

As a result of network planning, it was found that 49.46 km of pipes are necessary. From this quantity, 36.21 km will be PVC and 13.25 km DI. The following table presents the length of the required new pipes.

Table 3.4.6-1: Planned New Pipes in the Project (km)

Sector	Diameter (mm) and Length (km)							Total
	100	150	200	250	300	350	400	
83A		1.61						1.61
83B		3.06	0.16	0.19				3.41
84	0.55		0.31	4.01				4.87
85	2.38	2.11		0.32	1.07	0.19	1.48	7.55
212	3.55	0.81	0.64	0.01				5.01
213	2.52	1.15	0.38					4.05
259	0.88	0.90	0.23					2.01
345		0.21						0.21
346		1.86						1.86
347	1.23	1.46	0.59					3.28
348		0.75		0.13	0.65			1.53
349	0.78	2.48		0.63	0.16			4.05
350	0.62	0.68	1.13	1.62	0.54	1.69		6.28
351	0.35	0.45						0.80
368A		0.65	0.72	0.18				1.55
369A		1.05		0.26	0.12			1.43
Total	12.86	19.23	4.16	7.35	2.54	1.88	1.48	49.50
Per Material*	PVC: 36.25 km			DI: 13.25 km				-

*: See 3.4.6 (4) 2)
Source: JICA Study Team

2) Hydraulic Modeling and Calculation

Based on the planned secondary networks, a hydraulic model is prepared for network pipes by Water CAD.

Calculation is carried out following the National Sanitation Standard, which regulates the friction factor (C value), minimum diameter, velocity, and service pressure. Each model is calculated in two cases, which are a case of minimum flow and a case of maximum flow, to assure that the hydraulic conditions satisfy the maximum pressure and minimum pressure.

Detailed information and explanations on the hydraulic calculation are given in Appendix B2.1.

3) Determination of Pipe Diameter

Primary and secondary pipes diameters are determined according to the results of the hydraulic calculation and the optimum design term (13 years for gravity pressure pipes, 14 years for pumping pressure pipes and 18 years for sector inlet pipes and distribution networks). The calculation is shown in Appendix B2.1, and in the calculation, a scale economy factor and a discount rate of 10% have been considered.

4) Comparison of Calculated Diameter with Existing Pipes

Calculated diameters of the network pipes are compared with those of the existing ones. Pipes without sufficient diameter shall be upgraded to meet the required diameters.

As a result of the hydraulic calculations, it was found that 12.84 km of the existing pipes, including those which do not have enough hydraulic capacity and those which do not satisfy the minimum diameter, shall be upgraded in the Project. Detailed information and explanations on the hydraulic calculation are given in Appendix B2.1.

Table 3.4.6-2: Pipes to be Upgraded based on the Hydraulic Calculation (km)

Sector	Sub-sector	Unit	AC (Km) Diameter (mm)					PVC (Km) Diameter (mm)					Total
			50	75	100	110	150	75	90	110	160	250	
83A	83 A-2	km			1.36								1.36
83 B	83 B-1	km			0.83								0.83
	83 B-2	km	0.09	0.06	2.33							0.04	2.52
	85 B-2	km			0.18								0.18
259	259	km		1.47	0.11				0.06				1.64
346	346-2	km			0.6						0.01		0.61
347	347-1	km								0.38			0.38
	347-2	km								0.41	0.1		0.51
348 A	348 A	km			0.16								0.16
349 A	349 A-1	km		0.27			0.01	0.33					0.61
	349 A-3	km			0.01			0.41					0.42
349B	349 B-2	km								0.1			0.1
	349 B-3	km			0.05		0.03	0.41		0.05			0.54
350	350-1	km			1.74								1.74
	350-2	km			0.34								0.34
368 A	368 A-2	km				0.77							0.77
369 A	369 A	km								0.13			0.13
Total		km	0.09	1.8	7.71	0.77	0.04	1.15	0.06	1.07	0.11	0.04	12.84

Source: JICA Study Team

5) Evaluation by Pipe Material and Condition

As analyzed in Section 2.5.8, there are pipes which have problems due to materials and conditions. In addition, there are some pipes which should ideally be replaced early in order to prevent serious and rapid deterioration of the water supply networks in the future. In this step, among the existing networks having enough capacity in the service pipes, pipes to be replaced are selected based on their materials and conditions. Criteria for selection of the pipes to be renewed are explained in the following item.

(4) Criteria of the Pipes to be Renewed

1) Pipes that shall be considered for Renewal

From the result of the diagnoses shown in Section 2.5.8 and in view of reduction of NRW and achievement of a sustainable water supply system, existing pipes considered by the Study to be in need of renewal are:

- Pipes with problems related to material; the pipes made of iron pipe (ACER), galvanized iron pipe (FoFo) or a type of polyvinyl chloride pipe (PVC) called "ITINTEC",
- Pipes with problems related to conditions; pipes were not installed in compliance with technical requirements or are located within private property,
- Network pipes and other very important pipes of asbestos cement (AC) that can cause much larger water leakage than other pipes, and
- Other AC pipes (service pipes)depending on endurance and lifespan.

It is presumed that considerations for pipeline evaluation and replacement might include those spans where incidents were detected. In this way, the concept that, poor quality pipes and poorly installed pipes cause incidents is indirectly taken into account.

Pipes with problems related to material and condition obviously need to be replaced with reliable material and a proper installation work.

AC pipes included in network pipes also need to be considered for renewal with more reliable materials, in view of reducing of water leakage and promoting sustainability of the water supply system. Network pipes have larger diameters than the other service pipes, and the water pressures also tend to be higher, both of them are conditions that cause a great amount of water leakage. Moreover, network pipes are highly important for an ongoing water supply with proper pressure. Serious accidents should be avoided in the network pipes, and frequent maintenance works shall also be avoided, in order to sustain SEDAPAL's service level.

At present, AC pipes belonging to service pipes may not be causing much water leakage. However, it is clear that water leakage from these pipes will increase gradually in the future, and it could raise the NRW ratio over 25% again after the project had lowered NRW to below 25%.

2) Options for AC Pipe to be Considered for Renewal

In the pipe conditions survey carried out in the Study, AC pipes were inspected at 20 test pits; 12 of such test pits were for AC pipes between 10 years and 30 years old, and the other 8 test pits were for those over 30 years old. All test pits were prepared in a way so that it would expose at least one pipe joint, and water leakage was observed at the pipe joints. The result showed that the AC pipes are not causing much water leakage, rather the water leakage was at a negligible rate.

In addition, as explained in item (4) of Section 2.5.8, AC pipe strength tends to deteriorate rapidly at around 20 years after installation, and usually, the deterioration becomes obvious at around 40 years after installation.

In principle, AC pipe is inferior to PVC in terms of water-tightness at joints, especially the “corporation” joint, structural endurance, endurance against chemical soils, and lifespan. Therefore, it is clear that renewing all AC pipes will contribute to reducing NRW. However, replacing all AC pipes might be an excessive measure to achieve the target NRW 25% ratio.

Therefore, two options are considered as criteria for AC pipe renewal based on pipe age. The first option is to set 25 years as the limit age (these pipes will be over 30 years old in the project completion year of 2015) and the second option is to set 15 years as the limit age (these pipes will be over 20 years old in 2015.)

The 25-year old age limit is considered based on the existing situation and anticipated future deterioration of AC pipes. The proposal is to replace AC pipes 10 years before they reach their usage limit, assuming that the AC pipe lifespan is 40 years, based on the general tendencies of AC pipe deterioration.

The 15-year old age limit is considered because the deterioration of AC pipes is usually noted 20 years after their installation.

3) Priorities for Pipes to be Renewed

Priorities and quantities for pipes to be renewed are presented in Table 3.4.6-3. Quantities do not include the pipes to be upgraded for capacity increase purposes. Moreover, if a pipe has multiple characteristics, length of the pipe is counted in a higher priority category to avoid double counting. For example, an AC network pipe over 25 years old is included only in the “AC network pipe” category.

Pipes with problems must be renewed. Network AC pipes have second priority because they might be causing more water leakage, as explained above, and they play an important part in the water supply system.

Table 3.4.6-3: Priorities for Pipes to be Considered for Renewal

Priority	Category		Quantity			
			Each Category		Accumulation	
			Length[*1] (km)	%[*2]	Length[*1] (km)	%[*2]
1	A B	Pipes without enough capacity. Pipes with material problems and Pipes with installation problems	35.60	4.60%	35.60	4.60%
2	C	Network pipes of AC	75.54	9.77%	111.14	14.37%
3	D	AC pipes over 25 years old	67.88	8.78%	179.02	23.15%
4	E	AC pipes between 15 and 25years old	94.08	12.16%	273.10	35.31%

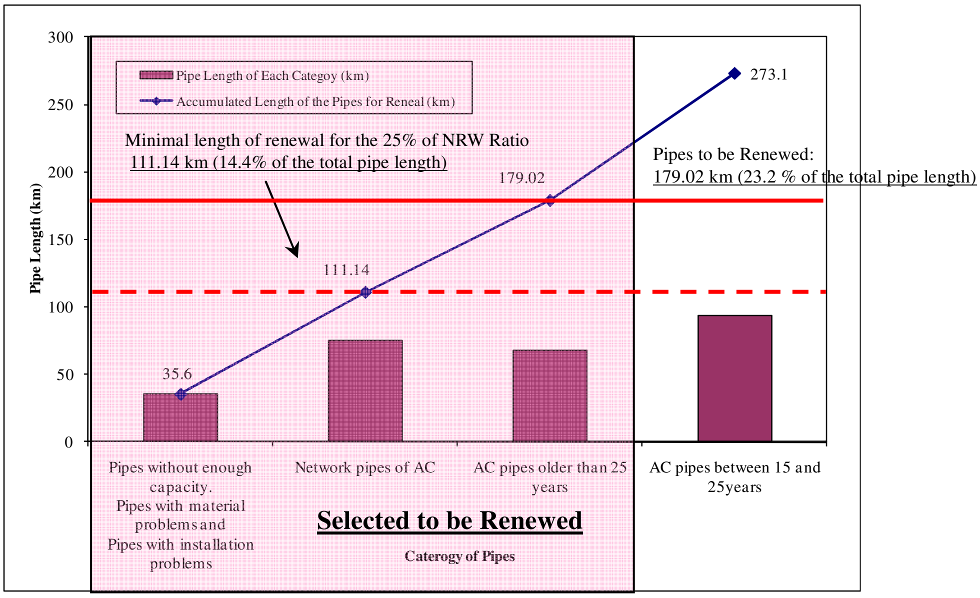
*1: Pipes that can belong to multiple categories rank in a higher priority category, so that double counting is avoided.

*2: Percentage against the total pipe length (773.45 km)

Source: JICA Study Team

4) Determination of Criteria for Pipe Renewal

In order to reach a NRW ratio of 25%, as analyzed under 3.4.1, 15 % of the pipelines would need to be replaced. As rehabilitation of priority levels 1 and 2 alone would fail to reach this goal, it would be necessary to include those pipes under priority 3. Even though the combination of all 3 priorities represents 23.15 % of the pipelines to be replaced, somewhat higher than the goal of 15 %, it could better ensure the 25% NRW goal. Figure 3.4.6-3 shows the pipeline lengths to be considered for replacement, as opposed to 15 % of the pipeline total length.



Source: JICA Study Team

Figure 3.4.6-3: Determination of Pipes for Renewal

(5) Results of the Upgrading and Renewal Plan for Secondary Pipes

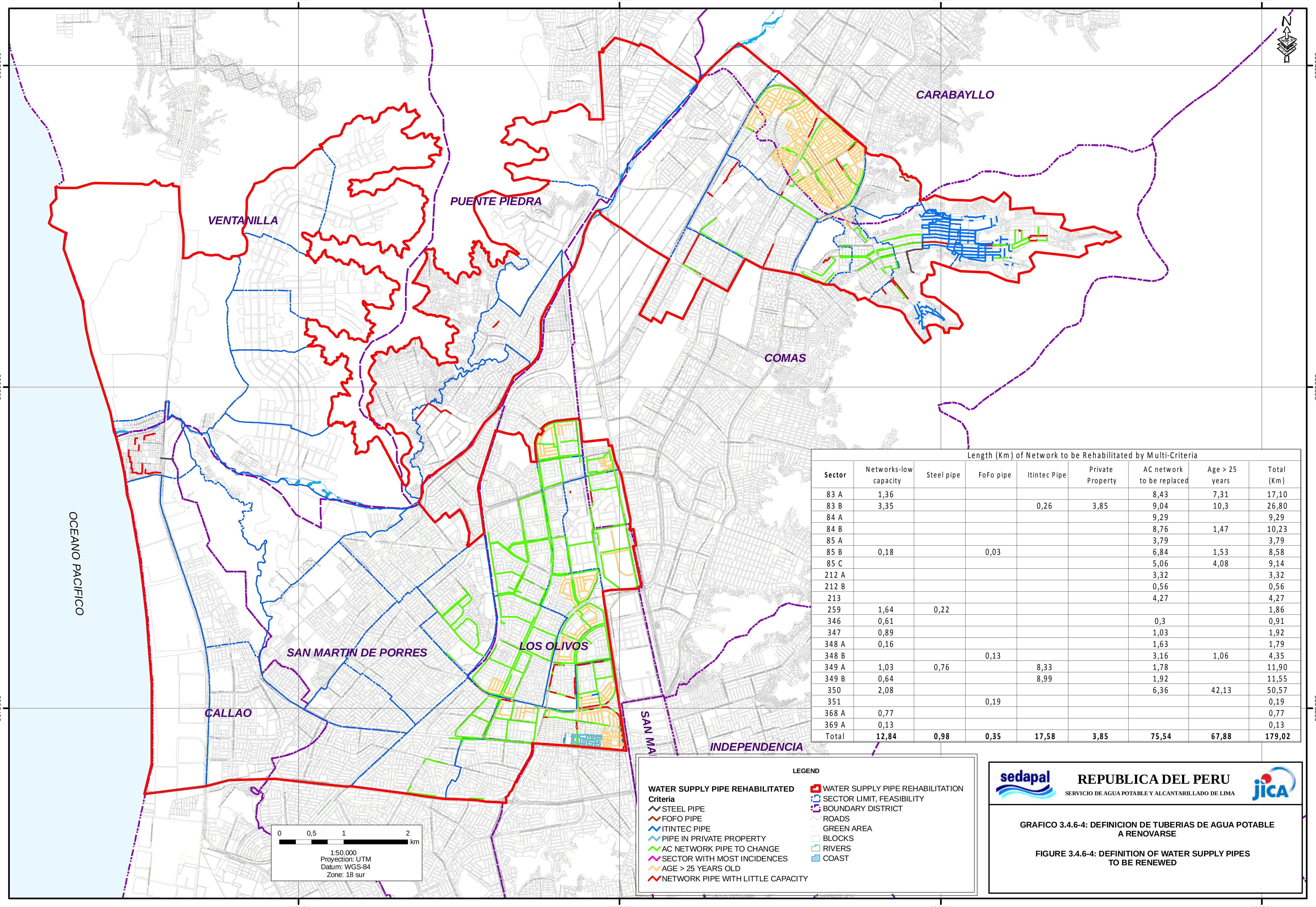
Figure 3.4.6-4 presents pipe length for upgrading and renewal in secondary networks by their purpose and by sub-sector, based on the hydraulic calculations and studies on the pipe conditions above. Table 3.4.6-4 summarizes the pipe length by sub-sector.

Table 3.4.6-4: Summary of the Planned Upgraded and Renewed Pipes in the Project (km)

Sector	Pipes to be Renewed		New Pipes		Pipes Without Changes		Total Pipes by Sector	
	Km	%	Km	%	Km	%	Km	%
83A	17.10	50.12%	1.61	4.72%	15.41	45.16%	34.12	100%
83B	26.80	54.38%	3.41	6.92%	19.07	38.70%	49.28	100%
84A	9.29	15.25%	2.34	3.84%	49.27	80.90%	60.90	100%
84B	10.23	22.35%	2.53	5.53%	33.02	72.13%	45.78	100%
85A	3.79	20.06%	1.51	7.99%	13.59	71.94%	18.89	100%
85B	8.58	32.00%	3.02	11.26%	15.21	56.73%	26.81	100%
85C	9.14	49.03%	3.02	16.20%	6.48	34.76%	18.64	100%
212A	3.32	6.22%	3.01	5.64%	47.06	88.14%	53.39	100%
212B	0.56	1.92%	2.00	6.87%	26.55	91.21%	29.11	100%
213	4.27	10.39%	4.05	9.86%	32.77	79.75%	41.09	100%
259	1.86	11.58%	2.01	12.52%	12.19	75.90%	16.06	100%
345			0.21	1.55%	13.37	98.45%	13.58	100%
346	0.91	5.20%	1.86	10.63%	24.07	89.686%	26.84	100%
347	1.92	3.62%	3.28	6.18%	47.89	90.21%	53.09	100%
348A	1.79	22.10%	0.46	5.68%	5.85	72.22%	8.10	100%
348B	4.35	19.74%	1.07	4.85%	16.62	75.41%	22.04	100%
349A	11.90	37.81%	2.11	6.70%	17.46	55.48%	31.47	100%
349B	11.55	40.77%	1.94	6.85%	14.84	52.38%	28.33	100%
350	50.57	64.69%	6.28	8.03%	21.32	27.27%	78.17	100%
351	0.19	2.69%	0.80	11.32%	6.08	86.00%	7.07	100%
368A	0.77	2.64%	1.55	5.32%	26.81	92.04%	29.13	100%
369A	0.13	0.49%	1.43	5.34%	25.21	94.17%	26.77	100%
TOTAL	179.02		49.50		490.14		718.66	

- Diameter after upgraded or renewed is 100 – 300mm
- Only sectors of the area of influence are shown

Source: JICA Study Team



Length (Km) of Network to be Rehabilitated by Multi-Criteria								
Sector	Networks-low capacity	Steel pipe	FoFo pipe	Itintec Pipe	Private Property	AC network to be replaced	Age > 25 years	Total (Km)
83 A	1,36					8,43	7,31	17,10
83 B	3,35			0,26	3,85	9,04	10,3	26,80
84 A						9,29		9,29
84 B						8,76	1,47	10,23
85 A						3,79		3,79
85 B	0,18		0,03			6,84	1,53	8,58
85 C						5,06	4,08	9,14
212 A						3,32		3,32
212 B						0,56		0,56
213						4,27		4,27
259	1,64	0,22						1,86
346	0,61					0,3		0,91
347	0,89					1,03		1,92
348 A	0,16					1,63		1,79
348 B			0,13			3,16	1,06	4,35
349 A	1,03	0,76		8,33		1,78		11,90
349 B	0,64			8,99		1,92		11,55
350	2,08					6,36	42,13	50,57
351			0,19					0,19
368 A	0,77							0,77
369 A	0,13							0,13
Total	**12,84**	**0,98**	**0,35**	**17,58**	**3,85**	**75,54**	**67,88**	**179,02**

LEGEND

WATER SUPPLY PIPE REHABILITATED
Criteria
- STEEL PIPE
- FOFO PIPE
- ITINTEC PIPE
- PIPE IN PRIVATE PROPERTY
- AC NETWORK PIPE TO CHANGE
- SECTOR WITH MOST INCIDENCES
- AGE > 25 YEARS OLD
- NETWORK PIPE WITH LITTLE CAPACITY

- WATER SUPPLY PIPE REHABILITATION
- SECTOR LIMIT, FEASIBILITY
- BOUNDARY DISTRICT
- ROADS
- GREEN AREA
- BLOCKS
- RIVERS
- COAST

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GRAFICO 3.4.6-4: DEFINICION DE TUBERIAS DE AGUA POTABLE A RENOVARSE

FIGURE 3.4.6-4: DEFINITION OF WATER SUPPLY PIPES TO BE RENEWED

Table 3.4.6-5: Pipes for Upgrade and Renewal

Location		Type of material and diameter		Length of pipes to be rehabilitated or renewed by conditions (Km)*3							
				1a priority	2a priority				3a priority	4a priority	
Sector	Sub-sector	ype of material	Diameter*2 (mm)	Network pipes without enough	Steel pipe	FoFo	ITINTEC	Pipes to be installed in private property	AC networks	AC pipe age > 25 years	Total
83 A	83 A-1	AC	100						1.79	2.34	4.13
		AC	200						0.53	0.23	0.76
		AC	250						0.62	0.8	1.42
		AC	300							0.19	0.19
	Total 83 A-1								2.94	3.56	6.5
	83 A-2	AC	100	1.36					1.55	2.91	5.82
		AC	150						1.11	0.83	1.94
		AC	200						1.38	0.01	1.39
		AC	250						1.45		1.45
	Total 83 A-2			1.36					5.49	3.75	10.6
83 B	83 B-1	AC	100	0.83					0.43	1.64	2.9
		AC	150						2.15	0.37	2.52
		AC	200							0.08	0.08
		AC	250						0.08	0.28	0.36
		AC	300						0.05	0.15	0.2
		PVC	160				0.13				0.13
	Total 83 B-1			0.83			0.13		2.71	2.52	6.19
	83 B-2	AC	100	2.33				2.62	1.6	4.26	10.81
		AC	150					0.6	3.03	1.44	5.07
		AC	200					0.26	0.92	0.02	1.2
		AC	250					0.37	0.78	0.61	1.76
		AC	300							0.01	0.01
		AC	50	0.09						0.97	1.06
		AC	75	0.06						0.47	0.53
		PVC	110				0.07				0.07
		PVC	160								
		PVC	250	0.04							0.04
		PVC	200				0.01				0.01
		PVC	63				0.05				0.05
	Total 83 B-2			2.52			0.13	3.85	6.33	7.78	20.61
84 A	84 A-1	AC	100						1.62		1.62
		AC	150						0.56		0.56
		AC	200						0.72		0.72
		AC	300						0.36		0.36
	Total 84 A-1								3.26		3.26
	84 A-2	AC	100						2.06		2.06
		AC	150						1.11		1.11
		AC	200						2.37		2.37
		AC	250						0.49		0.49
	Total 84 A-2								6.03		6.03
84 B	84 B-1	AC	100						2.33	0.73	3.06
		AC	150						2.82		2.82
		AC	200						1.68	0.43	2.11
	Total 84 B-1								6.83	1.16	7.99
	84 B-2	AC	100						0.84	0.15	0.99
		AC	150						0.47		0.47
		AC	200						0.58	0.16	0.74
		AC	250						0.04		0.04
	Total 84 B-2								1.93	0.31	2.24
85 A	85 A	AC	100						1.35		1.35
		AC	150						1.06		1.06
		AC	200						1.2		1.2
		AC	300						0.18		0.18
	Total 85 A								3.79		3.79
85 B	85 B-1	AC	100						0.25		0.25
		AC	150						0.76		0.76
		AC	200						0.58		0.58
		FOFO	200			0.03					0.03
	Total 85 B-1					0.03			1.59		1.62
	85 B-2	AC	100	0.18					0.62		0.8
		AC	150						0.6		0.6
		AC	200						0.19		0.19
		AC	250						0.77		0.77
	Total 85 B-2			0.18					2.18		2.36
	85 B-3	AC	100							0.46	0.46
		AC	150						0.97	0.57	1.54
		AC	200						1.02	0.45	1.47
		AC	250						1.08	0.05	1.13
	Total 85 B-3								3.07	1.53	4.6
85 C	85 C	AC	100						1.49	3.94	5.43
		AC	150						2.84	0.14	2.98
		AC	200								
		AC	250						0.73		0.73
	Total 85 C								5.06	4.08	9.14
212 A	212 A-1	AC	100						0.74		0.74
		AC	150						0.2		0.2
		AC	200						0.1		0.1
		AC	250						0.17		0.17
	Total 212 A-1								1.21		1.21
	212 A-2	AC	100						0.37		0.37
		AC	150						1.27		1.27
		AC	200						0.47		0.47
	Total 212 A-2								2.11		2.11
212 B	212 B-1	AC	100						0.24		0.24
	Total 212 B-1								0.24		0.24
	212 B-2	AC	100						0.24		0.24
		AC	150						0.08		0.08
	Total 212 B-2								0.32		0.32
213	213-1	AC	100						1.91		1.91
		AC	150						1.93		1.93
		AC	200						0.43		0.43
		AC	250								
	Total 213-1								4.27		4.27
259	259	AC	100	0.11							0.11
		AC	75	1.47							1.47
		ACER	250		0.22						0.22
		PVC	90	0.06							0.06
	Total 259			1.64	0.22						1.86
346	346-2	AC	100	0.6					0.3		0.9
		PVC	160	0.01							0.01
	Total 346-2			0.61					0.3		0.91
347	347-1	AC	100						0.2		0.2
		PVC	110	0.38							0.38
	Total 347-1			0.38					0.2		0.58
	347-2	AC	100						0.83		0.83
		PVC	110	0.41							0.41
		PVC	160	0.1							0.1
	Total 347-2			0.51					0.83		1.34
348 A	348 A	AC	100	0.16					1.63		1.79
	Total 348 A			0.16					1.63		1.79
348 B	348 B-1	AC	100						3.16	0.81	3.97
		AC	150							0.24	0.24
		AC	300							0.01	0.01
	Total 348 B-1								3.16	1.06	4.22
	348 B-2	FOFO	50			0.13					0.13
	Total 348 B-2					0.13					0.13
349 A	349 A-1	AC	100						1.78		1.78
		AC	150	0.01							0.01
		AC	200								
		AC	75	0.27							0.27
		ACER	300		0.7						0.7
		PVC	75	0.33							0.33
	Total 349 A-1			0.61	0.7				1.78		3.09
	349 A-2	PVC	110				1.12				1.12
		PVC	160				0.33				0.33
		PVC	75				0.65				0.65
	Total 349 A-2						2.1				2.1
	349 A-3	AC	100	0.01							0.01
		ACER	300		0.06						0.06
		PVC	110				1.78				1.78
		PVC	160				1.67				1.67
		PVC	200				0.47				0.47
		PVC	75	0.41			2.31				2.72
	Total 349 A-3			0.42	0.06		6.23				6.71
349 B	349 B-1	PVC	110				1.33				1.33
		PVC	160				1.6				1.6
		PVC	250				0.21				0.21
		PVC	63				0.03				0.03
		PVC	75				2.4				2.4
		PVC	90				0.06				0.06
	Total 349 B-1						5.63				5.63
	349 B-2	AC	100						0.51		0.51
		PVC	110	0.1			0.43				0.53
		PVC	160				0.86				0.86
		PVC	200				0.18				0.18
		PVC	50				0.03				0.03
		PVC	75				1.31				1.31
		PVC	90				0.1				0.1
	Total 349 B-2			0.1			2.91		0.51		3.52
	349 B-3	AC	100	0.05					1.41		1.46
		AC	150	0.03							0.03
		PVC	110	0.05							0.05
		PVC	75	0.41			0.45				0.86
	Total 349 B-3			0.54			0.45		1.41		2.4
350	350-1	AC	100	1.74					4.29	15.45	21.48
		AC	150						0.14	6.51	6.65
		AC	200						0.01	1.72	1.73
		AC	250							0.15	0.15
		AC	300							0.98	0.98
		AC	50							0.02	0.02
	Total 350-1			1.74					4.44	24.83	31.01
	350-2	AC	100	0.34					1.79	12.22	14.35
		AC	150						0.13	2.64	2.77
		AC	200							1.72	1.72
		AC	250							0.56	0.56
		AC	300							0.16	0.16
	Total 350-2			0.34					1.92	17.3	19.56
351	351-3	FOFO	100			0.19					0.19
	Total 351-3					0.19					0.19
368 A	368 A-2	PVC	110	0.77							0.77
	Total 368 A-2			0.77							0.77
369 A	369 A	PVC	110	0.13							0.13
	Total 369 A			0.13							0.13
TOTAL				**12.84**	**0.98**	**0.35**	**17.580**	**3.85**	**75.54**	**67.88**	**179.02**

Source: JICA Study Team

(6) Basic Specifications for Secondary Networks

1) Soil Conditions

The soil mechanical survey in the Study found the following specifications related to secondary network design:

- It is estimated that 60% of the soil within the Study area has a strong presence of chemicals that are aggressive to the foundation soil and to the concrete and ductile iron pipes.
- The foundation soil for pipe support is not expected to suffer any serious problems due to the presence of the high water table, loose soils, or soils of very low bearing capacity. Hence, it requires no other treatment of the foundation prior to mechanical compaction, with the exception of those cases where material is anthropogenic and/or all the material up to the depth of influence will have to be removed.
- Minimum coverage should be 1.2 m and backfill should be properly compacted.

2) Pipe Material

Pipe materials that have been applied in the SEDAPAL water supply network are: Ductile Iron (DI) pipe, polyvinyl chloride (PVC) pipe and high density polyethylene (PE) pipe.

Table 3.4.6-6 compares the characteristics of the pipe materials. As explained in the table, PVC shall be mostly used in the secondary networks. However, in some critical sections, DI is recommended to be applied, for better security. The critical section is defined by the following considerations:

- Among the secondary pipes, the sections from the reservoirs to the network units are more important than other pipes because they are mostly the only passages to convey water from reservoirs to the network units, and thus accidents in those sections have a strong, direct effect on the water supply.
- Even though the water pressures are controlled by the reservoirs, the pressures in those sections are higher than in the other sections; this can cause accidents in pipes with higher rates than other sections.
- In view of cost-efficiency, if the existing sections have PVC pipes with sufficient capacity, these pipes shall be utilized. If the sections are not currently AC pipes, or they are pipes with insufficient diameter, they shall be replaced to DI pipes, according to their diameter.
- If the pipe diameters are not less than 250mm, DI pipes shall be applied to the section.

3) Earth Cover

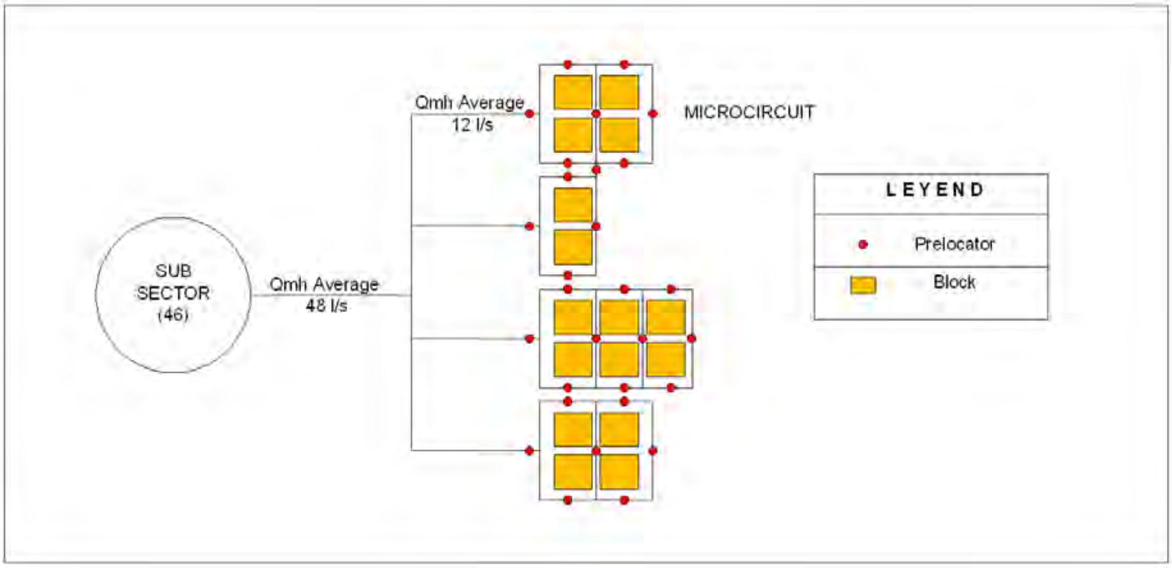
As recommended by the geotechnical survey result, earth cover is 1.2 m, in principle.

4) Pipe protection against Aggressive Soil

Though HD pipe has much better endurance against aggressive soil than steel pipe, SEDAPAL´s experience has proven that HD pipe can still be affected by aggressive soil.

5) Pre-locators

Pre-locators have been distributed at the beginning of each microcircuit and between them; it forms one network section of approximately 200 meters as shown in Figure 3.4.6-5.



Source: JICA Study Team

Figure 3.4.6-5: Pre-locators Configuration Scheme

Table 3.4.6-6: Selection of Pipe Material for Secondary Networks

Items		Ductile Iron (DI)	Polyvinyl Chloride (PVC)	High Density Polyethylene (PE)
General	Photo	 http://www.hida-group.co.jp/p_77.html	 http://www.chusai.co.jp/info/info.cgi	 http://www.xhrz.com.cn/rzqyml
	Description	- A product with hard structural and anti-chemical strength by combination of steel's resistance and cast gray iron's long life span	- Widely used plastic constructed of repeating vinyl groups having one of their hydrogens replaced with a chloride group.	- The most widely used plastic consisting of long chains of the monomer ethylene
Cost		- 310 \$ (75mm×4m)	- 13 \$ (63mm×6m)	- 130 \$ (75mm×5m)
Weight		- Heavy	- Light in weight	- Light in weight
Material Properties		- Successful watertight sealing - Sensitive to the damage of anticorrosion coating - Greatest resistance to breakage and chemical corrosion - Flexible joint to follow ground deformation, which prevents breakage or water leakage	- Successful watertight sealing. - No change of inner surface roughness - Low tolerence for specific organic solvents - Flexibility of material to follow ground deformation	- Successful watertight sealing - No change of inner surface roughness. - Low tolerence for specific organic solvents - Joint-free installation (Welded connection of the pipes by thermo fusion) which prevents breakage or water loss
Pressure Endurance		- 64 Kgf/cm^2	- 16 Kgf/cm^2	- 16 Kgf/cm^2
Usage Trend in SEDAPAL		- Widespread use in primary networks	- Widespread use in secondary networks	- Limited use
Others		- PE protection is necessary when it is installed in chemically aggressive soil	-	- It can be easily installed with a constant earth cover even in undulating areas
Evaluation		- It is not cost-effective to use widely in secondary networks. However, it is recommened to be applied to the critical sections of the secondary networks in view **Partly Applied**	- It has sufficient quality in structural strength, water tightness, pressure endurance and anti-chemical endurance to use in secondary networks. **Mainly Applied**	- It has superior qualities to PVC but cost much to use widely in secondary network.

Source: JICA Study Team

(7) Design of Accessories

1) Accessories for Secondary Networks

Accessories for secondary networks are pressure reducing valves, sluice valves, air valves, drain valves, and hydrant valves.

2) New Installation, Renew and Rehabilitation of Sluice Valves

Sluice valves will be newly installed so that the service pipes can formulate network units, and some existing sluice valves are to be renewed in the Project for the construction works, especially renewal works for house connections, and for future maintenance works. The number of the new installations in each network unit is two, and that of renewal is three.

Existing sluice valves not to be renewed shall be removed and replaced with PVC pipes because the existing valves are of galvanized iron. This will remove current water leakage caused due to corroded valves, and it will also remove any future water leakage. Moreover, it will prevent contamination of the supplied water from oxidized iron.

In principle, these works are to be implemented throughout the entire Project Area. However, in sectors 361, 368B and 369B, only new installation shall be carried out in the Project, but replacement of the existing sluice valves with PVC will not be implemented because valves in these sectors are new.

As for Sector 370, which will be rehabilitated by other project, no sluice valve construction is carried out, because network units will be established in the scheduled rehabilitation project.

3) Installation of Pressure Reduction Valves

Pressure reduction valves are necessary based on the hydraulic calculation in the sub-sectors 349 A-3 and 349 B-3.

4) Renewal of other Accessories

Air valves, drain valves, and hydrant valves shall be renewed in all pipes that are upgraded or replaced. Although new installations are not planned in the Study, it is recommended that some accessories should be newly installed in the Project, if necessary (eg.. Hydrant valves in front of hospitals and social facilities or newly developed commercial areas).

Constructions above are carried out in all the sectors in the Project Area, except for Sectors 361, 368B, 369B and 370.

5) Protection of Concrete Structure

According to the result of the geotechnical survey, concrete structures for accessories shall be prepared with “Type V Cement,” which has an anti-chemical strength.

(8) Construction Items and Quantities

Construction items and quantities in the secondary network are listed in Table 3.4.6-7.

Table 3.4.6-7: Quantity of Construction Works in the Secondary Networks

Item	Unit	Quantity	Remarks
1. Rehabilitation and renewal of existing pipes			
1-1 Chloride of polyvinyl (AC replacement)	km	156.91	100 – 300mm
1-2 Chloride of polyvinyl (PVC replacement)	km	22.11	100 – 300mm
Partial		179.02	
2. Installation of new pipes			
2-1 Ductil Iron (DI)	km	13.25	250 – 400mm
2-2 Chloride of polyvinyl (PVC)	km	36.25	100 – 200mm
Patial	km	49.50	
TOTAL		228.52	
3. Valves and accesories (911valves)			
3-1 Pressure reducing valve, new and replacement	Unit	5	100-150mm
3-2 Air valve, new and rehabilitation	Unit	38	25mm
3-3 Drain valve, new and rehabilitation	Unit	12	100-300mm
3-4 Sluice valve, new and rehabilitation	Unit	580	
3-5 Hydrant valve, new and rehabilitation	Unit	276	150-200mm
TOTAL		911	Valves

Source: JICA Study Team

These works comprise rehabilitation of 156.91 Km of AC pipes with PVC pipes of same or higher diameter, from the considerations of lack of capacity, pipes installed under private properties and pipes older than 25 years old.

For PVC/iron/FoFo pipes, which do not fulfill the present technical regulations (SO 4422 on quality and pipes equal or bigger than DN 100 mm), are considered for replacement.

For the pipe materials, DI is considered for diameters higher than DN 250 mm; and PVC for the rest.

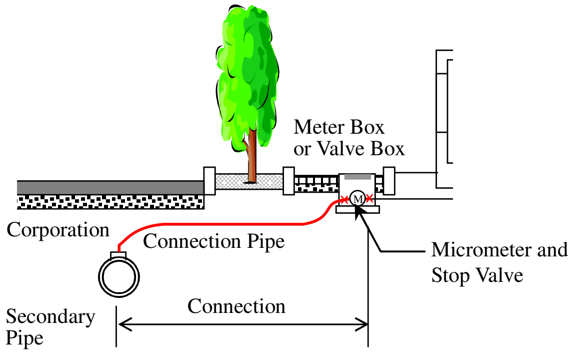
In relation to accessories, two new pressure reducing valves pit (sector 259 and 368A) will be installed; 3 pressure reducing valves pit (one in sector 349A and two in 351) will be rehabilitated. Besides, 15% of sluice valves (580), 22% of drain valves and 38 air valves will be installed.

For the installation of check-points, the numbers and their distribution depends on type of material; the separation should be 200 m for AC networks, 300 m for PVC and 500 m for DI pipes. Calculation of the required quantity has been carried out sector by sector, resulting installations of 951 pre-locators in AC, 1,684 in PVC and 26 in DI.

3.4.7 House Connection Improvement and Micrometer Installations

(1) Introduction

A house connection consists of a corporation, connection pipe and micrometer box (in case of a connection without micrometer, it is called “valve box”.). Its purpose is to divert water from secondary distribution pipes and to supply water to each household or establishment, as shown below:



Water inlet for polyetylen pipes

PVC clamp

Source: JICA Study Team

Figure 3.4.7-1: Typical Connection Layout

(2) Renewal of House Connections

1) Target of Renewal

As shown in Table 2.5.8-3, about 90% of the incidents in the Study Area are reported at the house connections. Moreover, from SEDAPAL's experience on secondary pipe maintenance works, it is commonly known that there is high water loss at the diversion device, due to the device's structural problems and poor construction. It is, therefore, important to replace connection pipes together with the diversion device, in order to reduce water loss.

In the Study, it is proposed that connection pipes and "corporation" joints are renewed in the Project Area, except for sectors 361, 368B, 369B, and 370, where networks are new or are to be rehabilitated by another project. Renewal of all house connections contributes not only to reducing technical loss, but also to reducing commercial loss by detecting illegal connections.

However, it is believed that some house connections are in good conditions, and some house connections will be renewed before commencement of the Project. It is recommended that conditions of house connections are studied in the detailed design stage, in order to justify the number of renewed house connections. At the moment, it is proposed to keep the budget for replacement of all house connections.

Table 3.4.7-1 shows the number of the connections to be renewed in the Project by sector.

Table 3.4.7-1: Number of House Connections to be Renewed in the Project

Sector	Number of Connections
83 A	4,096
83 B	5,341
84 A	7,586
84 B	5,690
85 A	2,184
85 B	2,099
85 C	1,657
212 A	5,428
212 B	2,970
213	3,201
259	2,282
345	415
346	2,605
347	3,845
348 A	841
348 B	2,212
349 A	2,983
349 B	2,295
350	7,287
351	1,035
368 A	2,058
369 A	2,179
Total	**70,289**

Source: JICA Study Team

2) Material for Renewed House Connections

In recent SEDAPAL projects, two types of house connections--PVC and PE--have been used for new installations and rehabilitations, as indicated below:

Table 3.4.7-2: Selection of House Connection Types

Item	PVC	PE
Pipe material	PVC pipe	PE pipe
Type of clamp	PVC-U telescopic thermoplastic clamp	2-parts C-PRR thermoplastic clamp
Installation work	Existing core on the pipes can be utilized for the renewed connection.	A perforation jointed to current clamp makes necessary a preparation of new core or perforation.
Watertightness	Both “corporation” joint and PVC pipe have sufficient watertightness.	The “corporation” joint has sufficient watertightness. Moreover, PE pipe has higher watertightness because it has no joints.
Cost	480S/nos (15mm)	510S/nos (15mm)
Evaluation	Although it has sufficient quality and is less costly, it is somehow inferior to PE in watertightness. In case of the rehabilitation, however, new core is not necessary.	It is more costly but is superior to PVC in watertightness. In case of replacement, existing core needs to be closed, which increases water loss risk.
Conclusion	Applied in **house connection renewals from the existing secondary pipes.**	Applied in **house connection renewals from the newly installed or renewed secondary pipes.**

Source: JICA Study Team

(3) Installation of Micrometers

A micrometer is a very important device which allows a water supply utility to charge proper tariffs to users and to accurately grasp actual conditions of water distribution. It contributes to water supply sustainability. Micrometers should be installed to all connections. At present, however, ratio of metered connections was about 70% in December 2009, according to the SEDAPAL cadastre.

As explained in section 2.5.8, a SEDAPAL project called “Sistema Integral de Gestión Comercial” (Comprehensive Commercial Management System”) is being executed; it will rehabilitate the existing micrometers and install new micrometers to the non-metered connections that are currently offering a 24-hour continuous water supply.

The study proposes micrometers to be installed to all connections in the area even without 24-hour continuous water supply. This will supplement the “Sistema Integral de Gestión Comercial,” and will achieve 100% micrometer installation in the Project Area.

Table 3.4.7-3 shows the number of the connections to be equipped with micrometers in the Project by sector. These zones have service continuity problem andhigh water loss level; and are not included into the implementation area of above mentioned project.

Table 3.4.7-3: Number of Micrometers to be Installed by Sector

Sector	Number of Micrometer to be Installed	Selection Criteria		
		Service Continuity	Loss Rate	SIAC Intervention
259	752	**12**	**58**	**NO**
345	78	**24**	**49**	**NO**
348A	827	**5-7**	**45**	**NO**
348B	2,055	**5-7**	**45**	**NO**
349A	2,793	**3**	**45**	**NO**
349 B	1,893	**3**	**45**	**NO**
350	2,089	**24**	**45**	**NO**
351	50	**24**	**48**	**NO**
Total	**10,537**			

Source: JICA Study Team

(3) Construction Items and Quantities for Connections and Micrometers

Table 3.4.7-4 presents construction items and quantities for house connections and micrometers.

Table 3.4.7-4: Quantity of Construction Works in the House Connections and Micrometers

Item	Unit	Quantity	Remarks
House Connection Renewals (PVC, 15-25mm)	Nos	54,031	Average pipe length per connection is 6m.
House Connection Renewals (PE, 15-25mm)	Nos	16,258	Average pipe length per connection is 6m.
Total	Nos	70,289	-
Micrometer Installations (Type B: Multiple Flow Type)	Nos	10,537	-

Source: JICA Study Team

3.4.8 Improvement of Wells

(1) Introduction

Many of the existing wells in the distribution area of La Atarjea WTP have not been used for more than five years. In the Study, it is proposed that all 23 wells selected in the *Perfil*, based on water quality, are to be used as a stand-by water source for emergencies. From these 23 wells, only one well (N° 259) is currently operating. Pipeline from the wells will be connected to the reservoirs so that the groundwater would improve of shortage of water from La Atarjea WTP. Table 3.4.8-1 lists the wells to be used and the reservoirs to accept groundwater.

Table 3.4.8-1: Wells in the Project

No.	Code	Status*	Reservoir	
			Name	Sub-sector
1	423	A	Villa Sol R-1	83A-1
2	474	A	Villa Sol R-1	83A-1
3	498	A	Villa Sol R-1	83A-1
4	720	A	Olivos de Pro R-1	84A-1
5	691	B	Programa Confraternidad 2	84A-2
6	692	C	Programa Confraternidad 2	84A-2
7	693	A	Programa Confraternidad 2	84A-2
8	695	A	Programa Confraternidad 1	84B-1
9	694	C	Programa Confraternidad 1	84B-1
10	618	A	Comité Aposte	84B-2
11	716	A	Comité Aposte	84B-2
12	696	C	Comité Aposte	84B-2
13	351	A	Puerta de Pro R-1	85A
14	717	C	Puerta de Pro R-1	85A
15	704	A	Rio Santa R-1	85B-1
16	280	C	Rio Santa R-1	85B-1
17	687	A	Virgen de Las Nievas R-4	212A-1
18	727	B	Virgen del Rosario R-1	212A-2
19	728	B	Virgen del Rosario R-1	212A-2
20	729	B	Virgen del Rosario R-1	212A-2
21	689	C	Rosario del Norte R-3	212B-1
22	688	B	Jazmines de Naranjal R-2	212B-2
23	569	D	Cerro Oquendo RP-2	-

* A: With Complete Pumping Equipment, B: With Partial Equipment, C: Without Pumping Equipment,
D: Operating

Source: JICA Study Team

(2) Design of Wells

1) Typical Design of Wells

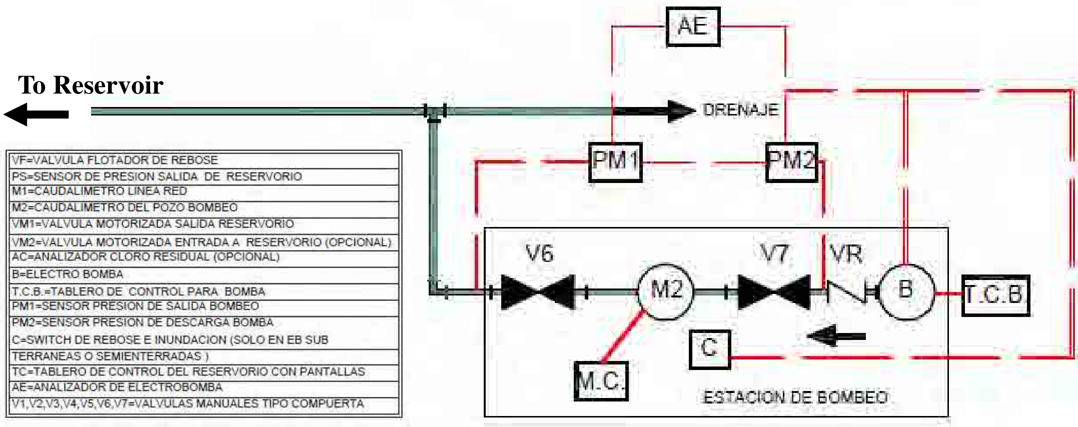
Twenty (20) of all 23 wells have not been operating for several years. The site inspection of civil works and electromechanical equipment found that all 23 wells need some civil and electromechanical equipment rehabilitation, such as installations of power panel, solid state starters, chlorine analyzers, injectors, and control panels, even though 3 wells are operating and 11 wells have complete equipment to operate the pumps.

However, none of the wells has complete equipment to assure the required water quality or a convenient environment for maintenance work; so equipment upgrading is required from this aspect.

Therefore, in addition to repairing the pumping houses of the wells, electromechanical equipment shall be rehabilitated and upgraded. The wells should comply with the system shown in Figure 3.4.8-1 and should include the following characteristics or capabilities:

- Pump outflow meter, which is to be installed so that it could measure the flow when the water is drained
- Pressure monitoring of the inlet and outlet pipe
- Monitoring of water level
- Booster chlorination system

- Residual chlorine analyzer
- Pump inlet and outlet valve automation
- Instrument panel board
- Auxiliary power source for the panels
- Security system for entrance of pumping house



Source: JICA Study Team

Figure 3.4.8-1: Well System Scheme

2) Renewal of Pump Equipment

The wells will not be operated on continuous basis, but the pump equipment capacities are extremely important. In cases of serious draught, the wells become the valuable water resource, and the pumping equipment must have enough capacity to utilize the groundwater, as much as possible, to preserve peoples' lives and activities.

The diagnosis shown in Section 2.5.8 found that the groundwater level has recovered in the last few years, and the capacities of wells have also increased in comparison to the period when the wells were constructed.

Therefore, the Study proposes to complete pumping tests for all 23 wells, and the pump facilities and their accessories are to be re-designed and renewed, in order to meet the current capacities of the wells.

(3) Construction Items and Quantities of Wells

Table 3.4.8-2 presents construction items and their quantities for wells. Figure 3.4.8-2 illustrates locations of the wells to be improved by the Project and the reservoirs to be connected to the wells.

Table 3.4.8-2: Quantity of Construction Works in the Wells

Item	Unit	Qty	Remarks
Electromechanical equipment renewal	Nos	3	Operating wells
Electromechanical equipment renewal, pumping house rehabilitation	Nos	20	Non-operating well

Source: JICA Study Team

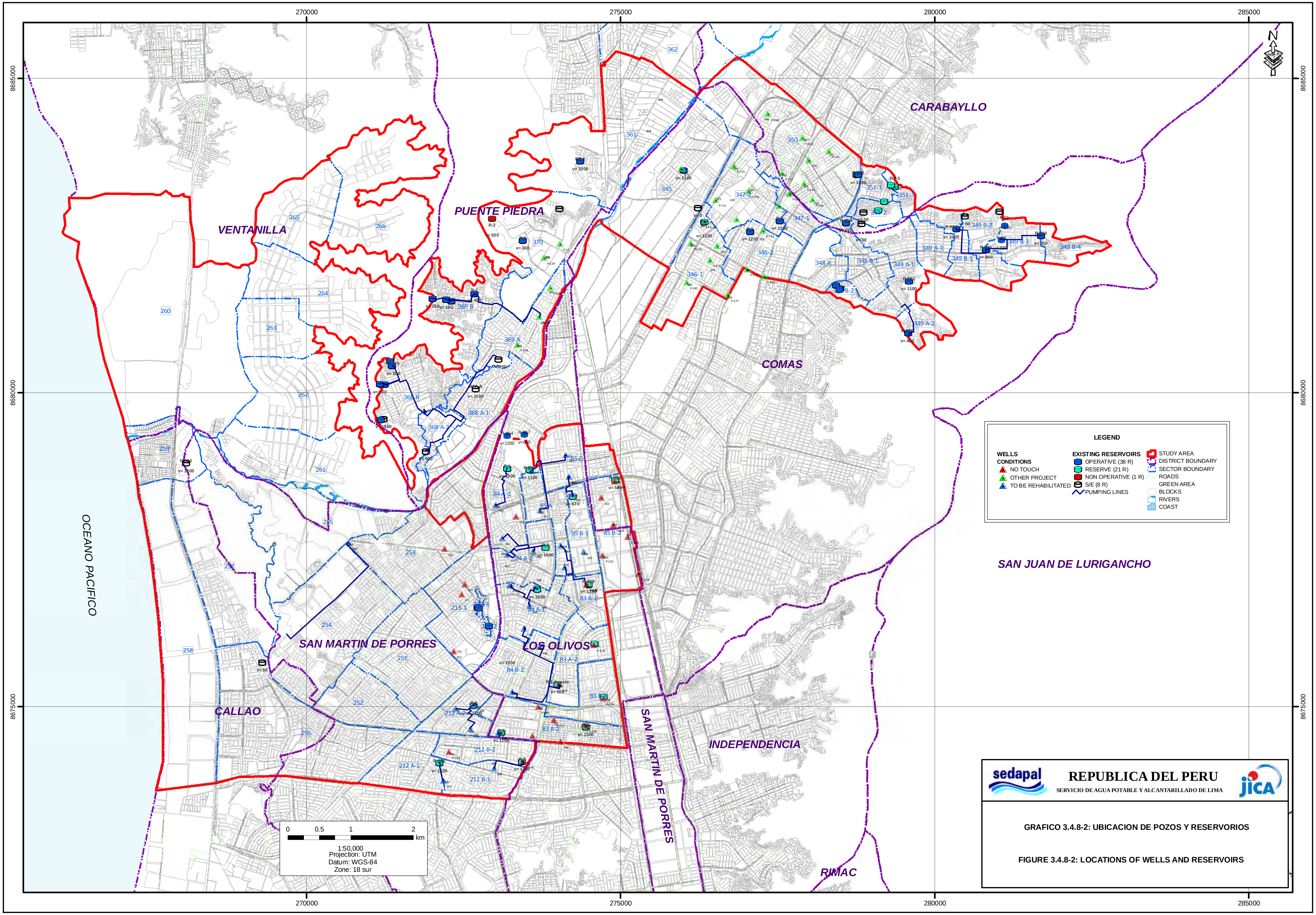


GRAFICO 3.4.8-2: UBICACION DE POZOS Y RESERVORIOS

FIGURE 3.4.8-2: LOCATIONS OF WELLS AND RESERVOIRS

3.4.9 Installation of SCADA System

(1) Introduction

The SCADA (Supervision and Data Acquisition) system is a system that monitors water distribution, operates automatically, and remotely controls and enhances the water system's functions, and makes the operation efficient.

The water distribution network management is proposed to be optimized in the Project through the sectorization and control scheme, in order to make the current water distribution and control conditions easier, both under normal conditions and emergency situations. This will transform a branched distribution system into an array of independently controlled sectors that can also work as an integrated system.

With the proposed SCADA system, coupled with an automated data collection, it is possible to monitor and analyze all data and to operate the required equipment either locally or from a remote control station. This will help sorting out operational problems and applying corrective measures. In an emergency situation, any sector can be easily separated from the other sectors, and a problem can be confined to a local area.

In the Study, the type of SCADA system to be applied in the Project is studied and selected. In addition, the system's basic plan is also prepared.

(2) Target Facilities and Items of Works under the SCADA

All reservoirs, pumping stations, wells, and pressure reducing valve pits in the Project Area shall be monitored and operated under the proposed SCADA system.

To get the maximum benefit from the SCADA system, it is important to install automated devices to measure hydraulic variables, such as inlet and outlet pressures, inflows, electrical variables, water quality parameters, water levels, etc. It is also important to install control switches for inlet and outlet valve regulation, booster chlorination, motor or pump on/off, etc.

All reservoirs, pumping stations and wells that are to be rehabilitated in the Project shall be equipped with new SCADA-friendly equipment in the Project. From all valve pits - 5 of which are newly constructed and 9 are to be rehabilitated, as shown in Table 3.4.4-2, - 5 new valve pits and 6 rehabilitated valves shall be equipped with SCADA-friendly equipment in the Project. In addition, SCADA-friendly equipment shall be newly installed to one (Collique 8) of the reservoirs that has been rehabilitated by other projects because the rehabilitation project did not install it.

(3) Types of SCADA Systems

The SCADA system will transfer the collected data to the Comas Service Center (CS) and to SEDAPAL´s Main Control Center. It is proposed that the new system complies with SEDAPAL's current SCADA protocol that uses Profibus communications. A non-licensed radiofrequency network will be set up; and if it is not available, WIMAX systems will be set up, with the Comas (CS) as a base station.

Under SEDAPAL's current SCADA operation, all of its gravity-based facilities are operated by the INFOPLUS application, whereas all pump-based (or pressurized) systems are operated by the SURVALENT application.

(4) System Specifications

The suggested control and automation system is as follows:

- PLC remote programming through the Ethernet Network with MODBUS, TCP, ETHERNET IP or DNP 3 protocol, by using the SCADA software communications controllers and the OPC data server; this allows for operation of more than one protocol at the same time, if required by SEDAPAL.
- In the case of Profibus DP instrumentation, adjustment to the PLC and remote field sensor can be configured from the control center.
- Remote diagnosis to the remote stations, PLC and sensors.
- Main Communications System (SCP) that supports data transfer between the CC and the remote stations (ER), by using Ethernet radio frequency Band 1.3 to 1.7 GHz or 3.65 GHz to 3.7 GHz, whatever the Ministry of Transportation and Communication approves. System will communicate via Modbus TCP; and will have open Industry protocol for Ethernet Files Management. Also the system will have redundant 1+1 at Master Hydraulic installation, repeaters and head of the system.

Required equipment at remote stations should include:

- One modular and industrial Programmable Logic Controller (PLC) with Profibus DP and Ethernet IP communications capacity.
- Pressure sensors, flow meters, and level sensors with Profibus DP communication.
- Valves with an actuator or with direct electric control, or electrovalves with network communication and Profibus DP.
- SCADA compatible reservoir inlet and outlet valves, pressure reducing chambers, or valve pits.
- Network analyzers, electronic speed variators, etc., all equipped with Profibus DP protocol, Ethernet IP, or ETHERNET TCP/IP for multiple variable transmission in an industrial and standardized open field bus.
- Multiparty control cables, vulcanized and screened wherever applicable.
- AC and DC power supply.
- All accessories required for installation of the above.
- DC and AC thermomagnetic switches.
- Logic programming software and PLC high level programs.
- Asset management software (PAM).
- Configuration software with native diagnosis.
- Flood detection instruments (only for underground or semi-buried ERs).

Detailed quantities of various equipment required for the SCADA implementation within the scope of the Project can be found in Appendix B3.

(5) Construction Items and Quantities of SCADA System

It is proposed to rehabilitate unsuitable 27 reservoirs in the Study Area. It tended to install SCADA for 27 reservoirs which include Cerro Oquendo and Patria Nueva. However as SCADA for Cerro Oquendo will be installed by other project; and Patria Nueva is a small reservoir used to maintain the water pressure for a small community, installation of SCADA in these reservoirs is not required. Moreover, Collique R-8 is not within 27 reservoirs because it doesn’t required rehabilitation, but it has no SCADA, therefore it is proposed for SCADA installation in the Project. Accordingly, 26 reservoirs are proposed for SCADA installation in the Project.

Table 3.4.9-1 presents facilities to which the SCADA system will be newly installed and that are to be integrated to the system. Among the facilities shown in the table, reservoirs that have been or will be equipped in other projects and 3 pressure reducing valve pits with working equipment do not need equipment for SCADA installation in the Project.

Table 3.4.9-1: Quantity of Target Facilities for SCADA System

Item	Unit	Quantity	Remarks
(1) Reservoirs			
-Installation of equipment	Nos	26	All reservoirs except for Cerro Oquendo and Patria Nueva to be rehabilitated in the Project, and Collique-8
-Integration to the system*1	Nos	65	All reservoirs related to the Project Area
(2) Pumping Stations			
-Installation of equipment and integration to the system	Nos	4	CR-76, Collique R-4, CR-96 (Collique R-5), Collique R-6
(3) Wells			
-Installation of equipment and integration to the system	Nos	23	Including 1 renewal (569)
(4) Pressure Reducing Valves			
-Installation of equipment	Nos	11	5 new valve pits and 6 existing valve pits without equipment
-Integration to the system*1	Nos	14	Including 3 existing valve pits to be rehabilitated (84A, 212A&B, and 213)

*1: Facilities integrated to the SCADA system to start operation under the system

Source: JICA Study Team

3.4.10 Improvement of Sewerage Networks

In Section 3.2.2, the zones for pipe replacement were defined according to lack of hydraulic capacity of pipes and deterioration of the pipes by corrosion. Moreover, in that Section, it is identified that 36.45% of the pipes, or 237.49 km, are already deteriorated.

For the replacement of these pipes, two construction methodologies have been considered in project execution:

- Cracking method, or "without trench" method.
- Traditional method, or "with trench" method.

(1) "Cracking Method," or "Without Trench" Method

The replacement of networks by fragmentation or "cracking" is a method called "without trench" in which deteriorated pipes are replaced with new High Density Polyethylene (HDPE) Pipes, without the need to excavate trenches. The system fractures the existing deteriorated pipe, and at the same time it introduces the new HDPE pipe in the same direction and slope. It is applicable for rehabilitation of sewerage networks with a diameter of up to 14 inches.

1) When to employ the "Cracking" Method

It is preferable to use the cracking method in the following situations:

- In consolidated urban localities and/or localities with historic heritage.
- When attempting to minimize the disturbances for users of the service, businesses, tourism, and pedestrian and vehicular traffic.
- Where there is evidence of the existing deep lines and/or narrow streets.
- Pipes with high level of deterioration.
- Presence of phreatic water table.
- Unstable ground.
- When improving the hydraulic capacity by increasing the diameter of the existing line.
- A combination of above characteristics.

2) Advantages of the "cracking" system

The most important advantages of this system in comparison with the traditional open trench method are:

- Technical
- Environmental
- Safety
- Institutional Image

(a) Technical Advantages

- The HDPE piping is of better quality than PVC, which is reflected in its parameters of resistance and durability.

- It makes improvements in hydraulic capacity possible in the existing line by incrementing the diameter.
- The construction schedule could be affected by traffic condition, which is not like “with trench method”.

(b) Environmental

- Disturbances are minimal for the users of the service, businesses, and tourism, as there is a dramatic reduction in environmental pollution from noise and dust, and especially from large amounts of piled excavation material, which is often contaminated.
- Effects on pedestrian and vehicular traffic are reduced because the period of road interference is reduced.

(c) Safety

- The number of accidents is reduced for workers, vehicles, and passers-by.

(d) Institutional Image

- The service-rendering company is able to strengthen their image as efficient, modern, and respectful to the user and of the environment, which translates into fewer complaints.

The “cracking” technology, in addition to reducing environmental impacts, is the logical and economical solution for the rehabilitation of underground networks, as the existing pipes are replaced with pipes of greater resistance and durability. Further, trenches in public roads are avoided and the execution periods are shortened.

(2) Traditional or “With Trench” Method

The main activities to be carried out in this method are: cutting and breaking the pavement, excavation of a trench, making the pipes exposed, then proceeding to the substitution of pipes, back filling, compacting of the trench, reconstruction of pavement, and the elimination of discarded soil.

One advantage of this method compared to the “without trench” method is that this method is less costly to employ. Table 3.4.10-1 shows the comparative costs for both methods.

Table 3.4.10-1: Comparative Costs for Pipe Installation Methods

Method	Cost (Soles) per one meter installation						
	Re-position of Pavement	Pipes and Accessories Ø 200 mm	Installation of Pipes and Accessories Ø 200 mm	Provisional Works	New Manholes	Rehabilitated Manholes	Total
Trench-less			256.61	16.7		16.7	290.01
Trench	54.89	29.00	50.17	16.70	52.8		203.56

Source: JICA Study Team

(3) Criteria for Using "With Trench" Method or "Without Trench" Method

In view point of cost-efficiency, the traditional "with trench" method shall be applied in the Project. However, the "without trench" method is used in the sections or areas under the following conditions:

- High Traffic Areas

  In these areas, it is desirable to reduce the time to execute works in order to avoid social disturbance.

- Areas with Social and Environmental issues

One important point to emphasize is avoiding odors and other environmental disturbances for the population when this method is chosen in highly populated zones, hospitals and educational institutions (schools, universities, institutions for higher education, etc.)

(4) Estimate of Pipes, Manholes, and House Connections to be Replaced

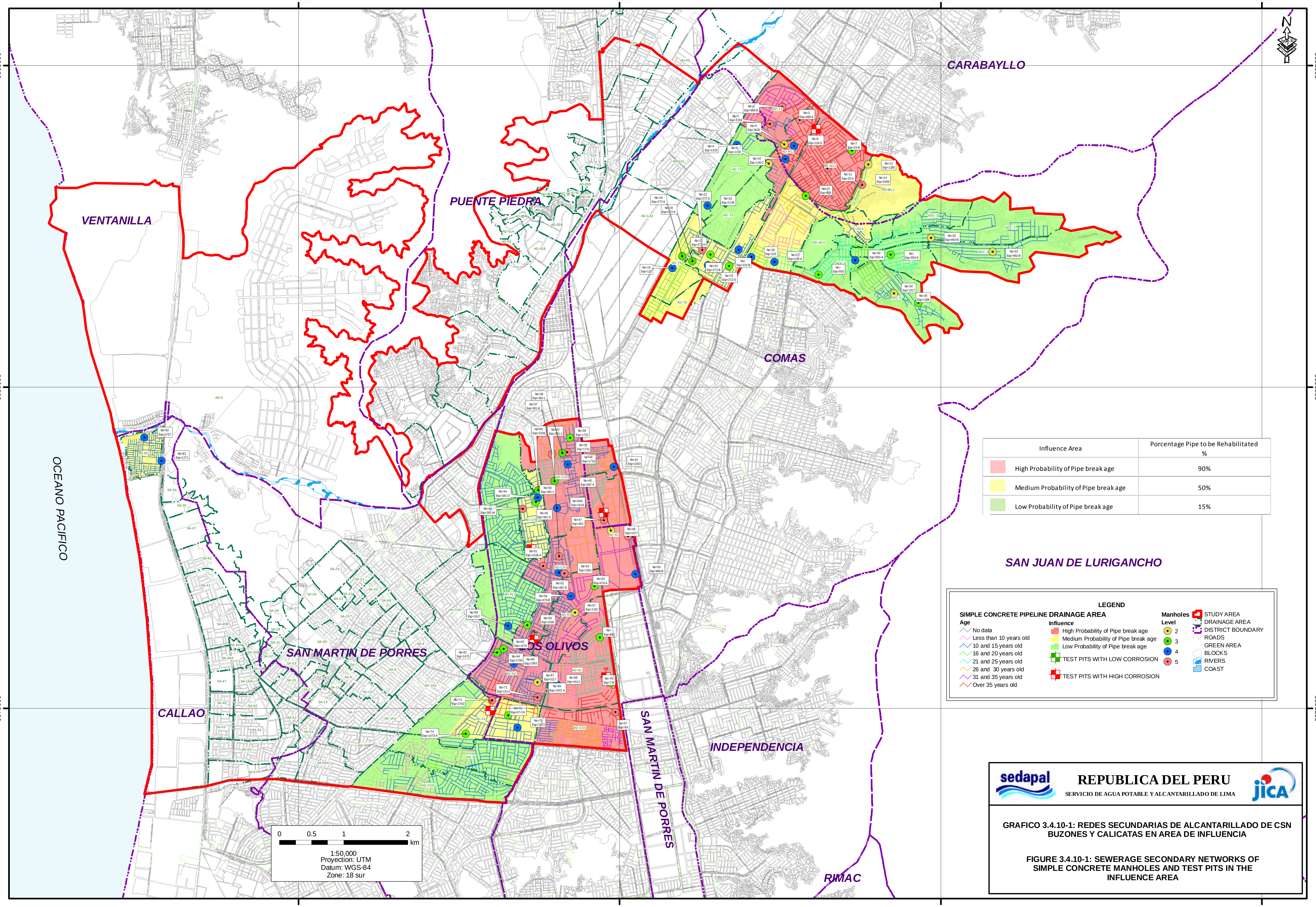
According to the criteria established in point 3.4.10.3, Table 3.4.10-2 shows the total of pipes, manholes and house connections that will be rehabilitated by drainage areas.

Figure 3.4.10-1 shows the areas where rehabilitation will be carried out. Exact pipe lengths will be confirmed at Detail Design Stage.

Table 3.4.10-2 Pipes, Manholes and House Connections that will be rehabilitated By Drainage Areas

Drainage Area	Pipes to be rehabilitated Km	Total of manholes GIS Unit	Total of house connection GIS Unit	Construction method		Manholes to be changed	
				Trench Method Km	Trench less Method Km	New Unit	Rehabilitation Unit
AD-A1	9.47	234	1,709	6.63	2.84	164	70
AD-A2	2.94	59	456	2.06	0.88	41	18
AD-AG1	0.96	74	551	0.67	0.29	52	22
AD-AG2	23.87	464	2,957	16.71	7.16	325	139
AD-AG3	10.80	217	1,124	7.56	3.24	152	65
AD-AG4	12.05	349	1,454	8.44	3.61	244	105
ADC-1	1.51	29	187	1.06	0.45	20	9
ADC-2	2.02	36	296	1.41	0.61	25	11
ADC-3	0.75	16	103	0.53	0.22	11	5
ADC-4	1.04	18	120	0.73	0.31	13	5
ADC-5	2.05	38	263	1.44	0.61	27	11
ADC-6	1.71	30	218	1.20	0.51	21	9
AD-CH1	21.75	482	3,605	15.23	6.52	337	145
AD-CH2	6.01	104	824	4.21	1.80	73	31
AD-CH3	19.58	309	2,391	13.71	5.87	216	93
AD-CO1	17.99	200	1,504	12.59	5.40	140	60
AD-CO2	3.25	68	454	2.28	0.97	48	20
AD-M1	5.87	136	1,076	4.11	1.76	95	41
AD-N1	17.14	372	2,777	12.00	5.14	260	112
AD-N2	20.25	328	2,718	14.18	6.07	230	98
AD-PL1	3.33	178	1,725	2.33	1.00	125	53
AD-PL2	3.02	57	479	2.11	0.91	40	17
AD-R1	12.49	206	1,002	8.74	3.75	144	62
AD-R2	14.79	284	2,315	10.35	4.44	199	85
AD-T1	9.97	209	1,598	6.98	2.99	146	63
AD-T2	0.35	17	101	0.25	0.10	12	5
AD-T3	0.01			0.01	0.00		
AD-T4	6.19	102	1,010	4.33	1.86	71	31
AD-T5	5.03	81	623	3.52	1.51	57	24
AD-T6	1.30	20	96	0.91	0.39	14	6
Total	**237.49**	**4,717**	**33,736**	**166.28**	**71.21**	**3,302**	**1,415**

Source: JICA Study Team



Influence Area	Porcentage Pipe to be Rehabilitated %
High Probability of Pipe break age	90%
Medium Probability of Pipe break age	50%
Low Probability of Pipe break age	15%

GRAFICO 3.4.10-1: REDES SECUNDARIAS DE ALCANTARILLADO DE CSN BUZONES Y CALICATAS EN AREA DE INFLUENCIA

FIGURE 3.4.10-1: SEWERAGE SECONDARY NETWORKS OF SIMPLE CONCRETE MANHOLES AND TEST PITS IN THE INFLUENCE AREA

3.4.11 Improvement of SEDAPAL's Business Management Capacity

(1) Introduction

As identified in Section 2.5.14, SEDAPAL is facing several problems with operation and maintenance aspects. Section 2.6 proposed the actions to be implemented in the Project against the problems, which are:

- To provide necessary equipment for operation and maintenance of water supply and sewerage to improve maintenance in SEDAPAL facilities;
- To improve cadastre system of SEDAPAL for more efficient and preventive maintenance work; and
- To establish a new team for planning of preventive maintenance, which will establishe a long-term vision and policy for SEDAPAL's facility maintenance utilizing the improved cadastre system. This can be a kind of asset management, and should have the power to request sufficient budget for the implementation of maintenance works, in order to maintain the proper function of the existing facilities.

At present, a large portion of SEDAPAL's staff for maintenance work is devoted to the corrective works against the incidents which have been reported to the "Client Service Team." However, it has been generally proven that such a maintenance style cannot improve the service level, and it costs more compared to the maintenance works under a well-developed maintenance program with the proper combination of preventive measures and corrective measures. In addition, this situation is preventing SEDAPAL from utilizing their financial and human resources for planning and implementing the long-term maintenance program, which creates a negative cycle in the water supply and sewerage system.

In order to introduce and implement the proper maintenance program, it is necessary for SEDAPAL to have enough capacity to carry out the fundamental daily maintenance works and respond to all incidents promptly. Then, SEDAPAL will be able to allocate the resources needed to develop and execute a well-developed maintenance program.

(2) Procurement of Equipment for Maintenance Work

The most fundamental daily activities in the maintenance works of water supply networks and sewers are i) water leakage detection on water supply networks and repair works when necessary, ii) periodical cleaning of manholes and sewers, and iii) inspection of sewer conditions.

As presented in Section 2.5.12, SEDAPAL has some equipment for leakage detection and sewer cleaning. However, as explained in Section 2.5.13, leakage detection and sewer cleaning works have not been implemented often enough to maintain facility function because of the lack of equipment and workers.

Moreover, SEDAPAL lacks equipment for pipe inspection, which is usually a TV camera unit, and this prevents SEDAPAL from knowing the exact conditions of the sewers.

It was discovered through interview surveys with SEDAPAL's local offices that there was an intention to employ the workers needed to increase the utility's capacity. Therefore, it is proposed to include the procurement of the equipment in the Project as presented in Table 3.4.11-1.

Table 3.4.11-1: Equipment for Maintenance Works to be Purchased in the Project

No.	Items	Quantity
1	**Equipment for Water Leakage Detection**	
1)	Vehicle	2
2)	Correlator with accessories (red and blue radio)	2
3)	Wheel meter	2
4)	Acoustic Water Leak Detector	2
5)	Metal Detector	2
6)	Geophones	4
7)	Generator	2
8)	Drill	2
9)	Miscellaneous Tools	2
10)	Pre locators (Mobile)	200
11)	Data capture	2
12)	Workstation platform including CAD/GIS	2
2	**Equipment for Sewerage Cleaning**	
1)	Mini hydro jet with vehicle	2
2)	8.50 m3 Hydro Jet equipment	3
3)	6 m3 Hydro Jet equipment	3
4)	16 m3 capacity tank truck	3
5)	8 to 10 m3 capacity tank truck	3
6)	Nozzles 15 ° for Hydro jet	6
7)	Nozzles 35 ° for Hydro jet	6
3	**Equipment for Sewer Inspection**	
1)	Computer and Software	1
2)	TV inspection unit for potable water (equipment + mobile unit)	3
3)	TV inspection unit for sewerage (equipment + mobile unit)	3

Source: JICA Study Team

(3) Improvement of Information Management System

At present, the GIS data and inventory data are managed at the local offices. However, the data is not properly stored in a systematic way so that necessary information can be found easily when it is necessary. In addition, the data includes a considerable amount of incorrect information, mainly that of facilities which were constructed and transferred from the municipalities. Also, the information is not shared completely with the headquarters; this can cause the responsible staff or department to make inappropriate decisions regarding the business plan.

In order to create and carry out a proper maintenance plan, it is indispensable to have information that is accurate and readily available. Therefore, a complete inventory survey is proposed for the Project, as well as a complete information update. Moreover, all updated data shall be stored as electronic data and registered in an information management system linked with GIS, which shall be shared with the headquarters.

(4) Establishment of New Team for Preventive Maintenance

1) Purpose and Disposition

In order to develop the long-term maintenance program and secure enough financial and human resources, the establishment of a new preventive maintenance team is proposed. It can be located at the headquarters office or at the local offices (Comas and Callao). However, considering that the plan shall not only focus on a local area, but will also cover the entire area of SEDAPAL´s administration, it is recommended that the team belongs to the Development and Investment Department, sharing the cadastre information with the local office through the information management system.

2) Function of the Team

The new team shall have the following functions:

- To design and establish an information management system to be applied to the entire SEDAPAL administration area, for which all inventory data shall be registered and shared between the local offices and headquarters.
- To develop or introduce a model to simulate and find an efficient maintenance plan, a process which would determine the proper content, locations and frequency of maintenance works in view of asset management.
- To coordinate with the General Department in order to secure sufficient budget allocation for maintenance works.

3) Activities to be taken on in the Project for the Establishment of the New Team

In order to establish the new team and develop it so that it can perform as expected, the following actions are proposed in the Project:

- Inventory survey to update the information on existing facilities
- Provision of computer and software for the new team
- Support for the new team in terms of introducing the new information management system and registering the updated inventory data
- Training of the new team´s staff to develop the capacity for the maintenance plan, focusing on enhancing knowledge of asset management and operation of the related software

4) Introduction of Asset Management System

As explained above, the new team for preventive maintenance shall carry out their tasks in view of asset management.

Infrastructure Asset Management is the discipline of managing infrastructure assets that underpin an economy, such as roads, water supply, wastewater, storm water, power supply, flood management, recreational and other assets. Investment in these assets is made with the intention that dividends will accrue through increased productivity, improved living conditions and greater prosperity.

A well-defined Standard of Service (SoS) is the foundation of Infrastructure Asset Management. The SoS states, in objective and measurable terms, how an asset will perform, including a suitable minimum condition grade in line with the impact of asset failure. There are two main objectives of Infrastructure Asset Management relating to standard of service:

(a) Sustain SoS (System Preservation):

Sustain SoS is to maintain or deliver an agreed standard of service in the most cost-effective way through the operation, maintenance, refurbishment, and replacement of assets. Management of this objective is the focus of Asset Management Plans.

This practice starts with a defined “standard of service”, for example, how success or failure will be measured, and how the customer understands what to expect in return for the expenditure on the asset system. The first part of “standard of service” is a measurable specification of how the asset should perform. This would normally include a specification of the attributes of the asset which are important to its function.

The next part of SoS is the establishment of minimum condition. This promotes informed decision making about when to maintain, repair, refurbish or replace an asset. With a performance-based asset management approach, decisions are flexible and depend predominantly on the current condition of the asset, the age of the asset, and its likely future deterioration profile. This differs from a planned maintenance approach (which does not take into account the current condition) by responding to the actual deterioration and performance of an asset. For example, a storm water debris screen is cleared after a rain event, when it is partially blocked, rather than, say, every two weeks.

Asset Management attempts to optimize the trade-off between maintenance and replacement. This can be explained by the “total life cycle cost approach.” This iteration is carried out by a well-developed mathematical model, which leads to an Asset Management Plan.

(b) Change SoS (Capacity Expansion)

Change SoS is to make strategic changes and improvements to the standard of service of the asset portfolio through the creation, acquisition, improvement and disposal of assets. Changes to the SoS are usually managed as a program based on strategic objectives regarding the asset portfolio.

The main component is the “Asset Portfolio Strategy”, which revolves around meeting customer needs in the most effective and efficient way. This can be a combination of creation or acquisition of new assets or the disposal or improvement of existing assets; depending on the drivers for change. Here again, this iteration is carried out by a well-developed mathematical model, which leads to an Improvement Management Plan.

The following are components of asset management that must be introduced:

- Grade assessment procedure
- Asset valuation techniques
- Asset creation and acquisition decision-making
- Asset disposal decision-making

- Whole-life cost management techniques
- Auditing the asset condition and expenditure
- Training

3.4.12 Formulation of the Project

Through the series of the studies and analyses which were shown from Section 3.4.1 to Section 3.4.10, project scope of the NORTH LIMA METROPOLITAN AREA WATER SUPPLY AND SEWERAGE OPTIMIZATION PROJECT (II) has been formulated as summarized below:

Table 3.4.12-1: Scope of the Project

No	Item and Specifications	Unit	Quantity
I.	**Optimization of Water Supply System**		
I-1	Development of primary network		
	- Primary pipes (Ductile Iron Pipe, 150-700mm)	km	40.55
	- Pressure reducing valve pit	Unit	14
I-2	Improvement of reservoirs and pumping stations		
	- Rehabilitation of reservoirs	Unit	27
	- Rehabilitation of pumping stations	Unit	4
I-3	Improvement of secondary networks		
	- Upgrading and renewal of existing pipes	km	179.02
	- Installation of new pipes	km	49.50
I-4	Rehabilitation of house connections and installation of micrometers		
	- Renewal of existing house connections (PVC, PE)	Unit	70,289
	- Installation of micrometers	Unit	10,537
I-5	Rehabilitation of wells	Unit	23
I-6	Introduction of SCADA		
	- Reservoirs	Unit	26
	- Pumping stations	Unit	4
	- Wells	Unit	23
	- Pressure reducing valve pit	Unit	11
II.	**Optimization of Sewerage System**		
	- Upgrading and renewal of existing simple concrete pipes (PVC, 100-350mm)	km	237.49
	- Rehabilitation of manholes	Unit	1,415
	- Construction of new manholes	Unit	3,302
	- Renewal of house connections (PVC)	Unit	33,736
III.	**Optimization of Business Management of SEDAPAL**		
III-1	Procurement of equipment for maintenance work		
	- Equipment for water leakage detection (Acoustic water leakage detector and leakage detection system)	Unit	2
	- Equipment for sewer cleaning (Hydro jet and Tank Truck)	Unit	8
	- Equipment for sewer inspection (TV inspection unit)	Unit	6
III-2	Improvement of information management system		
	- Inventory survey	Unit	1
	- Support on upgrading information management system	Unit	1
III-3	Establishment of new team for preventive maintenance	Unit	1

Source: JICA Study Team

Works to be executed for the water supply classified by sectors are shown below, reinforcement matrix and SCADA are also explained separately:

(1) REINFORCEMENT MATRIX

Reinforcement matrix to the Northern Branch will benefit the Los Olivos and San Martin de Porres districts, and contemplates the installation of 1,538.49 m pipeline (open cut method) material: DI Class K-9 and 700 mm diameter, to be installed along the central berm on Honduras, 25 de Enero, and Confraternidad Avenues, thus ensuring supply to sectors 83A, 83B ,84A ,84B, 85A, 85B, 85C, 212A, 212B, 213

Table 3.4.12-2: Supporting Main Pipe

Diameter (mm)	Length (m)	Material	Class	Method
700	1,538.49	DI	K-9	Trench

Source: JICA Study Team

(2) SCADA System

The SCADA System contemplates interconnection to 26 reservoirs, 4 pumping stations, 23 wells, and 11 pressure reducer chambers; thus, installation of the following devices is necessary:

1) SCADA devices in reservoirs

- 01 modular PLC with communications modules a Profibus DP, variables discretas, soporte Modbus TCP, Ethernet IP, Industrial Ethernet TCP/IP with its relevant ports
- 01 hydrostatic piezoresistive pressure sensor for reservoir level measurements with Profibus DP outlet.
- 01 upstream pressure sensor for each inflow checking valve with Profibus DP outlet
- 01 reservoir overflow detector
- 01 electromagnetic flow measurer with Profibus DP outlet
- Valve with electric actuator and da Profibus DP outlet
- 01 waste chlorine measurer with Profibus DP communicator
- 01 flooding detector

2) SCADA devices in re-pumping chambers

- 01 modular PLC according to characteristics
- 01 hydrostatic piezoresistive pressure sensor for dynamic level measurement and DP Profibus outlet
- 01 pressure sensor at the well outlet (Pressure P1). Profibus DP outlet
- 01 pressure sensor at the pumping line inlet (Pressure P2). Profibus DP outlet

- 01 pressure differential sensor between the chlorine pump pressure and the pressure at the pumping line (Pressure P3). Profibus DP outlet
- 01 electromagnetic flow measurer with Profibus DP outlet
- Electric actuator valve with Profibus DP outlet
- 01 multifunction general power network analyzer. Profibus DP outlet or Ethernet IP.
- 01 power network analyzer for the pumping equipment. Profibus DP outlet or Ethernet IP.
- 01 chlorine injection system with automatic balloon replacement
- With a P&D automatic control capacity with regard to waste chlorine, minimum flow; the use of artificial intelligence or neural networks will be allowed.
- 01 scaling system with 4 load cells and communications by network to the PLC
- 01 flooding detector.
- 01 water extraction system for sump flooding
- 01 switchboard door opening detector for each switchboard
- 01 audible siren for serious failures.
- 01 Ethernet video camera for video surveillance, SXGA at 8 FPS, night vision, will support IEE 802.3AF min, 1 Mega pixel or superior resolution, and IP66, remote programmable with TCP, IP, UDP, HTTP, etc. protocol. A microphone will be conditioned for communication with the Major Control Center, for maintenance operator's communication, and tele-command capacity.
- 01 analyzer for ammonium, nitrite, nitrates lines. With DP communication
- 01 pH analyzer. With DP communication

3) SCADA devices in wells

- 01 modular PLC with Profibus DP communications modules, discreet variables, Modbus TCP support, Ethernet IP, Industrial Ethernet TCP/IP with its relevant ports.
- 01 submergible hydrostatic piezoresistive pressure sensor for dynamic level measurement, with Profibus DP outlet
- 01 pumping line outlet pressure sensor, with Profibus DP outlet
- 01 electromagnetic flow measurer on the pumping line with Profibus DP outlet
- 01 electromagnetic flow measurer at the reservoir inlet with Profibus DP outlet
- 01 overflow detector and minimum level sensor integrated to the pump command circuit

- 01 checking valve with electric actuator and Profibus DP outlet
- 01 general power multifunction network analyzer with an option for electric parameter optical Reading and power quality (general measurement) with Profibus DP protocol.
- 01 power network analyzer related to each electric pump for electric parameter measurements and Profibus DP protocol, 01 AC/DC charger rectifier
- 01 flooding detector.
- 01 water extraction system for sump flooding
- 01 switchboard door opening detector for each switchboard
- 01 audible siren for serious failures.
- 01 Ethernet video camera for video surveillance, SXGA at 8 FPS, night vision, will support IEE 802.3AF min, 1 Mega pixel or superior resolution, and IP66, remote programmable with TCP, IP, UDP, HTTP, etc. protocol. A microphone will be conditioned for communication with the Major Control Center, for maintenance operator's communication, and tele-command capacity

(3) SECTOR 83 A

This sector has a surface area of 0.47 km2. It has 4,096 water supply connections and 2 elevated reservoirs.

Its boundaries are: to the North, the Central highway; to the South, the Los Alisos highway; to the East, the Northern Panamerican freeway; and to the West, the Universitaria highway and the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A total of 1,617.85 m long gravity pressure line will be installed (open cut method) to be installed along the Universitaria Ave. central berm, and along the Bustamante, Blondet, and Las Palmeras streets, thus ensuring supply from Villa Sol and Villa del Norte reservoirs.

Table 3.4.12-3: Transmisión Line - Sector 83A

Diameter (mm)	Length (m)	Material	Class	Method
250	169.88	DI	K-9	Trench
200	1,447.97	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 1,709.05 m long pumping line will be installed (open cut method), DI K-9 class and 200 mm and 250 mm diameters, to be installed along the Santa Elvira Ave. central berm, and the Dos, Egúzquiza, Manuel de Lara, Bustamante San Manuel, and San Ernesto streets, thus ensuring supply from Villa Sol and Villa del Norte reservoirs.

Table 3.4.12-4: Pumping Line - Sector 83A

Diameter (mm)	Length (m)	Material	Class	Method
250	435.97	DI	K-9	Trench
200	1,273.08	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories

Table 3.4.12-5: Reservoirs Rehabilitation - Sector 83A

Description	R Villa Sol		R Villa del Norte	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	200	1
Adjusting valve	200/150	2	250/200	2
Sluice valve	200/150	6	250/200	6
Bends	200	7	250	7
Tee	200	5	250	5
Dresser Joint	200	5	250	5
Nipple	200	9	250	9

Source: JICA Study Team

b) Civil works

Villa Sol Reservoir

Structure requires maintenance at the structure base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base and the lower part of the tank belt; and rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination. Eventually, some cracks that were left during the construction process will be patched, and the structure will be painted.

Villa del Norte Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; replacing the sluice valves, and rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the structure. A sidewalk around the shaft will be constructed to prevent erosion of the walls as it is in touch with the damp soil. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

17.10 Km of water networks will be rehabilitated, and 1.61 Km of new pipe will be installed as follows:

Table 3.4.12-6: Rehabilitation of secondary networks - Sector 83A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC	Installation of new pipes	
				PVC	DI
83A	100	8.59			
	150	3.3		1.61	
	200	2.15			
	250	2.87			
	300	0.19			
TOTAL		17.1		1.61	

Source: JICA Study Team

As a supplement to above, the following will be rehabilitated:

- 11 fire hydrants.
- 28 sluice valves, 2 air valves and 1 drain valves
- Installation of 132 pre-locators.

5) House connections

4,096 water connections will be installed: 1,609 connections in sub sector 83 A-1 and 2,487 connections in sub sector 83 A-2.

6) Wells

Wells No. 498,474 and 423 will be equipped in this sector.

Motor and pump, chlorination equipment and relief and sluice check valves will be optimized; power panel for pump control and new flow metes will be installed.

(4) SECTOR 83 B

This sector has a surface area of 1.69 Km2, it has 5,341 water supply connections and 2 elevated reservoirs.

Its boundaries are: to the North, the Central highway; to the South, the Los Alisos highway; to the East, the Northern Panamerican freeway; and to the West, the Universitaria highway and the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A total of 1,125.55 m long gravity pressure line will be installed (open cut method), DI, K-9 Class, and 250 mm and 250 mm diameter, to be installed along the Universitaria Ave. central berm, and along the Bustamante, Blondet, and Las Palmeras streets, thus ensuring supply from Parque Naranjal and Cueto Fernandini reservoirs.

Table 3.4.12-7: Transmission Line Installation - Sector 83B

Diameter (mm)	Length (m)	Material	Class	Method
250	106.67	DI	K-9	Trench
200	1,018.88	DI	K-9	Trench

Source: JICA Study Team

2) Checking and / or storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed that will include all checking and regulation accessories.

Table 3.4.12-8: Reservoirs Rehabilitation - Sector 83B

Description	R Parque Naranjal		R Cueto Fernandini	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	200	1
Adjusting valve	200/150	2	250/200	2
Sluice valve	200/150	6	250/200	6
Bends	200	7	250	7
Tee	200	5	250	5
Dresser joint	200	5	250	5
Nipple	200	9	250	9

Source: JICA Study Team

b) Civil works

Parque de Naranjal Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the structure. A sidewalk around the shaft will be constructed to prevent erosion of the walls since it is in touch with the damp soil. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

Cueto Fernandini Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the structure. A sidewalk around the shaft will be constructed to prevent erosion of the walls since it is in touch with the damp soil. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

3) Secondary networks

26.80 Km of water networks will be rehabilitated and 3.41 Km of new pipe will be installed, as follows.

Table 3.4.12-9: Secondary Networks Rehabilitation - Sector 83B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes	
				PVC (km)	DI (km)
83B	**100**	12.14	0.12		
	150	10.75	0.13	3.06	
	200	1.28	0.01	0.16	
	250	2.12			0.19
	300	0.21	0.04		
TOTAL		**26.50**	**0.30**	**3.41**	

Source: JICA Study Team

As a supplement to above, the following will be rehabilitated:

- 27 fire hydrants.
- 45 sluice valves, 2 air valves and 1 drain valve
- Installation of 186 pre-locators.

4) House connections

5,314 water connections will be installed: 1,273 connections in sub sector 83 B-1 and 4,068 connections in sub sector 83 B-2.

(5) SECTOR 84 A

This sector has a surface area of 2.31 Km2. It has 7,586 water supply connections, 01 elevated reservoir and 01 standing reservoir.

Its boundaries are: to the North, the “Cerro Pro” archaeological site; to the south, the Naranjal freeway and the Los Alisos highway; to the East, the Universitaria highway and the Huandoy highway; and to the West, the Canta – Callao freeeway.

Works to be executed are as follows:

1) Gravity pressure lines

A total of 4,526.64 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 4,00 mm, 350 mm and 250 mm diameters, to be installed along the Huandoy Ave. 2 de Octubre Ave., and Betancourt Ave. central berms, and along the Alfredo Mendoza and Turquezas streets, thus ensuring supply from Olivos de Pro and Confraternidad 2 reservoirs.

Table 3.4.12-10: Transmission Line Installation - Sector 84A

Diameter (mm)	Length (m)	Material	Class	Method
400	2,429.00	DI	K-9	Trench
350	1,595.11	DI	K-9	Trench
200	502.53	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

2 pumping lines will be installed.

A total of 1,272.05 m long pumping line will be installed (open cut method), DI, K-9 class and 250 mm diameter, to be installed along the Jazmines, Violetas, and Turquezas streets, thus ensuring supply from Olivos de Pro reservoir.

Another 1,104.73 m long pumping line will be installed (open cut method), DI, K-9 class, 200 mm and 250 mm diameters, to be installed along the San Martin Ave. central berm and the Guanábana and Atlante streets.

Table 3.4.12-11: Pumping Line Installation - Sector 84A

Diameter (mm)	Length (m)	Material	Class	Method
250	1,104.73	DI	K-9	Trench
200	1,272.05	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-12: Reservoirs Rehabilitation - Sector 84A

Description	R Olivos de Pro		R Confraternidad 2	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	200	1	150	1
Adjusting valve	250/200	2	200/150	2
Sluice valve	250/200	6	200/150	6
Bends	250	7	200	7
Tee	250	5	200	5
Dresser Joint	250	5	200	5
Nipple	250	9	200	9

Source: JICA Study Team

b) Civil works

Olivos de Pro Reservoir

Structure is currently out of service; it requires specific repair of damages on the external vault with concrete, and maintenance works to the inner tank walls with epoxy paint, in order to prevent any organic growth. Micro cracks will be patched and checked on the tank outer walls. In addition, all the iron pipe system, handrails, ladders, and anchors will be given surface anti-corrosion treatment. An electric wire will be installed on the perimeter fence to restrain access of non – authorized people to the facilities; masonry wall cracks will be patched, electric installations will be repaired at the valve house, and finally, the whole structure will be painted.

Confraternidad 2 Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations; replacing the sluice valves and iron accessories that have been out of service for a longtime, rehabilitating all the iron pipe system, handrails, ladders, and anchors with surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure. Electric installations will be replaced and conditioned, a sidewalk around the shaft will be constructed to prevent erosion of the walls in touch with the damp soil. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

9.29 Km of water networks will be rehabilitated and 0.71 Km of new pipe will be installed, as follows.

Table 3.4.12-13: Secondary Networks Rehabilitation - Sector 84A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
84A	**100**	3.68		0.55	
	150	1.67			
	200	3.09		0.16	
	250	0.49			
	300	0.36			
TOTAL		**9.29**		**0.71**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 15 fire hydrants.
- 45 sluice valves and 2 air valves
- Installation of 242 pre – locators.

5) House connections

7,586 water connections will be installed: 1,273 ,477 connections in sub sector 84 A-1 and 3,109 connections in sub sector 84 A-2.

6) Wells

Wells No. 720, 691, 692, and 693 will be equipped in this sector.

Motor and pump, chlorination equipment and relief and sluice check valves will be optimized; power panel for pump control and new flow metes will be installed.

(6) SECTOR 84 B

This sector has a surface area of 1.62 Km2. It has 5,690 water supply connections and 2 elevated reservoirs.

Its boundaries are: to the North, the Central highway; to the South, the los Alisos highway; to the East, the Panamericana Norte freeway; and to the West, the Universitaria highway and the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A 2,284.73 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 200 mm and 300 mm diameters, to be installed along the Universitaria Ave. Huandoy Ave., Los Olivos Ave., and Santa Rosa Ave. central berms, and along the Zeus, Ayax, Cuatro, and Dos streets, thus ensuring supply from Confraternidad 1 and Comité Aposte reservoirs.

Table 3.4.12-14: Transmission Line Installation - Sector 84B

Diameter (mm)	Length (m)	Material	Class	Method
300	18.11	DI	K-9	Trench
200	2,266.62	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

2 pumping lines will be installed.

A 918.69 m long pumping line will be installed (open cut method), DI, K-9 class and 200 mm and 250 mm diameters, to be installed along Pólux, Ícaro, Ayax, and Venus streets, thus ensuring supply from Confraternidad 1 reservoir.

Another 2,776.35 m long pumping line will be installed (open cut method), DI, K-9 class, 150 mm, 200 mm and 250 mm diameters, to be installed along the San Martin Ave. Central Norte Ave., and the Atlante and Medea streets, thus ensuring supply from Comité Aposte and Confraternidad 1 reservoirs.

Table 3.4.12-15: Pumping Line Installation - Sector 84B

Diameter (mm)	Length (m)	Material	Class	Method
250	594.94	DI	K-9	Trench
200	1,213.49	DI	K-9	Trench
150	1,886.61	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-16: Reservoirs Rehabilitation - Sector 84B

Description	R Aposte		R Confraternidad 1	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	200	1
Adjusting valve	200/150	2	250/200	2
Sluice valve	200/150	6	250/200	6
Bends	200	7	250	7
Tee	200	5	250	5
Dresser Joint	200	5	250	5
Nipple	200	9	250	9

Source: JICA Study Team

b) Civil works

Confraternidad 1 Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; installing a new slab (floor), after demolishing the existing one; replacing the sluice valves; rehabilitating all the iron pipe system, handrails, ladders, and anchors with surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure. Electric installations will be replaced and conditioned, a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

Aposte Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations, replacing the sluice valves and iron accessories that have been out of service for a longtime, rehabilitating all the iron pipe system, handrails, ladders, and anchors with surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure. A sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

10.23 Km of water networks will be rehabilitated and 4.16 Km of new pipe will be installed, as follows.

Table 3.4.12-17: Secondary Networks Rehabilitation - Sector 84B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
84B	**100**	4.05			
	150	3.29			
	200	2.85		0.15	
	250	0.04			4.01
TOTAL		**10.23**		**4.16**	

Source: JICA Study Team

As a supplement to above, the following will be rehabilitated:

- 17 fire hydrants.
- 37 sluice valves, 2 air valves and 1 drain valves
- Installation of 185 pre - locators.

5) House connections

5,690 water connections will be installed: 4,021 connections in sub sector 84 B-1 and 1,669 connections in sub sector 84 B-2.

6) Wells

Wells No. 694, 695, 696, 716 and 618 will be equipped in this sector.

Wells No. 694 and 696 will be equipped with new motor, pump, power panel, flow meter, chlorination equipment, relief and sluice check valves.

For wells No. 695 and 716, motor and pump will be rehabilitated, new power panel and flow meter will be installed and chlorination equipment, relief and sluice check valves will be optimized.

For well No. 618, new power panel and flow meter will be installed and motor, pump, chlorination equipment, relief and sluice check valves will be optimized.

(7) SECTOR 85 A

This sector has a surface area of de 0.64 Km2. It has 2,184 water supply connections and 01 standing reservoir.

Its boundaries are: to the North, the Los Ángeles highway; to the South, the Universitaria highway and the Central highway; to the East, the Metropolitana highway; and to the West, the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A 292.83 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 200 mm diameter, to be installed along the Huandoy Ave. and Pasaje (Passageway) 11, thus ensuring supply from Puerta de Pro reservoir.

Table 3.4.12-18: Transmission Line Installation - Sector 85A

Diameter (mm)	Length (m)	Material	Class	Method
200	292.83	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 1,689.82 m long pumping line will be installed (open cut method), DI, K-9 class and 150 mm and 200 mm diameters, to be installed along the Huandoy Ave., Los Portales Ave. central berms, and the Igualdad, Trece streets, and Pasaje (Passageway) 11, thus ensuring supply from Puerta de Pro reservoir.

Table 3.4.12-19: Pumping Line Installation - Sector 85A

Diameter (mm)	Length (m)	Material	Class	Method
200	330.10	DI	K-9	Trench
150	1,359.72	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-20: Reservoirs Rehabilitation - Sector 85A

Description	R Puerta de Pro	
	DN (mm)	Un
Electromagnetic meter	150	1
Adjusting valve	200/150	2
Sluice valve	200/150	6
Bends	200	7
Tee	200	5
Dresser Joint	200	5
Nipple	200	9

Source: JICA Study Team

b) Civil Works

<u>Puerta de Pro Reservoir</u>

Structure is currently out of service; it requires specific repair of damages on the external roof surface with concrete, and maintenance works to the inner tank walls with epoxy paint in order to prevent any organic growth. Micro cracks will be patched and checked on the outer walls. In addition, all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment will be rehabilitated. A perimeter fence with electric wires will be constructed / installed to restrain access of non – authorized people to the facilities; the cut slope will be kept with galvanized mesh anchors with concrete or retaining walls. Finally, masonry wall cracks will be patched, electric installations will be repaired at the valve house, and the whole structure will be painted.

4) Secondary networks

3.79 Km water networks will be rehabilitated and 4.49 Km of new pipe will be installed, as follows:

Table 3.4.12-21: Secondary Networks Rehabilitation - Sector 85A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
85A	**100**	1.35		2.38	
	150	1.06		2.11	
	200	1.2			
TOTAL		**3.79**		**4.49**	

Source: JICA Study Team

As a supplement to above, the following will be rehabilitated:

- 7 fire hydrants.
- 19 sluice valves and 1 air valve
- Installation of 85 pre - locators.

5) House connections

2,184 water connections will be installed in sub sector 85 A.

6) Wells

Wells No. 717 and 351 will be equipped in this sector.

For well No. 717, new power panel, flow meter, motor, pump, chlorination equipment, relief and sluice check valves will be installed.

For well No. 351, new power panel and flow meter will be installed and motor, pump, chlorination equipment, relief and sluice check valves will be optimized.

(8) SECTOR 85 B

This sector has a surface area of 1.68 Km2. It has 2,099 water supply connections, 02 elevated reservoirs and 01 standing reservoir.

Its boundaries are: to the North, the Los Ángeles highway; to the South, the Universitaria highway and the Central highway; to the East, the Metropolitana highway; and to the West, the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A 1,006.98 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 150 mm and 300 mm diameters, to be installed along the Confraternidad Ave. and 25 de Enero Ave. central berms and the Seis and Doce streets, thus ensuring supply from Río Santa and Santa Luisa reservoirs.

Table 3.4.12-22: Transmission Line Installation - Sector 85B

Diameter (mm)	Length (m)	Material	Class	Method
300	10.78	DI	K-9	Trench
150	996.20	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 446.37 m long pumping line will be installed (open cut method), DI, K-9 class and 200 mm diameters, to be installed along the Confraternidad Ave. central berm, and the Doce and Cuarenta streets, thus ensuring supply from Río Sana reservoir.

Table 3.4.12-23: Pumping Line Installation - Sector 85B

Diameter (mm)	Length (m)	Material	Class	Method
200	446.37	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-24: Reservoirs Rehabilitation - Sector 85B

Description	R Santa Luisa		R Rio Santa	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	200	1
Adjusting valve	200/150	2	250/200	2
Sluice valve	200/150	6	250/200	6
Bends	200	7	250	7
Tee	200	5	250	5
Dresser Joint	200	5	250	5
Nipple	200	9	250	9

Source: JICA Study Team

b) Civil works

Santa Luisa Reservoir

Damaged portions of the structure's protection slab need to be repaired with mortar and joining additive to protect main slab from external erosion agents. Tank's inner impervious surface will be given maintenance with expoy paint. Sluice valves will be replaced. In addition, all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment will be rehabilitated. Millimetric meshes will be added to restrain access of birds and bugs to the tank, and so prevent contamination of the facilities. Finally, masonry wall cracks will be patched, and the whole structure will be painted.

Rio Santa Reservoir

The structure's tank base needs to be repaired by breaking and patching, and applying mortar and impervious joining additive to prevent leakages to the base. Sluice valves will be replaced. In addition, all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment will be rehabilitated. Some items will be installed to restrain access of birds and bugs to the facilities, and so prevent their contamination. Finally, masonry wall cracks that were left behind during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

8.58 Km of water networks will be rehabilitated and 1.39 Km of new pipe will be installed, as follows.

Table 3.4.12-25: Secondary Networks Rehabilitation - Sector 85B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
85B	**100**	1.33			
	150	3.08			
	200	2.24	0.03		
	250	1.9			0.32
	300				1.07
TOTAL		**8.55**	**0.03**	**1.39**	

Source: JICA Study Team

As a supplement to above, the following will be rehabilitated:

- 16 fire hydrants.
- 18 sluice valves and 3 air valves and 1 drain valve
- Installation of 99 pre locators

5) House connections

2,099 water connections will be installed in sub sector 85 B.

6) Wells

Well No280 will be equipped in this sector. New power panel, flow meter, motor, pump, chlorination equipment, relief and sluice check valves will be installed.

(9) SECTOR 85 C

This sector has a surface area of 0.65 Km2. It has 1,657 water supply connections and a standing reservoir.

Its boundaries are: to the North, the Central highway; to the South, the Los Alisos highway; to the East, the Panamericana Norte freeway, and to the West, the Universitaria highway and the Huandoy highway.

Works to be executed are as follows:

1) Gravity pressure lines

A 1,464.80 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 400 mm and 450 mm diameters, to be installed along the Universitaria Ave. central berms and the Bustamante, Blondet, and Las Palmeras streets, thus ensuring supply from Pro Reservoir.

Table 3.4.12-26: Transmission Line Installation - Sector 85C

Diameter (mm)	Length (m)	Material	Class	Method
450	744.83	DI	K-9	Trench
400	719.97	DI	K-9	Trench

Source: JICA Study Team

2) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-27: Reservoirs Rehabilitation - Sector 85C

Description	R Pro	
	DN (mm)	Un
Electromagnetic meter	150	1
Adjusting valve	250/200	2
Sluice valve	250/200	6
Bends	250	7
Tee	250	5
Dresser Joint	250	5
Nipple	250	9

Source: JICA Study Team

b) Civil works

Pro Reservoir

Structure is currently out of service; it requires specific repair of damages on the lower parts of the wall and the external vault coverage roof surface with concrete, and construction of a wall and a sidewalk around. In addition, maintenance works will be made to the inner tank walls with epoxy paint, in order to prevent any organic growth. Micro cracks will be patched and checked on the tank outer walls. All the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment will be rehabilitated. An electric wire will be installed on the perimeter fence to restrain access of non – authorized people to the facilities; the cut slope will be stabilized with galvanized mesh anchors with concrete or retaining walls, and finally, masonry wall cracks will be patched, electric installations will be repaired at the valve house, and the whole structure will be painted.

3) Secondary networks

9.14 Km water networks will be rehabilitated and 1.67 Km of new pipe will be installed, as follows.

Table 3.4.12-28: Secondary Networks Rehabilitation - Sector 85C

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
85C	**100**	5.43			
	150	2.98			
	200				
	250	0.73			
	300				
	350				0.19
	400				1.48
TOTAL		**9.14**		**1.67**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 11 fire hydrants.

- 14 sluice valves and 1 air valve
- Installation of 62 pre - locators

4) House connections

1,657 water connections will be installed

(10) SECTOR 212 A

This sector has a surface area of 1.9 Km2. It has 5,428 water supply connections, 2 elevated reservoirs.

Its boundaries are: to the North, the Naranjal freeway and the Los Alisos highway; to the South, the Carlos Eizaguirre highway; to the East, the Universitaria highway; and to the West, the Canta Callao freeway.

Works to be executed are as follows:

1) Gravity pressure lines

A 2,131.75 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 200 mm, 250 mm and 300 mm diameters, to be installed along the Los Alisos Ave., Del Rosario Ave., and Los Olivos Ave. central berms and the Diez street, thus ensuring supply from Virgen de las Nieves and Virgen del Rosario reservoirs

Table 3.4.12-29: Transmission Line Installation - Sector 212A

Diameter (mm)	Length (m)	Material	Class	Method
300	492.06	DI	K-9	Trench
250	845.67	DI	K-9	Trench
200	794.02	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 1,268.76 m long pumping line will be installed (open cut method), DI, K-9 class and 200 mm and 250 mm diameters, to be installed along the Santa Elvira Ave. and Central Ave. central berms, and the Dos, Egúzquiza, Manuel de Lara, Bustamante, San Manuel, and San Ernesto streets, thus ensuring supply from Villa Sol reservoir.

Table 3.4.12-30: Pumping Line Installation - Sector 212A

Diameter (mm)	Length (m)	Material	Class	Metodo
250	106.91	DI	K-9	Trench
200	1,161.85	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories (inflow)

Table 3.4.12-31: Reservoirs Rehabilitation - Sector 212A

Description	R Virgen de las Nieves		R Virgen del Rosario	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	200	1	200	1
Adjusting valve	250/200	2	250/200	2
Sluice valve	250/200	6	250/200	6
Bends	250	7	250	7
Tee	250	5	250	5
Dresser Joint	250	5	250	5
Nipple	250	9	250	9

Source: JICA Study Team

b) Civil works

Virgen de las Nieves Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; patching the erosion damaged portions at the shaft; replacing the sluice valves; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

Virgen del Rosario Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; replacing the sluice valves; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

3.32 Km of water networks will be rehabilitated and 2.42 Km of new pipe will be installed, as follows.

Table 3.4.12-32: Secondary Networks Rehabilitation - Sector 212A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
212A	**100**	1.11		1.77	
	150	1.47			
	200	0.57		0.64	
	250	0.17			0.01
TOTAL		**3.32**		**2.42**	

Source: JICA Study Team

a. As a supplement to the above, the following will be rehabilitated:

- 20 fire hydrants
- 46 sluice valves and 2 air valves and 1 drain valve
- Installation of 187 pre - locators.

5) House connections

5,428 water connections will be installed: 3,344 connections in sub sector 212 A-1 and 2,084 connections in sub sector 212 A-1.

6) Wells

Wells No. 687, 727, 728 and 729 will be equipped in this sector.

For well No. 728 and 729, new power panel, flow, motor, pump, chlorination equipment, relief and sluice check valves will be installed.

For well No. 727, motor and pump will be rehabilitated, new power panel and flow meter will be installed and chlorination equipment, relief and sluice check valves will be optimized.

For well No. 687, new power panel and flow meter will be installed and motor, pump, chlorination equipment, relief and sluice check valves will be optimized.

(11) SECTOR 212 B

This sector has a surface area of 0.98 Km2. It has 2,970 water supply connections, 2 elevated reservoirs.

Its boundaries are: to the North, the Naranjal freeway and the Los Alisos highway; to the South, the Carlos Eizaguirre highway; to the East, the Universitaria highway; and to the West, the Canta Callao freeway.

Works to be executed are as follows:

1) Gravity pressure lines

A 980.26 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 250 mm and 300 mm diameters, to be installed along the Los Alisos Ave. central berm and the Los

Portales and Los Laureles streets, thus ensuring supply from Rosario del Norte and Jazmines de Naranjal reservoirs

Table 3.4.12-33: Transmission Line Installation - Sector 212B

Diameter (mm)	Length (m)	Material	Class	Method
300	442.42	DI	K-9	Trench
200	537.84	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 720.79 m long pumping line will be installed (open cut method), DI, K-9 class and 150 mm and 200 mm diameters, to be installed along the El Rosario Ave. and Los Portales and Siete streets, thus ensuring supply from Rosario del Norte and Jazmines de Naranjal reservoirs.

Table 3.4.12-34: Pumping Line Installation - Sector 212B

Diameter (mm)	Length (m)	Material	Class	Method
150	720.79	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-35: Rehabilitación de Reservorios - Sector 212B

Description	R Rosario del Norte		R Jazmines de Naranjal	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	150	1
Adjusting valve	200/150	2	200/150	2
Sluice valve	200/150	6	200/150	6
Bends	200	7	200	7
Tee	200	5	200	5
Dresser Joint	200	5	200	5
Nipple	200	9	200	9

Source: JICA Study Team

b) Civil works

<u>Rosario del Norte Reservoir</u>

Structure requires maintenance at the tank base. This maintenance includes applying a watertight agent and replacing the watertight layer (plaster coated and waterproofed) on specific locations, in order to prevent any filtrations; replacing the sluice valves; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

Jazmines de Naranjal Reservoir

Structure requires maintenance at the tank base. This maintenance includes replacing the watertight layer (plaster coated and waterproofed), in order to prevent any filtrations at the base; patching the erosion damaged portions at the shaft; replacing the sluice valves; rehabilitating all the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

4) Secondary networks

0.56 Km of water networks will be rehabilitated and 2.59 Km of new pipe will be installed, as follows.

Table 3.4.12-36: Secondary Networks Rehabilitation - Sector 212B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
212B	**100**	0.48		1.78	
	150	0.08		0.81	
TOTAL		**0.56**		**2.59**	

Source: JICA Study Team

As a supplement to the secondary distribution network rehabilitations and outlet pipe installations, and for operation assurance purposes, the following will be rehabilitated::

- 8 fire hydrants.
- 24 sluice valves and 2 air valves
- Installation of 101 pre - locators

5) House connections

2,970 water connections will be installed: 1,612 connections in sub sector 212 B-1 and 1,358 connections in sub sector 212 B-2.

6) Wells

Wells No. 688, 689 and 690 will be equipped in this sector.

Motor and pump will be rehabilitated, new power panel and flow meter will be installed and chlorination equipment, relief and sluice check valves will be optimized.

(12) SECTOR 213

This sector has a surface area of 1.63 Km2. It has 3,201 water supply connections, 01 standing reservoir and 02 elevated reservoirs.

Its boundaries are: to the North, Los Sauces Ave.; to the South, the Naranjal highway; to the East, the Canta Callao freeway; and to the West, Los Sauces Ave.

Works to be executed as as follows:

1) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-37: Reservoirs Rehabilitation - Sector 213

Description	R Vipol		R Choclo 1		R Choclo 2	
	DN (mm)	Un	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	200	1	100	1	100	1
Adjusting valve	250/200	2	150/100	2	150/100	2
Sluice valve	250/200	6	150/100	6	150/100	6
Bends	250	7	150	7	150	7
Tee	250	5	150	5	150	5
Dresser Joint	250	5	150	5	150	5
Nipple	250	9	150	9	150	9

Source: JICA Study Team

b) Civil works

Vipol Reservoir

Structure requires maintenance of the inner tank walls with epoxy paint, in order to prevent organic growth; filtration control at the base, patching and control of micro cracks on the tank outer walls; construction of a surrounding shaft, rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition , an electric fence should be placed to restrain access to non – authorized people to the facilities, the cut slope should be stabilized with retaining walls, and some cracks on the tank roof and masonry walls should be patched, electric installations in the valve house should be fixed, and finally, the whole structure should be painted.

Choclo 1 Reservoir

Structure requires overall maintenance: inner and outer surface paintings, rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

Choclo 2 Reservoir

Structure requires overall maintenance: inner and outer surface paintings, rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, some items have been included to restrain access of birds and bugs to the installations, and so, prevent any contamination to the water and the structure; a sidewalk around the shaft to prevent erosion of the walls in touch with the damp soil will be constructed. Eventually, some cracks that were left during the construction process will be patched, and the whole structure will be painted.

2) Secondary networks

4.27 Km of water networks will be rehabilitated and 4.05 Km of new pipe will be installed, as follows:

Table 3.4.12-38: Secondary Networks Rehabilitation - Sector 213

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
213	**100**	1.91		2.52	
	150	1.93		1.15	
	200	0.43		0.38	
TOTAL		**4.27**		**4.05**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 12 fire hydrants.
- 33 sluice valves, 3 air valves and 3 drain valves
- Installation of 151 pre - locators

3) House connections

3,201 house connections will be installed: 3,003 connections in sub sector 213-1, 68 connections in sub sector 213-2, and 130 connections in sub sector 213-3.

(13) SECTOR 259

This sector has a surface area of 1.03 Km2. It has 2,282 water supply connections and 01 standing reservoir.

Its boundaries are: to the North, Ramiro Prialé Ave.; to the South, Alameda del Vencedor Ave.; to the East, the hills; and to the West, the Pacific Ocean coastline.

Works to be executed are as follows:

1) Gravity pressure lines

A 5,235.92 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 250 mm diameters, to be installed along the Néstor Gambetta Avenue's auxiliary road and El Rosario Ave., and Los Olivos Ave. central berms and a street with no name, thus ensuring supply from Márquez reservoir.

Table 3.4.12-39: Transmission Line Installation - Sector 259

Diameter (mm)	Length (m)	Material	Class	Method
250	5,235.92	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 2,325.29 m long pumping line will be installed (open cut method), DI, K-9 class and 200 mm diameter, to be installed along the El Naranjal Ave. and San Nicolás Ave. central berms, thus ensuring supply from Cerro Oquendo reservoir.

Table 3.4.12-40: Pumping Line Installation - Sector 259

Diameter (mm)	Length (m)	Material	Class	Method
200	2,325.29	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories (inflow).

Table 3.4.12-41: Rehabilitación de Reservorio - Sector 259

Description	R Marquez	
	DN (mm)	Un
Electromagnetic meter	200	1
Adjusting valve	250/200	2
Sluice valve	250/200	6
Bends	250	7
Tee	250	5
Dresser Joint	250	5
Nipple	250	9

Source: JICA Study Team

b) Civil works

<u>Marquez Reservoir</u>

The valve house will be extended to hold the new hydraulic installations, the checking valve pit installations, and automation installations.

Structure requires maintenance of the inner tank walls with epoxy paint, in order to prevent organic growth; filtration control at the base, patching and control of micro cracks on the tank outer walls; construction of a surrounding shaft, replacement of sluice valves; rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, a perimeter fence with an electric wire should be placed to restrain access to non – authorized people to the facilities, the cut slope should be stabilized with retaining walls or anchored metal meshes with concrete plaster; and some cracks on the tank roof and masonry walls should be patched, electric installations in the valve house should be fixed, and finally, the whole structure should be painted.

4) Secondary networks

1.86 Km of water networks will be rehabilitated and 2.01 Km of new pipe will be installed, as follows:

Table 3.4.12-42: Secondary Networks Rehabilitation - Sector 259

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
259	**100**	1.47	0.06	0.88	
	150	0.11		0.90	
	200			0.23	
	250		0.22		
TOTAL		**1.58**	**0.28**	**2.01**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 5 fire hydrants
- 12 sluice valves and 1 pressure reducing valves
- Installation of 71 pre - locators

5) House connections

2,282 water connections will be installed in sector 259.

6) Wells

Well No. 569 will be equipped in this sector.

Motor and pump will be rehabilitated, new power panel and flow meter will be installed and chlorination equipment, relief and sluice check valves will be optimized.

(14) SECTOR 345

This sector has a surface area of 3,64 Km2. It has 415 water supply connections and 01 elevated reservoir.

Its boundaries are: to the North, the Chimpu Ocllo highway; to the South, the Sangarara highway; to the East, the Canta Callao freeway; and to the West, the left bank of the Rimac

River.

Works to be executed are as follows:

1) Secondary networks

1.61 Km PVC outlet pipes will be installed.

Table 3.4.12-43: Inlet to Sector Pipes Installation - Sector 345

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
345	100				
	150			0.21	
TOTAL				0.21	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 3 fire hydrants.
- 13 sluice valves and 1 air valve
- Installation of 48 pre - locators.

2) House connections

415 water connections will be installed in sector 345

(15) SECTOR 346

This sector has a surface area of 1,12 Km2. It has 2,605 water supply connections and 01 elevated reservoir.

Its boundaries are: to the North, the Los Incas highway; to the South, the 21 and 40 streets; to the East, the Universitaria highway and 16 street; and to the West, the Canta Callao freeway.

Works to be executed are as follows:

1) Secondary networks

0.91 Km water networks will be rehabilitated and 1.86 Km of new pipe will be installed as follows.

Table 3.4.12-44: Secondary Networks Rehabilitation - Sector 346

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
346	100	0.3			
	150	0.6		1.86	
	200		0.01		
TOTAL		0.9	0.01	1.86	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 14 fire hydrants.
- 24 sluice valves and 2 air valve
- Installation of 76 pre - locators.

2) House connections

2,605 water connections will be installed in sector 346

(16) SECTOR 347

This sector has a surface area of 2.01 Km2. It has 3,845 water supply connections, 1 elevated reservoir and 1 standing reservoir.

Its boundaries are: to the North, Los Incas highway; to the South, Los Incas highway; to the East, Túpac Amaru highway span; and to the West, the Canta Callao freeway.

Works to be executed are as follows:

1) Secondary networks

1.92 Km of water networks will be rehabilitated and 3.28 Km of inlet to sector pipe will be installed, as follows:

Table 3.4.12-45: Secondary Networks Rehabilitation - Sector 347

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
347	100	1.03		1.23	
	150		0.79	1.46	
	200		0.1	0.59	
TOTAL		1.03	0.89	3.28	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 15 fire hydrants.

- 38 sluice valves and 1 air valve
- Installation of 201 pre – locators.

2) House connections

3,845 water connections will be installed in sector 347

(17) SECTOR 348A

This sector has a surface area of 0.60 Km2. It has 841 water supply connections, 2 standing reservoirs.

Its boundaries are: to the North, the hills; to the South, Los Incas highway span; to the East, the Santa Rosa Ave. and Ancash Ave.; and to the West, Túpac Amaru highway.

Works to be executed are as follows:

1) Secondary networks

1.79 Km water networks will be rehabilitated and 0.75 Km of new pipe will be installed, as follows.

Table 3.4.12-46: Secondary Networks Rehabilitation - Sector 348A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
348A	100	1.63			
	150	0.16		0.75	
TOTAL		1.79		0.75	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 4 fire hydrants.
- 6 sluice valves and 1 air valve
- Installation of 32 pre - locators

2) House connections

841 water connections will be installed in sector 348A

(18) SECTOR 348B

This sector has a surface area of 0.82 Km2. It has 2,212 water supply connections and 02 standing reservoirs.

Its boundaries are: to the North, the hills; to the South, Los Incas highway span; to the East, the Santa Rosa Ave, and Ancash Ave.; and to the West, the Túpac Amaru highway.

Works to be executed are as follows:

1) Secondary networks

4.35 Km water networks will be rehabilitated and 0.78 Km of new pipe will be installed, as follows.

Table 3.4.12-47: Secondary Networks Rehabilitation - Sector 348B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
348B	100	3.97	0.13		
	150	0.24			
	200				
	250				0.13
	300	0.01			0.65
TOTAL		4.22	0.13	0.78	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 9 fire hydrants.
- 21 sluice valves and 1 air valve
- Installation of 94 pre - locators.

2) House connections

2,212 water connections will be installed in sector 348B

(19) SECTOR 349 A

This sector has a surface area of 1.38 Km2. It has 2,983 water supply connections, 3 standing reservoirs and 1 re-pumping chamber.

Its boundaries are: to the North, South, and East, the Collique hills; and to the West, Santa Rosa Ave. and Ancash Ave.

Works to be executed are as follows:

1) Gravity pressure lines

A 1,200.15 m long gravity pressure line will be installed (open cut method), DI K-9 Class, 150 mm diameter, to be installed along Milagro de Jesús Ave. central berms and Ricardo Palma and Pachacútec streets, thus ensuring supply from the Nueva Esperanza tank.

Table 3.4.12-48: Transmission Line Installation - Sector 349A

Diameter (mm)	Length (m)	Material	Class	Method
150	1,200.15	DI	K-9	Trench

Source: JICA Study Team

2) Pumping lines

A 654.11 m long pumping line will be installed (open cut method), DI, K-9 class 150 mm diameter, to be installed along the Toribio de Mogrovejo Ave. and Ciro Alegría Ave. central berms, thus ensuring supply from Nueva Esperanza reservoir.

Table 3.4.12-49: Pumping Line Installation - Sector 349A

Diameter (mm)	Length (m)	Material	Class	Method
150	654.11	DI	K-9	Trench

Source: JICA Study Team

3) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-50: Reservoirs Rehabilitation - Sector 349A

Description	R Nueva Esperanza	
	DN (mm)	Un
Electromagnetic meter	100	1
Adjusting valve	150/100	2
Sluice valve	150/100	6
Bends	150	7
Tee	150	5
Dresser Joint	150	5
Nipple	150	9

Source: JICA Study Team

b) Civil works

<u>Nueva Esperanza Reservoir</u>

Structure requires maintenance of the inner tank walls by removing damaged portions, and replacing them with special mortar, in addition to epoxy paint on them, in order to prevent organic growth; filtration control; patching and control of micro cracks on the tank outer walls; construction of a surrounding shaft, rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface perimeter treatment. In addition, a perimeter fence with electric wire should be placed to restrain access to non – authorized people to the facilities, the cut slope should be stabilized with retaining walls, and some cracks on the tank roof and masonry walls should be patched, electric installations in the valve house should be fixed, and finally, the whole structure should be painted .

4) Secondary networks

11.90 Km water networks will be rehabilitated and 1.80 Km of new pipe will be installed, as follows.

Table 3.4.12-51: Secondary Networks Rehabilitation - Sector 349A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
349A	**100**	2.05	6.6	0.4	
	150	0.01	2	1.24	
	200	0.01	0.47		
	250				
	300		0.76		**0.16**
TOTAL		**2.07**	**9.83**	**1.80**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 10 fire hydrants.
- 22 sluice valves and 3 air valves
- Installation of 125 pre – locators

5) House connections

2,983 water connections will be installed in sector 349A.

6) Pumping Station

Station No. CR-76 will be equipped in this sector.

New motor, pump, flow meter and line relief valve will be installed. Pump discharging valve, pumping closing valve and retaining valve will be rehabilitated.

(20) SECTOR 349 B

This sector has a surface area of 2.03 Km2. It has 2,295 water supply connections, 03 standing reservoirs, and 01 re-pumping chamber.

Its boundaries are: to the North, South, and East, the Collique hills; and to the West, Santa Rosa Ave. and Ancash Ave.

Works to be executed are as follows:

1) Gravity pressure lines

Pumping

A 2,235.40 m long pumping line will be installed (open cut method), DI, K-9 class and 150 mm, 250 mm, and 300 mm diameters, to be installed along the Revolución Ave. central berm, and the 9 de octubre, Los Andes, José Carlos Mariátegui, and 28 de Julio streets, thus ensuring supply from Collique R5, R6, and R7 reservoirs.

Table 3.4.12-52: Pumping Line Installation - Sector 349B

Diameter (mm)	Length (m)	Material	Class	Method
300	937.49	DI	K-9	Trench
250	581.09	DI	K-9	Trench
150	716.82	DI	K-9	Trench

Source: JICA Study Team

2) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed, and it will include the checking and regulation accessories.

Table 3.4.12-53: Reservoirs Rehabilitation - Sector 349B

Description	Collique R5		Collique R6		Collique R7	
	DN (mm)	Un	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	200	1	150	1	100	1
Adjusting valve	250/200	2	200/150	2	150/100	2
Sluice valve	250/200	6	200/150	6	150/100	6
Bends	250	7	200	7	100	7
Tee	250	5	200	5	100	5
Dresser Joint	250	5	200	5	100	5
Nipple	250	9	200	9	100	9

Source: JICA Study Team

b) Civil works

Collique R7 Reservoir

Structure requires outer rehabilitation by patching damaged portions with mortar and additives, after breaking and removing the brittle part, in addition to applying epoxy paint on to the inner parts, in order to prevent organic growth; filtration control; rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. A cat ladder is to be installed for access inside the tank. In addition an electric wire should be placed to restrain access to non – authorized people to the facilities, the cut slope should be stabilized with retaining walls, and some cracks on the tank roof and masonry walls should be patched, electric installations in the valve house should be fixed, and finally, the whole structure should be painted.

It must be pointed out that reservoirs R5 and R6 are undergoing structural rehabilitation.

3) Secondary networks

11.55 Km water networks will be rehabilitated and 2.25 Km of new pipe will be installed, as follows.

Table 3.4.12-54: Secondary Networks Rehabilitation - Sector 349B

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
349B	**100**	1.92	6.55	0.38	
	150	0.05	2.61	1.24	
	200	0.03	0.18		
	250		0.21		0.63
TOTAL		**2.00**	**9.55**	**2.25**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 7 fire hydrants.
- 18 sluice valves, 3 air valves and 1 pressure reducing valve
- Installation of 107 pre – locators

4) House connections

2,295 water connections will be installed in sector 349B.

5) Pumping Station

Stations No.CR-96 and CR-97 will be equipped in this sector.

In pumping station CR-96, new motor, pump, flow meter and line relief valve will be installed. Pump discharging valve, pumping closing valve and retaining valve will be rehabilitated.

In pumping station CR-97, motor and pump will be optimized, new flow meter and line relief valve will be installed. Pump discharging valve, pumping closing valve and retaining valve will be rehabilitated.

(21) SECTOR 350

This sector has a surface area of 2.84 Km2. It has 7,287 water supply connections and 02 standing reservoirs.

Its boundaries are: to the North, Chimpu Ocllo highway; to the South, Ancash highway span; to the East, Túpac Amaru highway; and to the West, the Canta Callao freeway.

Works to be executed are as follows:

1) Secondary networks

50.57 Km water networks will be rehabilitated and 6.28 Km of inlet to sector pipe will be installed, as follows.

Table 3.4.12-55: Secondary Networks Rehabilitation - Sector 350

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
350	**100**	33.77		0.62	
	150	11.5		0.68	
	200	3.45		1.13	
	250	0.71			1.62
	300	1.14			0.54
	350				1.69
TOTAL		**50.57**		**6.28**	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 48 fire hydrants
- 71 sluice valves 2 air valves and 2 drain valves
- Installation of 267 pre - locators.

2) House connections

7,287 water connections will be installed in sector 350.

(22) SECTOR 351

This sector has a surface area of 0.72 Km2. It has 1,035 water supply connections and 04 standing reservoirs

Its boundaries are: to the North, South, and East, the hills; and to the West, the Túpac Amaru highway

Works to be executed are as follows:

1) Checking and / or Storage structures

a) Hydraulic installations

A complete hydraulic tree will be installed for reservoirs R3 and R4

Table 3.4.12-56: Reservoirs Rehabilitation - Sector 351

Description	R 3		R 4	
	DN (mm)	Un	DN (mm)	Un
Electromagnetic meter	150	1	100	1
Adjusting valve	200/150	1	150/100	1
Sluice valve	200/150	2	150/100	1
Bends	200	1	150	1
Tee	200	1	150	1
Dresser Joint	200	3	150	2
Nipple	200	2	150	1

Source: JICA Study Team

b) Civil works

Reservoir R4

Structure requires maintenance of the tank walls with epoxy paint, in order to prevent organic growth; filtration control on the base; replacement of sluice valves; rehabilitation of all of the iron pipe system, handrails, ladders, and anchors that require surface anti-corrosion treatment. In addition, an electric wire should be placed to restrain access to non – authorized people to the facilities, the cut slope should be stabilized with retaining walls, and some cracks on the tank roof and masonry walls should be patched, electric installations in the valve house should be fixed, and finally, the whole structure should be painted.

2) Secondary networks

0.19 Km water networks will be rehabilitated and 0.80 Km of new pipe will be installed, as follows.

Table 3.4.12-57: Secondary Networks Rehabilitation - Sector 351

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
351	100		0.19	0.35	
	150			0.45	
TOTAL			0.19	0.80	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 2 fire hydrants.
- 7 sluice valves, 2 air valves and 2 pressure reducing valves
- Installation of 25 pre - locators.

3) House connections

1,035 water connections will be installed in sector 351.

(23) SECTOR 368A

This sector has a surface area of 1.59 Km2. It has 2,058 water supply connections and 2 standing reservoirs.

Its boundaries are: to the North, Los Olivos Ave., to the East, the Chillón River right bank; and to the South and West, hills.

Works to be executed are as follows:

1) Secondary networks

0.77 Km water networks will be rehabilitated and 1.55 Km of new pipe will be installed, as follows.

Table 3.4.12-58: Secondary Networks Rehabilitation - Sector 368A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
368A	100				
	150		0.77	0.65	
	200			0.72	
	250				0.18
TOTAL			0.77	1.55	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 8 fire hydrants.
- 22 sluice valves, 1 pressure reducing valve, 1 air valve and 1 drain valve
- Installation of 96 pre - locators

2) House connections

2,058 water connections will be installed in sector 268 A.

(24) SECTOR 369A

This sector has a surface area of 1.02 Km2. It has 2,179 water supply connections and 04 standing reservoirs

Its boundaries are: to the North, the Panarmericana Norte highway; to the South, Los Olivos Ave.; to the East, the Chillón River right bank; and to the West, the hills.

Works to be executed are as follows:

1) Secondary networks

0.13 Km water networks will be rehabilitated and 1.43 Km of new pipe will be installed, as follows.

Table 3.4.12-59: Secondary Networks Rehabilitation - Sector 369A

Sub Sector	Diameter (mm)	Replacement of AC pipes by PVC (km)	Replacement of PVC/ACERO/FoFo pipes by PVC (km)	Installation of new pipes (km)	
				PVC	DI
369A	100				
	150		0.13	1.05	
	200				
	250				0.26
	300				0.12
TOTAL			0.13	1.43	

Source: JICA Study Team

As a supplement to the above, the following will be rehabilitated:

- 7 fire hydrants.
- 17 sluice valves, 1 air valve and 1 drain valve
- Installation of 89 pre - locators

2) House connections

2,179 water connections will be installed in sector 369 A.

3.5 Costs

This section set the investment costs, as well as the operation and maintenance costs for both the "without" and "with" Project situations, in compliance with the Project technical scope. This scope consists of the construction of primary water supply works, the rehabilitation and/or renewal, improvement, and sectorization of water supply services, and the rehabilitation and/or renewal of the sewerage networks, as well as the procurement of equipment for water supply and sewerage network systems and service improvement management measures.

Calculation of costs will be in Nuevos Soles, as of June 2010 prices, and an exchange rate of 1 USD = S/. 2.838 will be used. Costs will be expressed at market prices and social prices.

Correction from private or market prices to social prices was made by applying the conversion factors for each investment component and operation and maintenance cost components, based on a standard cost structure, regulated by the Economy and Finances Ministry,[1] the correction factors, suggested by the DNS (Appendix B7), and additional factors calculated by the Study Team (see Annex B7).

3.5.1 Costs arise in the "without" Project situation

Costs in the "without" Project situation are given by the operation and maintenance costs currently incurred in by the utility, as it provides water and sewerage services, as well as the administration and commercialization costs in the project area of influence.

In order to calculate operation and maintenance costs for the water supply and sewerage systems, the "Process Costs by Elements" or SEDAPAL teams' ABC Costs for 2009 , have been used. These costs were updated, as of June 2010, with an average wholesale price index (IPM.)

Costs incurred in by the utility when providing potable water and sewerage services are generated in the following productive process systems:

1) Potable water production from the La Atarjea Water Treatment Plant (WTP)

2) Potable water purchase from the Chillón Water Treatment Plant (WTP)

3) Groundwater production from Wells

4) Operation, preventive and corrective maintenance of the water supply primary and secondary distribution and re-pumping systems

5) Wastewater primary and secondary collection

6) Commercial activities (metering, meter reading, and service to client costs at central level, by the North Services Management Office and the Commercial Teams)

[1] Evaluation parameters, Appendix SNIP 9

7) Administration (business management costs, human resources and financial management costs, IT system maintenance costs, and goods and services supply costs)

Unit costs are calculated by dividing the total spent amount by the total amount of produced potable water. Commercial and administrative activities are calculated by dividing their total expenses by the number of water supply connections.

Table 3.5.1-1, Table 3.5.1-2, and Table 3.5.1-3 show unit costs per activity in detail, at market and social prices, as of June, 2010 in ‘Without Project’ situation. It must be pointed out that unit potable water production cost at the Chillon WTP is S/. 0.9410, 18% VAT included and Huachipa WTP is S/. 0.1892, 18% VAT included. These values corresponds to the water supply value once it leaves the plant. The Huachipa WTP and the Northern Branch (Ramal Norte) just started operating in 2011.

It is necessary to mention that the North Management Office, additional to its own O&M costs for water distribution in primary and secondary networks, also incur corrective maintenance for secondary distribution and connections in North Service Area. The O&M cost for the secondary distribution network is high, with an annual value of S/. 10,865,467 Nuevos Soles, as a result of the poor conditions of the house connections, water intakes, and secondary distribution line spans. It is assumed that, from this amount, 30% of the total cost is allotted to the project area of influence, that is, S/. 3,259,640 per year, which is distributed according to connection ratio in the influence area and total connection in North Management office.

In order to estimate unit cost for commercial activities (central administration, technical cadastre, leakage and repair detections, water quality evaluation), annual expenses incurred in by SEDAPAL were divided by its number of total connections; and for the case of measuring and reading and the total cost of the commercial activity of the North Management Office has been estimated by dividing the incurred costs by this office by the existing number of connections. For the estimation of commercial and administration costs it has divided proportionally 50% for water and sewerage system respectively.

Table 3.5.1-1: Without Project situation - Unit costs per water supply processes [1/]

(Nuevos soles, as of June 2010)

Process	(1) Total cost VAT inc. S/.	(2) Produced volume m^3	(3) Production center	(4) Unit cost at market prices VAT inc. S/. / m^3 [5/]	(5) Unit costa t social price S/. / m^3
Potable water: Cost per produced m^3					
- Purchase of potable water Chillon WTP	**46,100,362**	**48,988,304**	Chillon WTP	**0.9410**	**0.7975**
- Surface water production SEDAPAL			Atarjea WTP		
Operation cost	28,831,441	528,520,953		0.0546	0.0474
Maintenance cost	8,524,163	528,520,953		0.0161	0.0140
Total	**37,355,604**			**0.0707**	**0.0613**
- Surface water production HUACHIPA WTP	**29,826,110**	**157,680,000**	Huachipa WTP	0.1892	0.1603
- Primary distribution			SEDAPAL		
Operation costs	5,791,616	671,604,142		0.0086	0.0075
Maintenance costs	7,603,313	671,604,142		0.0113	0.0098
Total	**13,394,929**			**0.0199**	**0.0173**
- Secondary distribution			North Management Office		
Operation costs	1,089,906	236,378,414		0.0046	0.0040
Maintenance costs	4,327,235	236,378,414		0.0183	0.0159
Corrective maintenance	10,865,467			3,259,640 [2/]	2,829,367.56
Total	**16,282,608**			**3,259,640**	**2,829,368**
- Potable water re-pumping			Re-pumping volume of North Management Office		
Operation costs	14,702,174	30,912,996		0.4756	0.4128
Maintenance costs	4,609,394	30,912,996		0.1491	0.1294
Total	**19,311,569**			**0.6247**	**0.5422**
- Operational accident insurances	6,236			**6,236** [3/]	**5,285**
- Well operation	**8,219,172**	16,566,056	Groundwater volume of North Management Office	**0.4961**	**0.4307**
- Well and pumping station control and maintenance	**6,804,970**	333	SEDAPAL wells	**20,435**[4/]	**17,738**

1/ No depreciation included
2/ Annual cost from the North Services Management Cost (GSN)
3/ Annual cost to pay for each accident
4/ Annual maintenance cost per well in Lima and Callao
5/ Components that are sensitive to VAT are included except personnel cost according to cost structure of SEDAPAL 2009 (Factor 1.12) (See annexe B4), except Chillon VAT(18%) y Huachipa VAT(18%)
Source: JICA study team, based on ABC costs, SEDAPAL Financial Operations Team, Development and Investment Management Office (GDI)

Table 3.5.1-2: Without Project situation - Unit costs per commercial and administrative activity processes [1/]

(Nuevos Soles, as of June 2010)

Process	(1) Total Cost VAT included (S/.)	(2) Connections (Units)	(3) Production source	(4) Unit costs at market prices VAT inc. (S/. / Connection / year) [2/]	(5) Unit costs at social prices (S/. / m^3)
Commercial activities: Cost per connections					
- Commercialization					
Metering and meter reading	6,586,166	1,019,718	SEDAPAL total connections	6.4588	5.6062
- Commercialization Costs	18,708,926	255,970	Comas/Callao total connections	73.0903	63.4424
- Meters					
- Cost per operative meter	90,001	179,501	CS Comas/Callao metered connections	0.5014	0.4352
- Administration	83,433,478	1,019,718	SEDAPAL total connections	81,8251	71,024.1
- Technical cadastre	884,048	1,019,718		0.8670	0.7525
- Leakage detection and repair	2,537,578	1,019,718		2.4885	2.160
- Water quality evaluation					
Physical chemical analysis	490,996.4	1,019,718		0.4815	0.4179
Biological bacteriological analysis	1,092,609.9	1,019,718		1.0715	0.9300

1/ Depreciation is not included

2/ Components that are sensitive to VAT are included except personnel cost according to cost structure of SEDAPAL 2009 (Factor 1.12) (See annexe B4), except Chillon VAT(18%) y Huachipa VAT(18%)

Source: JICA study team, based on ABC costs, SEDAPAL Financial Operations Team, Development and Investment Management Office (GDI)

Table 3.5.1-3: "Without" project situation - Unit costs per sewerage system activity processes [1/]

(Nuevos Soles, as of June 2010)

Process	(1) Total Cost VAT included (S/.)	(2) Collected volume (m^3)	(3) Production source	(4) Unit costs at market prices VAT inc. (S/. / m^3) [4/]	(5) Unit costs at social prices (S/. / m^3)
Sewerage: Cost per revenue m^3					
- Secondary collection			85% of produced amount North Service Management		
Maintenance cost	2,952,192	200,921,652		0.0147	0.0128
Corrective maintenance cost	9,688,010	200,921,652		2,906,403 [2/]	2,522,758
Total	**12,640,202**			**2,906,403**	**2,522,758**
- Primary collection					
Operation cost	2,651,457	570,863,521	85% of produced amount SEDAPAL	0.00464	0.0040
Total maintenance	5,707,407	570,863,521		0.01000	0.0087
Total	**8,358,865**			**0.0146**	**0.0127**
- Control					
Technical cadastre	**1,186,822**	1,019,718	Total connections SEDAPAL	**1.16387** [3/]	**1.0102**
Quality evaluation	**236,053**	1,019,718		**0.23149** [3/]	**0.2009**

1/ Depreciation is not included

2/ Annual cost of North Service Management

3/ Connection cost

4/ Components that are sensitive to VAT are included except personnel cost according to cost structure of SEDAPAL 2009 (Factor 1.12) (See annexe B4), except Chillon VAT(18%) y Huachipa VAT(18%)

Source: JICA study team, based on ABC costs, SEDAPAL Financial Operations Team, Development and Investment Management Office (GDI)

In order to determine unit costs from wastewater primary and secondary collection, costs incurred in by the North Services Management office have been considered, according to ABC cost of SEDAPAL. About 85% of the total is used based onthe relation between waste water volume and potable water production of year 2009 at SEDAPAL level as shown in Table 3.5.1-4.

Table 3.5.1-4: Production of potable water and waste water volume of SEDAPAL

Description	2005	2006	2007	2008	2009	Average
Water production (thousand m^3/year)	669,724	664,805	650,762	658,749	671,604	663,129
Waste water volumen (thousand m^3/year)	545,257	546,834	536,427	551,880	572,063	550,492
Relation waste water/produced water	**81%**	**82%**	**82%**	**84%**	**85%**	**83%**

Source: Statistic Yearbook 2008-2009 SEDAPAL

As for secondary sewerage collection, in North Management Office, according to ABC cost, the corrective maintenance costs of the system is S/. 9,688,010 per year. Likewise as water supply system, 30% (according to water connection number of the influence area and the total number of connection of the North Management Office) is assigned to the project area of influence which amount is S/. 2,906,403 per year.

Results of SEDAPAL's ABC costs for 2005-2009 show a tendency of decreasing the administrative costs compared to increasing operative costs. This reflects an improved efficiency in these areas, as SEDAPAL has grown in the last few years.

Annual operation and maintenance costs were calculated based on unit costs per activity for the "without" Project situation, by applying the following criteria: i) as for potable water production's primary and secondary distribution system, water supply demand in "without" project situation has been multiplied by its relevant unit costs, ii) as for commercialization and administration costs, relevant unit costs are multiplied by the number of connections projected for the project planning period, and iii) as for primary and secondary collection costs, relevant unit costs are multiplied by the wastewater volume and iv) as for estimation of corrective cost of secondary distribution and collection, it has been assumed, that the corrective cost of June 2010 will grow at 1.50% per year, considering average growth ratio of the connections in the planning horizon of the Project. Table 3.5.1-4 shows "without" Project water demand projections, number of water connections, and wastewater volumes.

It must be pointed out that water supply and sewerage connections will continue to increase, both in the "without" and "with" project situations; therefore, commercialization and administration costs will also increase following this same behavior with no changes. Micrometering coverage will also increase through the SIAC service that started in July 2010. In this sense, meter maintenance costs will also increase, both in the "without" and "with" project situations.

It has been established that potable water supply source in the "without" project situation will be the Huachipa WTP; this plant will interconnect to the project area via the Northern Branch

(Ramal Norte), the Northern Branch supplementary works, and the Lima North 1[2] primary works that will start operating in 2012. In the case of potable water supply deficit, demand will be covered by the La Atarjea WTP and, exceptionally, by the Chillón Project (plant and set of wells), according to the expected growth for such demand and increase of the technical losses, up to 50 %, from current 40% (See Table 3.5.1-9.)

It is assumed that the corrective maintenance costs in the secondary water supply networks and connections in the “without” Project situation will increase as a result of deterioration of current connections and water network spans. Likewise, corrective maintenance costs for the secondary sewerage networks will carry on increasing as a result of the deterioration of networks and connections. In addition, water supply breakages will increase insurance costs, in terms of payment to third parties or affected families. Therefore, the concept of that the maintenance costs in the secondary water supply networks and connections in the “without” Project situation will increase is important to take into account at the economic evaluation of the projects which is different from the comparison between “before” and “after” the project.

Tables 3.5.1-5 and 3.5.1-6 show break down of primary and secondary water distribution costs and Tables 3.5.1-7 and 3.2.5-8 show break down of waste water collection cost in primary and secondary networks.

Table 3.5.1-10, Table 3.5.1-11, Table 3.5.1-12 and Table 3.5.1-13 show summary of the annual cost projections of operation, maintenance, commercialization and administration for the potable water supply and sewerage systems in the Project area of influence for ‘without project’ situation, at market prices and social prices, for the 2016-2035 period. Detail calculation of operative costs is shown in Appendix B4.

Table 3.5.1-5: Cost of Equipment for network maintenance of Comas “without project” (Distribution in primary networks)
(Nuevos Soles at market prices)

Process	Total Cost (S/.)	SEDAPAL water production (m3)	Unit Cost (S/./m3)
Primary Distribution in Network			
1. Operation of the Primary Network			
D1001416 Primary distribution operation system	5,269,876	671,604,142	0.0078
C3211316 Sectors control	521,740	671,604,142	0.0008
Subtotal	**5,791,616**		**0.0086**
2. Maintenance of Primary Network			
C3101 Implementation of macro measuring in zone/sect	391,458	671,604,142	0.0006
D1101416 Improve primary distribution system	832,244	671,604,142	0.0012
M2001416 Corrective maintenance	2,780,705	671,604,142	0.0041
M2101416 Preventive maintenance	3,598,906	671,604,142	0.0054
Sub Total	**7,603,313**		**0.0113**
Total	**13,394,929**		**0.0199**

[2] Infrastructure optimization in water supply and sewerage networks: North Services Management Office (GSN) – Huachipa WTP, and Chillón Drainage Area sectorization, rehabilitation, and cadastre (investment phase.)

Table 3.5.1-6: Cost of Equipment for network maintenance of Comas "without project" (Distribution in secondary networks)
(Nuevos Soles at market prices)

Process	Total Cost (S/.)	North Management Office Water production (m3)	Unit Cost (S/./m3)
Secondary Distribution in Network			
1. Operation of the Secondary Distribution Network			
D2001421 Secondary operation system	1,089,906	236,378,414	0.0046
2. Maintenance of Secondary Network			
M7001421 Water network preventive maintenance	3,327,840	236,378,414	0.0141
M7003421 Storage structure cleaning	999,395	236,378,414	0.0042
Sub Total	5,417,141		0.0229
Corrective maintenance	10,865,467		10,865,467
Sub Total	**10,865,467**		**10,865,467**
Total	**16,282,608**		

Source: JICA Study Team based on ABC costs, Finance Operation Team of SEDAPAL GDI

Table 3.5.1-7: Cost of Equipment for network maintenance of Comas "without project" (Primary network of waste water collection)
(Nuevos Soles at market prices)

Process	Total Cost (S/.)	SEDAPAL 85% production (m3)	Unit Cost (S/./m3)
Primary Network Collection			
1. Operation of Collection Primary Network			
M3221417 Operation of collector system	2,651,457.28	570,863,521	**0.0046**
2. Maintenance of Secondary Network			
D1441417 Evaluation of primary collection system	407,135.37	570,863,521	0.0007
M3001417 Corrective maintenance of collectors	3,302,694.00	570,863,521	0.0058
M3021417 Preventive maintenance of collectors	1,997,578.09	570,863,521	0.0035
Sub Total	5,707,407.46	570,863,521	**0.0100**
Total	**8,358,864.74**	**570,863,521**	**0.0146**

Source: JICA Study Team based on ABC costs, Finance Operation Team of SEDAPAL GDI

Table 3.5.1-8: Cost of Equipment for network maintenance of Comas "without project" (Secondary network of waste water collection)

(Nuevos Soles at market prices)

Process	Total Cost (S/.)	SEDAPAL 85% production (m3)	Unit Cost (S/./m3)
Collection in Secondary Networks			
1. Secondary Network Maintenance			
M7201421 Sewerage network preventive maintenance	2,952,192	200,921,652	0.0147
Sub Total	**2,952,192**	**200,921,652**	**0.0147**
1. Corrective Maintenance in Secondary Network			
D2261421 Sewerage connection maintenance	2,506,626		2,506,626
M7202421 Sewerage network corrective maintenance	7,181,383		7,181,383
Sub Total	**9,688,010**		**9,688,010**
Total	**12,640,202**		

Source: JICA Study Team based on ABC costs, Finance Operation Team of SEDAPAL GDI

Table 3.5.1-9: Connections, Consumption, Water Demand and Waste Water Quantity without Project

Year	Water Connections (Units)	Water Consumption Quantity (m^3/year)	Water Demand (Necessary Production) (m^3/year)	Fuente			Waste Water Quantity (m^3/year)
				PTA Huachipa (m^3/ year)	PTA La Atarjea (m^3/ year)	PTA Chillon (m^3/ year)	
1	110,456	25,253,099	42,442,183	42,442,183			36,075,855
2	115,330	26,472,303	44,868,310	44,868,310			38,138,064
3	120,239	27,713,215	47,373,016	47,373,016			40,267,064
4	125,184	28,944,559	49,904,411	49,904,411			42,418,750
5	126,756	29,312,175	50,977,696	50,977,696			43,331,041
6	128,270	29,687,141	52,082,704	52,082,704			44,270,298
7	129,785	30,023,846	53,139,550	53,139,550			45,168,618
8	131,300	30,395,840	54,278,285	53,611,200	667,085		46,136,543
9	132,815	30,758,378	55,420,500	53,295,840	2,124,660		47,107,425
10	134,329	31,129,689	56,599,435	52,665,120	3,934,315		48,109,519
11	135,842	31,508,834	57,814,375	52,349,760	5,464,615		49,142,219
12	137,299	31,858,473	58,997,172	51,719,040	7,278,132		50,147,597
13	138,702	32,189,401	60,167,104	51,088,320	9,078,784		51,142,039
14	140,053	32,537,005	61,390,576	50,457,600	10,932,976		52,181,989
15	141,354	32,888,986	62,645,687	50,142,240	12,503,447		53,248,834
16	142,607	33,227,417	63,898,878	49,826,880	14,071,998		54,314,046
17	143,813	33,556,365	65,157,989	49,511,520	15,646,469		55,384,291
18	144,975	33,869,701	66,411,179	49,196,160	15,768,000	1,447,019	56,449,502
19	146,096	34,186,052	67,695,153	48,880,800	15,768,000	3,046,353	57,540,880
20	147,176	34,487,235	68,974,471	48,565,440	15,768,000	4,641,031	58,628,300

Source: JICA Study Team

Table 3.5.1-10: Production, distribution, commercialization, and administration costs for the "without" Project water supply system

(Nuevos Soles at market prices, as of June 2010)

Year	Water supply operation and maintenance costs										Commercialization and administration costs					Total
	Production (Chillon WTP)	Production (La Atarjea WTP)	Production (Huachipa WTP)	Well maintenance	Primary distribution	Secondary distribution	Re.pumping from Chillon WTP	Leakage control and cadastre	Water quality control	Total	Commercialization	Micrometer maintenance	Business management	Operational accidents insurance	Total	
Unit cost	**0.9410**	**0.0707**	**0.1892**	**444,000**	**0.0199**	**0.1020**	**0.6247**	**3.3555**	**1.5530**		**39.7746**	**0.2507**	**40.9125**			
1	-	0	8,028,191	444,000	846,496	4,330,820	-	370,633	171,537	14,191,677	4,393,358	27,691	4,519,053.29	78,181	9,018,283	23,209,960
2	-	0	8,487,108	444,000	894,884	4,436,793	-	386,984	179,105	14,828,874	4,587,187	28,913	4,718,428.22	80,323	9,414,851	24,243,725
3	-	0	8,960,888	444,000	944,840	4,545,322	-	403,459	186,730	15,485,238	4,782,466	30,144	4,919,294.11	82,523	9,814,427	25,299,664
4	-	0	9,439,716	444,000	995,328	4,655,229	-	420,049	194,408	16,148,731	4,979,129	31,383	5,121,583.93	84,784	10,216,880	26,365,611
5	-	0	9,642,734	444,000	1,016,734	4,732,500	-	425,325	196,850	16,458,142	5,041,661	31,777	5,185,905.45	87,107	10,346,451	26,804,594
6	-	0	9,851,753	444,000	1,038,773	4,811,287	-	430,405	199,201	16,775,418	5,101,876	32,157	5,247,842.27	89,493	10,471,368	27,246,786
7	-	0	10,051,662	444,000	1,059,851	4,889,772	-	435,488	201,554	17,082,327	5,162,134	32,537	5,309,824.69	91,945	10,596,440	27,678,768
8	-	47,149	10,051,662	444,000	1,082,563	4,970,948	-	440,573	203,907	17,240,803	5,222,407	32,917	5,371,822.47	94,464	10,721,610	27,962,413
9	-	150,170	10,081,225	444,000	1,105,344	5,053,030	-	445,657	206,260	17,485,686	5,282,668	33,296	5,433,806.87	97,052	10,846,823	28,332,509
10	-	278,075	9,961,921	444,000	1,128,858	5,136,792	-	450,737	208,611	17,608,994	5,342,888	33,676	5,495,750.47	99,710	10,972,025	28,581,019
11	-	386,236	9,902,268	444,000	1,153,089	5,222,231	-	455,812	210,960	17,774,596	5,403,043	34,055	5,557,625.84	102,442	11,097,166	28,871,762
12	-	514,415	9,782,964	444,000	1,176,680	5,307,797	-	460,701	213,223	17,899,779	5,460,999	34,420	5,617,240.54	105,248	11,217,908	29,117,687
13	-	641,684	9,663,660	444,000	1,200,014	5,393,944	-	465,410	215,402	18,024,113	5,516,814	34,772	5,674,652.60	108,132	11,334,371	29,358,484
14	-	772,737	9,544,355	444,000	1,224,415	5,482,209	-	469,943	217,501	18,155,161	5,570,556	35,111	5,729,932.32	111,094	11,446,694	29,601,855
15	-	883,738	9,484,703	444,000	1,249,448	5,572,102	-	474,308	219,521	18,327,820	5,622,298	35,437	5,783,154.06	114,137	11,555,026	29,882,846
16	-	994,602	9,425,051	444,000	1,274,443	5,662,869	-	478,511	221,466	18,500,941	5,672,119	35,751	5,834,400.88	117,264	11,659,535	30,160,477
17	-	1,105,885	9,365,398	444,000	1,299,555	5,754,701	-	482,559	223,340	18,675,439	5,720,102	36,054	5,883,756.56	120,477	11,760,389	30,435,828
18	1,361,715	1,114,475	9,305,746	444,000	1,324,550	5,847,343	903,963	486,459	225,144	21,013,395	5,766,330	36,345	5,931,307.22	123,777	11,857,759	32,871,154
19	2,866,765	1,114,475	9,246,094	444,000	1,350,158	5,941,649	1,903,078	490,218	226,884	23,583,322	5,810,890	36,626	5,977,142.05	127,168	11,951,826	35,535,148
20	4,367,435	1,114,475	9,186,442	444,000	1,375,674	6,036,821	2,899,285	493,844	228,562	26,146,537	5,853,869	36,897	6,021,350.23	130,652	12,042,768	38,189,305

Source: JICA study team and Appendix B4

Table 3.5.1-11: Collection, commercialization, and administration costs for sewerage, "without" Project

(Nuevos Soles at market prices, as of June 2010)

Year	Sewerage operation and maintenance costs					Commercialization and administration costs				Total
	Network primary collection	Network secondary collection	Technical cadastre updating	Physical-chemical quality control	Total	Commercialization	Micrometer maintenance	Business management	Total	
Unit cost										
1	528,240	3,524,321	128,557	25,569	4,206,688	4,393,358	27,691	4,519,053	8,940,102	13,146,790
2	558,436	3,599,535	134,229	26,698	4,318,898	4,587,187	28,913	4,718,428	9,334,528	13,653,426
3	589,610	3,676,404	139,943	27,834	4,433,792	4,782,466	30,144	4,919,294	9,731,904	14,165,695
4	621,116	3,754,291	145,698	28,979	4,550,084	4,979,129	31,383	5,121,584	10,132,096	14,682,180
5	634,474	3,814,661	147,528	29,343	4,626,005	5,041,661	31,777	5,185,905	10,259,344	14,885,350
6	648,228	3,876,131	149,290	29,693	4,703,341	5,101,876	32,157	5,247,842	10,381,875	15,085,216
7	661,381	3,937,715	151,053	30,044	4,780,193	5,162,134	32,537	5,309,825	10,504,495	15,284,688
8	675,554	4,001,048	152,817	30,395	4,859,813	5,222,407	32,917	5,371,822	10,627,146	15,486,959
9	689,770	4,065,160	154,580	30,745	4,940,256	5,282,668	33,296	5,433,807	10,749,771	15,690,027
10	704,443	4,130,479	156,342	31,096	5,022,361	5,342,888	33,676	5,495,750	10,872,315	15,894,675
11	719,565	4,197,007	158,102	31,446	5,106,120	5,403,043	34,055	5,557,626	10,994,724	16,100,843
12	734,286	4,263,904	159,798	31,783	5,189,771	5,460,999	34,420	5,617,241	11,112,660	16,302,431
13	748,847	4,331,421	161,432	32,108	5,273,808	5,516,814	34,772	5,674,653	11,226,239	16,500,047
14	764,074	4,400,401	163,004	32,421	5,359,901	5,570,556	35,111	5,729,932	11,335,600	16,695,500
15	779,696	4,470,582	164,518	32,722	5,447,518	5,622,298	35,437	5,783,154	11,440,889	16,888,407
16	795,293	4,541,556	165,976	33,012	5,535,837	5,672,119	35,751	5,834,401	11,542,271	17,078,108
17	810,964	4,613,434	167,380	33,291	5,625,069	5,720,102	36,054	5,883,757	11,639,912	17,264,981
18	826,561	4,686,080	168,733	33,560	5,714,935	5,766,330	36,345	5,931,307	11,733,982	17,448,917
19	842,542	4,759,966	170,037	33,819	5,806,364	5,810,890	36,626	5,977,142	11,824,658	17,631,022
20	858,464	4,834,661	171,294	34,070	5,898,490	5,853,869	36,897	6,021,350	11,912,116	17,810,605

Source: JICA study team and Appendix B4

Table 3.5.1-12: Production, distribution, commercialization, and administration costs for the "without" Project water supply system

(Nuevos Soles at social prices, as of June 2010)

Year	Water supply operation and maintenance costs										Water supply commercialization and administration costs					Total
	Production (La Chillon WTP)	Production (La Atarjea WTP)	Production (Huachipa WTP)	Well maintenance	Primary networks distribution	Secondary networks distribution	Re-pumping from Chillon WTP	Leakage control and cadastre	Water quality control	Total	Commercialization	Micrometer maintenance	Business management	Operational accidents insurance	Total	
Unit cost	**0.797**	**0.0613**	**0.160**	**17,738**	**0.0173**	**0.08857**	**0.542**	**2.913**	**1.348**		**34.524**	**0.218**	**35.512**	**6,236**		
1	-	-	6,803,552	385,392	734,758	3,759,152	-	321,709	148,894	12,153,458	3,813,434	24,036	3,922,538	67,861	7,827,870	19,981,327
2	-	-	7,192,464	385,392	776,759	3,851,136	-	335,902	155,463	12,697,118	3,981,678	25,096	4,095,596	69,720	8,172,091	20,869,208
3	-	-	7,593,973	385,392	820,121	3,945,339	-	350,202	162,081	13,257,108	4,151,180	26,165	4,269,947	71,630	8,518,922	21,776,031
4	-	-	7,999,760	385,392	863,944	4,040,739	-	364,603	168,747	13,823,184	4,321,884	27,241	4,445,535	73,593	8,868,252	22,691,436
5	-	-	8,171,809	385,392	882,525	4,107,810	-	369,182	170,866	14,087,583	4,376,162	27,583	4,501,366	75,609	8,980,720	23,068,303
6	-	-	8,348,943	385,392	901,655	4,176,197	-	373,591	172,907	14,358,685	4,428,428	27,912	4,555,127	77,680	9,089,147	23,447,832
7	-	-	8,518,358	385,392	919,951	4,244,322	-	378,004	174,949	14,620,975	4,480,732	28,242	4,608,928	79,808	9,197,710	23,818,685
8	-	40,926	8,518,358	385,392	939,665	4,314,783	-	382,417	176,991	14,758,532	4,533,049	28,572	4,662,742	81,995	9,306,358	24,064,889
9	-	130,348	8,543,411	385,392	959,439	4,386,030	-	386,830	179,034	14,970,483	4,585,355	28,901	4,716,544	84,241	9,415,042	24,385,525
10	-	241,369	8,442,306	385,392	979,848	4,458,736	-	391,240	181,075	15,079,966	4,637,627	29,231	4,770,311	86,548	9,523,717	24,603,683
11	-	335,253	8,391,753	385,392	1,000,881	4,532,896	-	395,644	183,113	15,224,934	4,689,841	29,560	4,824,019	88,920	9,632,340	24,857,273
12	-	446,512	8,290,647	385,392	1,021,358	4,607,167	-	399,888	185,077	15,336,043	4,740,147	29,877	4,875,765	91,355	9,737,144	25,073,187
13	-	556,982	8,189,542	385,392	1,041,612	4,681,944	-	403,976	186,969	15,446,416	4,788,595	30,182	4,925,598	93,859	9,838,234	25,284,650
14	-	670,736	8,088,437	385,392	1,062,793	4,758,557	-	407,911	188,790	15,562,616	4,835,243	30,476	4,973,581	96,430	9,935,730	25,498,346
15	-	767,084	8,037,884	385,392	1,084,521	4,836,585	-	411,700	190,544	15,713,710	4,880,155	30,759	5,019,778	99,071	10,029,763	25,743,472
16	-	863,315	7,987,331	385,392	1,106,216	4,915,370	-	415,348	192,233	15,865,204	4,923,399	31,032	5,064,260	101,785	10,120,477	25,985,681
17	-	959,908	7,936,778	385,392	1,128,014	4,995,081	-	418,862	193,859	16,017,893	4,965,049	31,294	5,107,101	104,574	10,208,018	26,225,911
18	1,153,996	967,364	7,886,226	385,392	1,149,709	5,075,493	784,640	422,247	195,425	18,020,492	5,005,175	31,547	5,148,375	107,438	10,292,535	28,313,027
19	2,429,462	967,364	7,835,673	385,392	1,171,937	5,157,351	1,651,872	425,510	196,936	20,221,497	5,043,853	31,791	5,188,159	110,382	10,374,185	30,595,681
20	3,701,216	967,364	7,785,120	385,392	1,194,085	5,239,961	2,516,579	428,657	198,392	22,416,766	5,081,158	32,026	5,226,532	113,406	10,453,122	32,869,888

Source: JICA study team and Appendix B4

Table 3.5.1-13: Collection, commercialization, and administration costs for sewerage, "without" Project

Year	Sewerage operation and maintenance				Commercialization and administration				Total
	Network secondary collection	Network primary collection	Wastewater physical-chemical quality	Total	Technical cadastre updating	Commercialization	Business management	Total	
Unit cost	**0.0127**	**0.083**	**1.010**	**0.201**		**34.524**	**0.218**	**35.512**	
1	458,513	3,059,110	111,588	22,194	3,651,405	3,813,434	24,036	3,922,538	7,760,008
2	484,723	3,124,396	116,511	23,173	3,748,803	3,981,678	25,096	4,095,596	8,102,370
3	511,782	3,191,119	121,471	24,160	3,848,531	4,151,180	26,165	4,269,947	8,447,292
4	539,129	3,258,724	126,466	25,153	3,949,473	4,321,884	27,241	4,445,535	8,794,659
5	550,724	3,311,125	128,054	25,469	4,015,373	4,376,162	27,583	4,501,366	8,905,111
6	562,661	3,364,482	129,584	25,774	4,082,500	4,428,428	27,912	4,555,127	9,011,467
7	574,079	3,417,937	131,114	26,078	4,149,208	4,480,732	28,242	4,608,928	9,117,902
8	586,381	3,472,909	132,645	26,382	4,218,318	4,533,049	28,572	4,662,742	9,224,363
9	598,720	3,528,559	134,176	26,687	4,288,142	4,585,355	28,901	4,716,544	9,330,801
10	611,457	3,585,256	135,705	26,991	4,359,409	4,637,627	29,231	4,770,311	9,437,169
11	624,582	3,643,002	137,233	27,295	4,432,112	4,689,841	29,560	4,824,019	9,543,420
12	637,360	3,701,068	138,705	27,588	4,504,721	4,740,147	29,877	4,875,765	9,645,789
13	649,999	3,759,674	140,123	27,870	4,577,665	4,788,595	30,182	4,925,598	9,744,376
14	663,217	3,819,548	141,488	28,141	4,652,394	4,835,243	30,476	4,973,581	9,839,301
15	676,776	3,880,465	142,802	28,403	4,728,445	4,880,155	30,759	5,019,778	9,930,692
16	690,314	3,942,071	144,067	28,654	4,805,106	4,923,399	31,032	5,064,260	10,018,691
17	703,917	4,004,461	145,286	28,897	4,882,560	4,965,049	31,294	5,107,101	10,103,444
18	717,455	4,067,518	146,460	29,130	4,960,563	5,005,175	31,547	5,148,375	10,185,097
19	731,326	4,131,650	147,592	29,355	5,039,924	5,043,853	31,791	5,188,159	10,263,803
20	745,147	4,196,486	148,684	29,572	5,119,889	5,081,158	32,026	5,226,532	10,339,716

Source: JICA study team and Appendix B4

3.5.2 Costs in the "with" project situation

Costs in the "with" project situation are made up of investment and operation and maintenance costs. Investment costs include the following items:

i) Potable water general works

ii) Rehabilitation of reservoirs, pumping stations, and wells

iii) Rehabilitation and/or renewal of secondary networks and connections, and water supply network sectorization

iv) Potable water automation and control system

v) Rehabilitation and/or renewal of secondary network and sewerage manholes

vi) Operation and maintenance equipment

vii) Activities for environmental mitigation, social intervention, and facility technical cadastre updating

viii) Engineering consultancy services to prepare works detailed design study, procurement of equipment, assistance during biddings, supervision, and liquidation of works

General expenses, contractor's profit, and General Sales Tax (18 %), as well as administration costs to be incurred in by the project executing unit, will be included.

Operation and maintenance costs to be generated during the Project period include the same items as those in the "without" Project situation, as explained in 3.5.1.

(1) Investment costs

1) Basic conditions for cost calculations

Cost calculations for this project are based on the conceptual designs shown in Appendix C. The following are the basic conditions for cost calculations:

(a) Currency, Price levels, and Exchange rate

These are calculated in Nuevos Soles, and the price level set is as of June 2010. Foreign currency components are calculated in US Dollars (US$), and an exchange rate of US$ 1.00 = S/. 2.838 will be used for their conversion to Nuevos Soles (S/.).

In addition, cost information is organized in both foreign currency and local currency components for JICA requirement.

(b) Cost components

Investment cost calculation summary for this Project is shown in Table 3.5.2-1.

Table 3.5.2-1: Cost Components [1/]

Items	Description
1. General works	Works on primary network for water supply
2. Reservoir, pumping station, and wells	Reservoir, pumping station, and wells rehabilitation. Works include civil works, mechanical and electrical supply and installation
3. Automation and control system for water supply	SCADA system supply and installation
4. Secondary pipeline network for water supply	Secondary network and house connection works for water supply
5. Secondary pipeline for sewerage	Secondary pipeline, manholes rehabilitation and house connection works for sewerage.
6. Equipments for O&M	O&M equipments for water supply and sewerage maintenance
7. Environmental impact mitigation, social intervention, and technical cadastre costs.	1) Environmental impact Mitigation, preventive measures and wastes management costs, 2) social intervention cost during Works execution by Contractor, 3) facility technical cadastre
8. Indirect cost	General expenses and Profit for Contractor.
9. Intangibles/ Engineering services	1) Detailed design study and Works supervision cost, 2) environmental impact evaluation and archaeological remains study, and 3) environmental monitoring and follow-up program
10. IGV (Value Added Tax)	General Sales Tax

1/ Physical and Price contingencies are not included, according to SNIP regulations
Source: JICA Study Team

(c) Source for unit prices

The cost of this Project is estimated on the basis of the structure applied by SEDAPAL and it is estimated by the budgeting software (S10). Each unit price is estimated and determined in consideration of the cost information from SEDAPAL, quotations of materials and equipment, and information from the COSTOS Journal.[3]

The costs below are applied from quotations.

- Mechanical and electrical equipment of reservoir, pumping station and wells
- Pipe, valves and meters
- Pipe Cracking Method (include pipe supply)
- Asbestos pipe transportation and final disposal
- Water leakage location system (include manhole and equipments)
- Equipment for operation and maintenance

(d) Foreign and Local Currency Cost Component

The foreign and local currency cost components include the following cost items:

<u>Foreign currency component</u>

[3] Costos Journal, Civil Construction Costs, June 2010.

i) Cost of imported materials (include transportation cost)

- Pipe material (Ductile Iron pipes), Valves, Meters
- Mechanical and electrical equipment for reservoirs, pumping stations and wells
- Cost of foreign consultants and labor

ii) The supervisor and specialists for consultancy service (Detailed design/ Pre-construction/ Supervision of works)

- General expenses for contractor
- Profit for contractor

<u>Local currency component</u>

- Cost of local materials (include transportation cost)
- Cost of local labor
- Environmental cost
- Social intervention cost
- Technical cadastre
- Local portion of engineering services (Detail Design, Supervision, EIA , Archeology Survey and Environmental Monitoring)
- Local portion of contractor general expenses (overhead) and profit
- IGV (General Sales Tax)

2) Cost Estimate Condition of Each Item and / or component

(a) General Works for water supply

General works include installation of valve pits, pipes, valves and accessories as the open cut method is applied to construct the primary network.

The cost estimation for the primary network is based on SEDAPAL's cost information. The JICA study team estimated the cost of general works, modifying the unit price of each item by the condition of conceptual design and the quotation for pipes, valves and accessories.

The road pavement type is checked by the field survey, and the study team set the pavement type ratio in the Project Area as follows:

- Flexible pavement: 81%
- Rigid pavement: 1%
- No pavement: 18%

Also the pavement costs of secondary pipe works (including secondary network and house connection for water supply and sewerage) are estimated following above pavement ratio.

(b) Rehabilitation of Reservoirs, Pumping stations and Wells

The rehabilitation of reservoirs, pumping stations, and wells consists of civil works as well as mechanical and electrical works. The civil works include the rehabilitation of reservoir and building of pumping station and wells. As a result of structural survey and mechanical and electrical survey, rehabilitation items were defined.

The cost estimations for reservoirs, wells and pumping stations are based on SEDAPAL's cost information. The JICA study team estimated the cost of rehabilitation of reservoirs, pumping stations and wells, by modifying the unit price of each item based upon the condition of rehabilitation plan and the quotation of mechanical and electrical equipment.

(c) Automation and control system for water supply

This is the cost for the new installation and rehabilitation of the SCADA system for facilities (Reservoirs, Pumping Stations and Wells) and pressure reducing chambers. The cost of the SCADA system is estimated with the information of similar project.

(d) Rehabilitation of secondary network for water supply

The works of the secondary network for water supply are i) upgrading diameter of secondary network pipes to replace the existing ones not having enough capacity, ii) construction of network units in subsectors, iii) replacement of asbestos cement pipes, iv) replacement of house connections and v) renewal and removal of valves and accessories. The open cut method is applied for the rehabilitation and upgrading of secondary networks.

The cost estimation of secondary network is based on SEDAPAL's cost information. The JICA study team estimated the cost of the secondary network for water supply by modifying the unit price of each item based on the condition of conceptual design and the quotation of the pipe, valves and accessories as well as the transportation, treatment and disposal of asbestos pipes.

Asbestos pipe disposal works should be carried out by the company which has the ability to treat the asbestos properly in order to prevent health problem for labors and residents. Therefore, the project team got a quotation from BEFESA, as it is currently the only company in Peru which has permission from DIGESA (*Dirección General de Salud Ambiental*, or General Directorate for Environmental Health) to treat all activities of asbestos materials (removal, transportation, treatment and final disposal).

(e) Rehabilitation of secondary sewerage network

The works of secondary network for sewerage are i) upgrading diameter of secondary network pipes not having enough capacity, ii) rehabilitation of simple concrete pipes, iii) rehabilitation of corroded manholes, and iv) rehabilitation of house connections. The open cut method and pipe bursting or pipe cracking methods are applied for the rehabilitation of the secondary network. Basically, the open cut method is applied because the construction cost is more economical, but the pipe bursting or pipe cracking methods should be applied where i) construction works should be carried out more quickly (eg: around hospitals and schools), ii) the open cut method is inappropriate considering social problems (eg: a road with heavy traffic), and iii) the open cut method is prohibited by municipal regulation. The rehabilitation method of each secondary pipe shall be defined in the Detailed Design

Stage; therefore the study team set a preliminary ratio of the applied method to estimate the project cost. In project cost estimation, the open cut method is applied to 70% of secondary network works and pipe bursting method is 30% of them.

The cost estimation of the secondary network is based on SEDAPAL's cost information. The JICA study team estimated the cost of the open cut method by modifying the unit price of each item based on the condition of conceptual design and the quotation of pipes. The unit price of the pipe bursting method is defined by the quotation because the contractor with the ability to apply this method is limited, and normally its price is estimated by the quotation.

(f) Equipment and System for Operation and Maintenance (O&M)

Requirements for O&M equipment and their specifications were jointly evaluated at the North Services Management (GSN) by the Comas and Callao Operation and Maintenance network teams that are in charge of the maintenance activities in the project area, and the Water Leakage Detection Section in the Development and Investigation Management Office (GDI).

Cost for O&M equipments is estimated by the quotation from suppliers.

(g) Cost for environmental impact mitigation, social intervention, and technical cadastre

<u>Cost for environmental impact mitigation</u>

Cost for environmental impact mitigation includes i) the Preventive Measure Program Cost (including safety gear, equipment for solid waste collection and signaling) and ii) Waste Management Program Costs for the contractor during the construction period. The calculated amount for environmental cost mitigation represents 1.3% of the total direct cost of works. Detail of calculation is shown in Annex B-4.

<u>Social intervention cost</u>

Social intervention activities in this Project have 2 components: A social intervention consultant and a works contractor.

a) Social intervention consultant

- Communications strategy design:

The communications strategy designs will set up the contents of the messages, the intervention routes, the neighborhood's priorities, the materials, the accessories, and the communications equipment.

The intervention plan promoters will be in charge of carrying out the surveys, preparing the educational material, calling the neighbors to informational and training meetings, organizing the neighbors in water supply checking and service – related problem solution committees, and finally making the population become aware of the value of water and the need not to waste it.

Information system will be refined so that users comply with their payment commitments per consumption, and the promoters are able to check with the users that the consumption meters do not generate any further expenses, but rather allow them to save water and money.

- Training to contractors

This implies training to the contractor's staff in disseminating the messages to the population.

- Supervision to social intervention

A monitoring and control process to the contractors should be set up, as they carry out their social intervention work within the Project area.

b) The Works contractor

The works contractor should develop a social intervention plan. This social intervention plan should state if any of these other activities should be excluded.

- Activity planning, should be set up during the phase prior to works execution
- Social promotion, a participation program for the population in the Project area should be carried out to motivate the users' interest in the works that will be executed, as these will improve their quality of living.
- Participatory diagnostics, this program will encourage the population to express their interests, intentions, and establish how much the neighborhood can get organized to mitigate impacts generated by system failures. References for this are the baseline before the works execution and the baseline after the works completion.
- Organization strengthening through talks, workshops, and other events towards consolidating the neighbor organization.

This social intervention plan is further detailed in Attachment A.7.5 Social Intervention Plan Matrix.

Attachment A.7.6 also shows a Social Contingencies Plan during the General and Secondary Works Execution. This proposal must contemplate social intervention actions from the beginning of the contract or agreement, by taking into account the activity planning, the physical infrastructure program development, such as topography, land conditioning, works execution, joints, and other actions that could emerge

One of the primary aspects that must be stressed by the contractor in the social intervention plan is the one related to water valuing. Attachment A.7.7 offers an overview about the aspects to be considered for water value.

The estimated amount for social intervention cost is shown in Table 3.5.2-2

Table 3.5.2-2 Social intervention estimated cost

Reference Budget

Activities	**Length**	**Cost**			
		Man month	**Quantity**	**Unit**	**Partial**
	(meses)			**(Soles)**	**(Soles)**
Consulting					
Design of communication strategy	6	6	36	10,500.00	378,000.00
Training to contractor	1	4	4	10,500.00	42,000.00
Supervision of social intervention	36	1	36	11,500.00	414,000.00
Social intervention assistant	30	1	30	7,000.00	210,000.00
Social benefits	51%				532,440.00
Facilities, equipment and educational material	GBL	1	1	281,766.00	281,766.00
				Sub total Consulting	**1,858,206.00**
Contractor					
Preparation of the social intervention plan	3	4	12	10,500.00	126,000.00
Follow up and consolidation of the plan	3	3	9	10,500.00	94,500.00
Implementation of the intervention plan	30	24	720	3,000.00	2,160,000.00
Experts	28	2	56	7,000.00	392,000.00
Social benefits[1/]	51%				1,413,975.00
Facilities, equipment and educational material	GBL	1	1	683,879.00	683,879.00
				Sub total Contractors	**4,870,354.00**
				TOTAL	**6,728,560.00**

1/ Includes AFP or National System of Pension, bonus, vacations, CTS, life insurance
Source: JICA Study Team

Cost for technical cadastre

Technical cadastre activities will include gathering and supplementing technical information from the new facilities (as-built drawings, sketches showing reference points for accessories at street corners (“esquineros”), cadastre records for the pumping houses, reservoir wells, valve pits, fire hydrants, and equipment). This information will be based on SEDAPAL forms that are used for facility breakdown in: lineal works, non-lineal works, equipment, etc. The technical cadastre cost is estimated at 2.3 % of the total direct cost of works. Detail of calculation is shown in Annex B-4.

(h) Indirect cost

This item is made up of fixed general and variable general expenses incurred in by the Contractor and the expected profit that is estimated in a percentage of the direct cost of works.

General Contractor Expenses

The general expenses are the costs accrued by the contractor during construction. These costs include following items:

1) Fixed general expenses

- Tendering, contracting and insurance costs
- Various fixed expenses (municipality permissions, registration in national supplier)

2) Variable general expenses

- Administration of main office expenses
- General expenses for construction works

The amount of general contractor expenses is estimated by the JICA study team to be 14.2% of the direct cost, taking as a reference of works in SEDAPAL´s past international bidding documents that were executed with external funding. Calculation of overhead for the project appears in Appendix B4.

Profit for the contractor

The profit for the contractor in this project is fixed at 10% of the direct cost, considering SEDAPAL´s past international bidding documents, which are the financial proposals of the bidders who were awarded the contracts (namely, the actual contractors).

Therefore, the study team reviewed SEDAPAL's past international bidding documents with costs over 10 million Nuevos Soles,[4] and sets general expenses in this project at 15% and the profit for the contractor as 10% of direct cost of works.

(i) Intangibles

Engineering Cost

The Engineering Cost includes the costs for Detailed Design for works and assets, assistance for project management in pre-qualification and tender technical and economic proposals, and Construction Supervision. Detailed Design cost includes the cost of the following: i) social intervention before construction, ii) soil mechanics survey, iii) topographic survey, iv) structural survey, and v) sewerage survey (manhole survey and TV camera survey). The Construction Supervision cost also includes the expenses for the contractor commission, to supervise the asbestos pipe removal, and transportation works. The amount of consultancy service is estimated as 16.0 % of total construction cost. Detail of calculation is shown in Annex B-4.

Environmental Impact Assessment

Environmental evaluation costs and archaeological remains study (CIRA) are considered to be part of the consultant's activities during the preparation of the Detailed Design study. Detail of calculation is shown in Annex B-4.

Environmental Monitoring

Environmental monitoring and archaeological monitoring costs are considered to be part of the consultant's activities during the Works supervision.

[4] The summary of the economic proposals of the bidders who awarded the contracts (namely, the actual contractors) is as follows: The general expenses are between 7.7% and 21.6%, and the contractor's profit is between 4.9% and 12.0 % of direct cost.

Project Administration Costs

Costs for project technical, financial administration, control, and supervision during the investment phase through SEDAPAL's PROMESAL (*Proyecto de Mejoramiento Sanitario de las Marginales de Lima* or Sanitation Improvement Project for the Marginal Areas of Lima) team. This item includes design evaluation, bidding process management, construction supervision, works quality check, and equipment to be provided by suppliers. Calculated amount for project administration expenses was estimated to be 1.6% of the total cost of construction. Detail of calculation is shown in Annex B-4.

(j) General Sales Tax (IGV)

IGV has been added, that is, 19%.

(k) Contingencies

Physical contingencies and price contingencies, separately, are not included in the project cost makeup, considering SNIP requirements.

3) Project Total Cost

Project total cost that includes all the above mentioned items, amounts S/. 481,284 thousand (JPY 15,398 million = USD 169,585 thousand), as shown in Table 3.5.2-3.

Investment makeup is as follows:

1) Water supply general Works	: 6.1%
2) Rehabilitation of reservoirs, pumping stations, and wells	: 5.7%
3) Water supply automation and control system	: 2.1%
4) Rehabilitation and/or renewal of water secondary networks	: 27.1%
5) Rehabilitation and/or renewal of sewerage secondary networks	: 22.5%
6) Equipment for operation and maintenance	: 3.7%
7) Environmental mitigation, social intervention, and technical cadastre	: 4.3%
8) Engineering consultancy services	: 12.1%
9) Project administration	: 1.2%
10) IGV General Sales Tax)	: 15.3%

Project implementation has been foreseen for 2012-2016. Investment execution breakdown is shown in Table 3.5.2-3.

Table 3.5.2-4 shows Project investment costs at social prices which adjustment factors for each component is shown in Appendix B4.

Table 3.5.2-5 shows project investment schedule.

Table 3.5.2-3: Project Investment Costs
(Currencies at market prices, as of June 2010)

ITEM	DESCRIPTION	Unit	Quantity	Total Cost	
				Nuevos Soles	US $
1	GENERAL WORKS			23,539,637	8,294,446
1.1	PRELIMINARY AND PROVISIONAL WORKS	glb		631,298	222,445
1.2	PRIMARY PIPELINES NETWORK FOR WATER SUPPLY			22,908,339	8,072,001
1.2.1	PAVEMENT WORKS	m	33,249	1,843,095	649,434
1.2.2	PIPE AND ACCESSORIES SUPPLY	m	40,547	13,399,884	4,721,594
1.2.3	PIPE AND ACCESSORIES INSTALLATION	m	40,547	4,779,138	1,683,981
1.2.4	VALVE PIT AND ACCESORIES INSTALLATION AND SUPPLY	glb		2,886,222	1,016,992
2	REHABILITATION OF RESERVOIR,PUMPING STATION AND WELLS			22,168,652	7,811,364
2.1	WATER SUPPLY			22,168,652	7,811,364
2.1.1	EQUIPMENT AND REHABILITATION OF RESERVOIR	Unit	27	9,281,135	3,270,308
2.1..2	EQUIPMENT AND REHABILITATION OF PUMPING STATION	Unit	4	2,114,539	745,081
2.1.3	EQUIPMENT AND REHABILITATION OF WELLS	Unit	23	10,772,979	3,795,976
3	AUTOMATION AND CONTROL SYSTEM			8,281,770	2,918,171
3.1	AUTOMATION AND CONTROL SYSTEM FOR WATER SUPPLY	glb		8,281,770	2,918,171
4	SECONDARY PIPELINES NETWORK FOR WATER SUPPLY			105,045,527	37,013,928
4.1	PRELIMINARY AND PROVISIONAL WORKS	glb		4,751,212	1,674,141
4.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			40,484,608	14,265,190
4.2.1	PAVEMENT WORKS	m	187,386	8,804,955	3,102,521
4.2.2	PIPE AND ACCESSORIES SUPPLY	m	228,520	13,235,465	4,663,659
4.2.3	PIPE AND ACCESSORIES INSTALLATION (AC-PVC)	m	156,910	9,963,816	3,510,858
4.2.4	PIPE AND ACCESSORIES INSTALLATION (PVC-PVC)	m	22,110	1,151,897	405,883
4.2.5	INSTALLATION OF DI PIPES AND ACCESORIES	m	49,500	3,119,749	1,099,277
4.2.6	SUPPLY AND INSTALLATION OF VALVE PIT	glb		4,208,727	1,482,991
4.3	REHABILITATION OF HOUSE CONNECTION	Unit	70,289	52,895,975	18,638,469
4.4	PROVISIONAL CONNECTIONS	glb	-	5,498,191	1,937,347
4.5	MICROMETER SUPPLY AND INSTALLATION	Unit	10,537	1,415,541	498,781
5	SECONDARY PIPELINES NETWORK FOR SEWERAGE			87,236,647	30,738,776
5.1	PRELIMINARY AND PROVISIONAL WORKS	glb		5,469,777	1,927,335
5.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			30,791,225	10,849,621
5.2.1	PAVEMENT WORKS	m	136,350	7,577,391	2,669,976
5.2.2	PIPE AND ACCESSORIES SUPPLY	m	166,280	4,894,960	1,724,792
5.2.3	PIPE AND ACCESSORIES INSTALLATION	m	166,280	8,358,623	2,945,251
5.2.4	MANHOLE REHABILITATION	Unit	1,415	1,181,129	416,184
5.2.5	MANHOLE CONSTRUCTION	Unit	3,302	8,779,122	3,093,419
5.3	REHABILITATION OF SECONDARY NETWORK (TRENCH-LES METHOD)	m	71,210	15,318,999	5,397,815
5.4	REHABILITATION OF HOUSING CONNECTION	Unit	33,736	31,296,410	11,027,629
5.5	PROVISIONAL CONNECTIONS	glb		4,360,236	1,536,376
6	EQUIPMENTS FOR O&M			14,164,385	4,990,974
6.1	EQUIPMENT FOR PREVENTIVE MAINTENANCE	glb		1,619,245	570,558
6.2	HYDROJET FOR SEWERAGE CLEANING	glb		11,191,738	3,943,530
6.3	EQUIPMENT FOR LEAKAGE REDUCTION	glb		1,353,402	476,886
7	ENVIRONMENTAL IMPACT MITIGATION, SOCIAL INTERVENTION AND TECHNICAL CADASTRE			16,587,379	5,844,742
7.1	ENVIRONMENTAL MITIGATION	glb		3,521,631	1,240,885
7.2	SOCIAL INTERVENTION	glb		6,728,560	2,370,881
7.3	TECHNICAL CADASTRE	glb		6,337,188	2,232,977
DIRECT COST				**277,023,997**	**97,612,402**
INDIRECT COST					
	GENERAL EXPENSES			39,218,946	13,819,220
	PROFITS			27,702,400	9,761,240
	SUBTOTAL			**66,921,346**	**23,580,460**
CONSTRUCTION COST				**343,945,342**	**121,192,862**
INTANGIBLES					
	DETAIL DESIGN			21,153,035	7,453,501
	SUPERVISION			33,549,625	11,821,573
	ENVIRONMENTAL IMPACT ASSESMENT			272,731	96,100
	ENVIRONMENTAL MONITORING			3,344,132	1,178,341
	ADMINISTRATION COSTS			5,602,530	1,974,112
	SUBTOTAL			**63,922,053**	**22,523,627**
SUBTOTAL				**407,867,396**	**143,716,489**
VAT(18%)				**73,416,131**	**25,868,968**
TOTAL				**481,283,527**	**169,585,457**

Source: JICA study team and detailed budget Appendix B4

Table 3.5.2-4: Project Investment Costs
(Nuevos Soles at social prices, as of June 2010)

ITEM	DESCRIPTION	Unit	Quantity	Total Cost Nuevos Soles
1	GENERAL WORKS			26,440,931
1.1	PRELIMINARY AND PROVISIONAL WORKS	glb		0
1.2	PRIMARY PIPELINES NETWORK FOR WATER SUPPLY			26,440,931
1.2.1	PAVEMENT WORKS	m	33,249	26,440,931
1.2.2	PIPE AND ACCESSORIES SUPPLY	m	40,547	17,031,166
1.2.3	PIPE AND ACCESSORIES INSTALLATION	m	40,547	5,741,395
1.2.4	VALVE PIT AND ACCESORIES INSTALLATION AND SUPPLY	glb		3,668,370
2	REHABILITATION OF RESERVOIR,PUMPING STATION AND WELLS			27,281,775
2.1	WATER SUPPLY			27,281,775
2.1.1	EQUIPMENT AND REHABILITATION OF RESERVOIR	Unit	27	11,421,796
2.1..2	EQUIPMENT AND REHABILITATION OF PUMPING STATION	Unit	4	2,602,250
2.1.3	EQUIPMENT AND REHABILITATION OF WELLS	Unit	23	13,257,729
3	AUTOMATION AND CONTROL SYSTEM			10,548,624
3.1	AUTOMATION AND CONTROL SYSTEM FOR WATER SUPPLY	glb		10,548,624
4	SECONDARY PIPELINES NETWORK FOR WATER SUPPLY			126,948,657
4.1	PRELIMINARY AND PROVISIONAL WORKS	glb		5,512,945
4.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			49,481,150
4.2.1	PAVEMENT WORKS	m	187,386	10,216,599
4.2.2	PIPE AND ACCESSORIES SUPPLY	m	228,520	16,858,225
4.2.3	PIPE AND ACCESSORIES INSTALLATION (AC-PVC)	m	156,910	11,969,985
4.2.4	PIPE AND ACCESSORIES INSTALLATION (PVC-PVC)	m	22,110	1,417,578
4.2.5	INSTALLATION OF DI PIPES AND ACCESORIES	m	49,500	3,839,308
4.2.6	SUPPLY AND INSTALLATION OF VALVE PIT	glb		5,179,456
4.3	REHABILITATION OF HOUSE CONNECTION	Unit	70,289	63,546,338
4.4	PROVISIONAL CONNECTIONS	glb	-	6,605,227
4.5	MICROMETER SUPPLY AND INSTALLATION	Unit	10,537	1,802,997
5	SECONDARY PIPELINES NETWORK FOR SEWERAGE			103,078,572
5.1	PRELIMINARY AND PROVISIONAL WORKS	glb		6,571,091
5.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			36,612,401
5.2.1	PAVEMENT WORKS	m	136,350	8,792,228
5.2.2	PIPE AND ACCESSORIES SUPPLY	m	166,280	6,221,462
5.2.3	PIPE AND ACCESSORIES INSTALLATION	m	166,280	10,041,594
5.2.4	MANHOLE REHABILITATION	Unit	1,415	1,370,492
5.2.5	MANHOLE CONSTRUCTION	Unit	3,302	10,186,625
5.3	REHABILITATION OF SECONDARY NETWORK (TRENCH-LES METHOD)	m	71,210	17,999,433
5.4	REHABILITATION OF HOUSING CONNECTION	Unit	33,736	36,772,482
5.5	PROVISIONAL CONNECTIONS	glb		5,123,165
6	EQUIPMENTS FOR O&M			18,002,841
6.1	EQUIPMENT FOR PREVENTIVE MAINTENANCE	glb		2,058,050
6.2	HYDROJET FOR SEWERAGE CLEANING	glb		14,224,627
6.3	EQUIPMENT FOR LEAKAGE REDUCTION	glb		1,720,165
7	ENVIRONMENTAL IMPACT MITIGATION, SOCIAL INTERVENTION AND TECHNICAL CADASTRE			21,520,865
7.1	ENVIRONMENTAL MITIGATION	glb		4,372,360
7.2	SOCIAL INTERVENTION	glb		8,873,596
7.3	TECHNICAL CADASTRE	glb		8,274,909
CONSTRUCTION COST				333,822,264
INTANGIBLES				
	DETAIL DESIGN			22,433,491
	SUPERVISION			35,540,868
	ENVIRONMENTAL IMPACT ASSESMENT			290,241
	ENVIRONMENTAL MONITORING			3,420,399
	ADMINISTRATION COSTS			6,009,386
	SUBTOTAL			67,694,385
TOTAL				401,516,649

Source: JICA study team and detailed budget Appendix B4 .

Table 3.5.2-5: Project Investment Schedule (Nuevos Soles at market prices, as of June 2010)

Item	Description	Total (S/.)	2012	2013	2014	2015	2016
1	**GENERAL WORKS**	**34,486,873**		**4,310,860**	**17,243,437**	**12,932,576**	
1.1	PRELIMINARY AND PROVISIONAL WORKS	924,887		115,611	462,444	346,832	
1.2	PRIMARY PIPELINES NETWORK FOR WATER SUPPLY	33,561,986					
1.2.1	PAVEMENT WORKS	2,700,236		337,530	1,350,118	1,012,588	
1.2.2	PIPE AND ACCESSORIES SUPPLY	19,631,572		2,453,947	9,815,786	7,361,839	
1.2.3	PIPE AND ACCESSORIES INSTALLATION	7,001,702		875,213	3,500,851	2,625,638	
1.2.4	VALVE PIT AND ACCESORIES INSTALLATION AND SUPPLY	4,228,476		528,559	2,114,238	1,585,679	
2	**REHABILITATION OF RESERVOIR,PUMPING STATION AND WELLS**	32,478,304		**4,059,788**	**16,239,151**	**12,179,365**	
2.1	WATER SUPPLY	32,478,304					
2.1..	EQUIPMENT AND REHABILITATION OF RESERVOIR	13,597,377		1,699,672	6,798,688	5,099,017	
2.1.2	EQUIPMENT AND REHABILITATION OF PUMPING STATION	3,097,917		387,240	1,548,958	1,161,719	
2.1.3	EQUIPMENT AND REHABILITATION OF WELLS	15,783,010		1,972,876	7,891,505	5,918,629	
3	**AUTOMATION AND CONTROL SYSTEM**	12,133,252		**1,516,656**	**6,066,626**	**4,549,970**	
3.1	AUTOMATION AND CONTROL SYSTEM FOR WATER SUPPLY	12,133,252		1,516,656	6,066,626	4,549,970	
4	**SECONDARY PIPELINES NETWORK FOR WATER SUPPLY**	153,897,517			**46,169,256**	**61,559,008**	**46,169,253**
4.1	PRELIMINARY AND PROVISIONAL WORKS	6,960,789			2,088,237	2,784,316	2,088,236
4.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)	59,312,194					
4.2.1	PAVEMENT WORKS	12,899,746			3,869,924	5,159,899	3,869,923
4.2.2	PIPE AND ACCESSORIES SUPPLY	19,390,689			5,817,207	7,756,276	5,817,206
4.2.3	PIPE AND ACCESSORIES INSTALLATION (AC-PVC)	14,597,543			4,379,263	5,839,017	4,379,263
4.2.4	PRESSURE REDUCTION VALVE PIT (PVC-PVC)	1,687,592			506,278	675,037	506,277
4.2.5	INSTALLATION OF DI PIPES AND ACCESORIES	4,570,605			1,371,181	1,828,242	1,371,182
4.2.6	SUPPLY AND INSTALLATION OF VALVE PIT	6,166,018			1,849,806	2,466,407	1,849,805
4.3	REHABILITATION OF HOUSE CONNECTION	77,495,534			23,248,660	30,998,214	23,248,660
4.4	PROVISIONAL CONNECTIONS	8,055,155			2,416,546	3,222,062	2,416,547
4.5	MICROMETER SUPPLY AND INSTALLATION	2,073,845			622,154	829,538	622,153
5	**SECONDARY PIPELINES NETWORK FOR SEWERAGE**	127,806,521			**38,341,957**	**51,122,609**	**38,341,955**
5.1	PRELIMINARY AND PROVISIONAL WORKS	8,013,526			2,404,058	3,205,410	2,404,058
5.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)	45,110,850					
5.2.1	PAVEMENT WORKS	11,101,298			3,330,389	4,440,519	3,330,390
5.2.2	PIPE AND ACCESSORIES SUPPLY	7,171,388			2,151,416	2,868,555	2,151,417
5.2.3	PIPE AND ACCESSORIES INSTALLATION	12,245,846			3,673,754	4,898,339	3,673,753
5.2.4	MANHOLE REHABILITATION	1,730,419			519,126	692,168	519,125
5.2.5	MANHOLE CONSTRUCTION	12,861,900			3,858,570	5,144,760	3,858,570
5.3	REHABILITATION OF SECONDARY NETWORK (TRENCH-LES METHOD)	22,443,183			6,732,955	8,977,273	6,732,955
5.4	REHABILITATION OF HOUSING CONNECTION	45,850,975			13,755,293	18,340,390	13,755,292
5.5	PROVISIONAL CONNECTIONS	6,387,987			1,916,396	2,555,195	1,916,396
6	**EQUIPMENTS FOR O&M**	20,751,609				**20,751,609**	**0**
6.1	EQUIPMENT FOR PREVENTIVE MAINTENANCE	2,372,283				2,372,283.25	
6.2	HYDROJET FOR SEWERAGE CLEANING	16,396,516				16,396,516.26	
6.3	EQUIPMENT FOR LEAKAGE REDUCTION	1,982,809				1,982,809.06	
7	**ENVIRONMENTAL IMPACT MITIGATION, SOCIAL INTERVENTION AND TECHNICAL CADASTRE**	24,301,429		**2,025,119**	**8,100,476**	**8,100,476**	**6,075,358**
7.1	ENVIRONMENTAL MITIGATION	5,159,385		429,949	1,719,795	1,719,795	1,289,845.53
7.2	SOCIAL INTERVENTION	9,857,713		821,476	3,285,904	3,285,904	2,464,429.20
7.3	TECHNICAL CADASTRE	9,284,332		773,694	3,094,777	3,094,777	2,321,083.54
DIRECT COST		**405,855,504**		**11,912,423**	**132,160,903**	**171,195,611**	**90,586,566**
INTANGIBLES							
	DETAIL DESIGN	24,960,581	9,360,218	15,600,363			
	SUPERVISION	39,588,558		3,299,047	13,196,186	13,196,186	9,897,139
	ENVIRONMENTAL IMPACT ASSESMENT	321,823	120,683	201,140			
	ENVIRONMENTAL MONITORING	3,946,076		328,840	1,315,359	1,315,359	986,518
	ADMINISTRATION COSTS	6,610,985	521,920	1,043,840	2,087,680	1,913,706	1,043,839
	SUBTOTAL	**75,428,023**	**10,002,821**	**20,473,230**	**16,599,225**	**16,425,251**	**11,927,496**
CONTINGENCY							
	PHYSICAL CONTINGENCY						
	PRICE CONTINGENCY						
	SUBTOTAL	**0**					
TOTAL		**481,283,527**	**10,002,821**	**32,385,653**	**148,760,128**	**187,620,862**	**102,514,063**

Source: JICA study team and detailed budget Appendix B4

(2) Operation and maintenance costs in the "with" Project situation

Operation and maintenance costs in the "with" Project situation include costs at market prices and social prices incurred in during actions and activities to operate water and sewerage systems that will be rehabilitated, improved and/or optimized, and sectorized.

In order to estimate operation and maintenance costs in the water supply and sewerage systems, methodology described in detail in 3.5.1 (Operation and maintenance costs in the "without" project situation) was followed, based on the "Process Costs by Elements" or SEDAPAL's ABC Costs for 2009. These costs were updated, as of June 2010, with the wholesale price indices (IPM). 18%VAT has been added to these cost for the cases as required, such as water purchase from Chillon WTP and Huachipa in the future; and for other O&M cost, based on cost structure of SEDAPAL, is 1.12 (see annex B-4).

In order to calculate the annual operation and maintenance costs for water supply production, primary and secondary distribution, and commercial and administrative activity costs, unit costs in the "with" project situation will be used. See Table 3.5.2-6, Table 3.5.2-7, and Table 3.5.2-8.

Likewise, "with" project unit costs will be used to calculate wastewater primary and secondary collection costs and control activities (physical and bacteriological analyses) as shown in Table 3.5.2-7. It must be mentioned that basic differences between the "with" and "without" project costs are given in corrective maintenance cost in the system of water supply secondary distribution network and collection of sewerage in secondary network in which the highest difference cost is in the corrective maintenance because of insurance payments or accidents payment to be assumed by SEDAPAL on behalf of third parties or affected families and for the cost for repair of connections and damaged pipes.

As a result of the Projects Lima North I and II, it is assumed that the corrective costs in water supply secondary distribution will decrease to 56.48%, it means a corrective maintenance costs reduction of 86.4% in the "with" Project situation (from 10,865,467 Nuevos soles in "without" Project situation to 1,668,119 Nuevos soles in "with" Project situation), corrective maintenance cost represents only 23.5% in "with" project situation, as shown in Table 3.5.2-9 and Table 3.5.2-10 in which is shown the estimated costs as of 2010. In conclusion, by effects of the project, maintenance cost of water connection in secondary distribution network will decrease in 20% and the corrective maintenance of water networks up to 10%. It will generate the O&M cost decreasing in secondary network in 56.48%.

Table 3.5.2-6: "with" Project situation – Unit cost by potable water process

(Nuevos Soles, as of June 2010)

Process	(1) Total cost VAT included (S/.)	(2) Produced volume (m^3)	(3) Production source	(4) Unit costs at market prices VAT inc. (S/. / Connection / year) [4/]	(5) Unit costs at social prices (S/. / Connection)
Potable water: Cost per produced m^3					
- Purchase of potable water Chillon WTP	**46,100,362**	48,988,304	Chillón WTP	0.9410	0.7975
- Surface water production SEDAPAL			Atarjea WTP		
Operation cost	28,831,441	528,520,953		0.0546	0.0474
Maintenance cost	8,524,163	528,520,953		0.0161	0.0140
Total	37,355,604	528,520,953		**0.0707**	**0.0613**
- Surface water production Huachipa WTP	**29,826,110**	157,680,000	Huachipa WTP	0.1892	0.1603
- Primary distribution			Production SEDAPAL		
Operation cost	5,269,876	671,604,142		0.0078	0.0068
Maintenance cost	8,125,053	671,604,142		0.0121	0.0105
Total	**13,394,929**	671,604,142		**0.0199**	**0.0173**
- Secondary distribution			North Management Office production		
Operation cost	1,089,906	236,378,414		0.0046	0.0040
Maintenance cost	5,995,354	236,378,414		0.0254	0.0220
Total	**7,085,26**0	236,378,414		**0.0300**	**0.0260**
- Re-pumping of potable water			Re-pumping volume of North Management Office		
Operation cost	14,702,174	30,912,996		0.4756	0.4128
Maintenance cost	4,609,394	30,912,996		0.1491	0.1287
Total	**19,311,569**	30,912,996		**0.6247**	**0.5415**
- Insurance against operative accidents	**6,236**		CCSS Comas	**6,236**	**5,284.6300**
- Operation of well	**8,219,172**	16,566,056	North Management Office groundwater production	**0.4961**	**0.4307**
- Controling and maintenance of well and pumping station	**6,804,970**	333	SEDAPAL wells	**20,435**	**17,738**

Source: JICA study team, ABC costs, Financial operation team of SEDAPAL, GDI

Table 3.5.2-7: "With" Project situation - Unit costs per commercial and administrative activity processes

(Nuevos Soles, as of June 2010)

Process	(1) Total Cost VAT included (S/.)	(2) Connections (Units)	(3) Production source	(4) Unit costs at market prices VAT inc. (S/. / Connection / year) [2/]	(5) Unit costs at social prices (S/. / Connection)
Commercial activities: Cost per connections					
- Central admnistration					
Metering and meter reading	**6,586,166**	**1,019,718**	SEDAPAL total connections	**6.4588**	**5.6062**
- Commercialization Costs	**18,708,926**	**255,970**	CCSS Comas total connections	**73.0903**	**63.4424**
- Meters					
- Cost per operative meter	**90,001**	**179,501**	CCSS Comas active connections	**0.5014**	**0.4352**
- Administration	**83,438,477.5**	**1,019,718**	SEDAPAL total connections	**81.8251**	**71.0241**
- Technical cadastre	**884,048**	**1,019,718**		**0.8670**	**0.7525**
- Leakage detection and repair	**2,537,578**	**1,019,718**		**2.4885**	**2.1600**
- Water quality evaluation					
Physical chemical analysis	**490,996.4**	**1,019,718**		**0.4815**	**0.4179**
Biological bacteriological analysis	**1,092,609.9**	**1,019,718**		**1.0715**	**0.9300**

Source: JICA study team, ABC costs, Financial operation team of SEDAPAL, GDI

Table 3.5.2-8: "With" project situation - Unit costs per sewerage system activity processes

Process	(1) Total Cost VAT included (S/.)	(2) Collected volume (m^3)	(3) Production source	(4) Unit costs at market prices VAT inc. (S/. / m^3) 4/	(5) Unit costs at social prices (S/. / m^3)
Sewerage: Cost per revenue m^3					
- Secondary collection			85% of produced amount North Service Management		
Maintenance cost	2,952,192	200,921,652		0.0147	0.0128
Corrective maintenance cost	1,937,602	200,921,652		0.0096	0.0084
	4,889,794			**0.0243**	**0.0211**
- Primary collection					
Operation cost	2,651,457	570,863,521	85% of produced amount SEDAPAL	0.00464	0.0040
Total maintenance	5,707,407	570,863,521		0.01000	0.0087
Total	**8,358,865**			**0.0146**	**0.0127**
- Control					
Technical cadastre	**1,186,822**	**1,019,718**	Total connections SEDAPAL	**1.16387**	**1.0102**
Quality evaluation	**236,053**	**1,019,718**		**0.23149**	**0.2009**

Source: JICA study team, ABC costs, Financial operation team of SEDAPAL, GDI

Table 3.5.2-9: O&M Costs for water distribution in secondary networks of North Management Comas Office, "without" Project (Secondary Network)
(Nuevos Soles at market prices, as of June 2010)

Process	Total Cost (S/.)	Distribution of cost %	North Management Office Production (m^3)	Unit Cost (S/./m^3)
Distribution in Secondary Network				
1. Operation of secondary network of distribution				
D2001421 Operation of water secondary system	1,089,906	7%	236,378,414	0.0046
2. Maintenance of secondary network				
M7001421 Preventive maintenance of water network	3,327,840	20%	236,378,414	0.0141
M7003421 Storage structure cleaning	999,395	6%	236,378,414	0.0042
Sub Total	**5,417,141**	**27%**		0.0229
Corrective Maintenance	10,865,467	67%		10,865,467
Sub Total	**10,865,467**	**67%**		**10,865,467**
Total	**16,282,608**	100%		

(*) It is assumed that it comprise preventive and corrective works as same proportion than registered to networks
Source: JICA study team, EPOF, ABC Costs – SEDAPAL, May 2010

Table 3.5.2-10: O&M Costs for water distribution in secondary networks of North Management Comas Office, "with" Project (Secondary Network)
(Nuevos Soles at market prices, as of June 2010)

Process	Total Cost (S/.)	Distribution of cost %	North Management Office Production (m^3)	Unit Cost (S/./m^3)
Distribution in Secondary Network				
1. Operation of secondary network of distribution				
D2001421 Operation of water secondary system	**1,089,905.77**	**15.4%**	236,378,414	0.0046
2. Maintenance of secondary network				
M7001421 Preventive maintenance of water network	3,327,840.50	47.0%	236,378,414	0.0141
M7003421 Storage structure cleaning	999,394.64	14.1%	236,378,414	0.0042
Sub Total	**5,417,140.91**	**61.1%**		0.0229
Corrective maintenance				
D2241421 Maintenance of water connection	1,163,145	16.4%	236,378,414	0.0049
M7002421 Corrective maintenance of water network	504,974	7.1%	236,378,414	0.0021
Sub Total	**1,668,119**	**23.5%**		0.0071
Total	**7,085,259.96**			**0.0300**

(*) It is assumed that it comprise preventive and corrective works as same proportion than registered to networks
Source: JICA study team, EPOF, ABC Costs – SEDAPAL, May 2010

Table 3.5.2-11: O&M Costs for secondary networks collection of North Management Comas Office - "without" Project (Wastewater Collection Secondary Network)
(Nuevos Soles at market prices, as of June 2010)

Process	Total Cost (S/.)	Distribution of cost %	% SEDAPAL production (m^3)	Unit cost (S/./m^3)
Collection of Secondary Networks				
1. Maintenance of Secondary Network				
M7201421 Preventive maintenance of sewerage networks	2,952,192	23.4%	200,921,652	0.0147
Sub Total	**2,952,192**	**23.4%**	**200,921,652**	**0.0147**
1. Corrective Maintenance of Secondary Network				
D2261421 Maintenance of sewerage connections	2,506,626	19.8%		2,506,626
M7202421 Corrective maintenance of sewerage networks	7,181,383	56.8%		7,181,383
Sub Total	**9,688,010**	**76.6%**		**9,688,010**
Total	**12,640,202**	100.0%		

Source: JICA study team, EPOF, ABC Costs – SEDAPAL, May 2010

Table 3.5.2-12: O&M Costs for secondary networks collection of North Management Comas Office - "with" Project (Wastewater Collection Secondary Network)
(Nuevos Soles at market prices, as of June 2010)

Process	Total Cost (S/.)	Distribution of cost %	North management office production (m^3)	Unit cost (S/./m^3)
Collection in Secondary Networks				
1. Maintenance of Secondary Network				
M7201421 Preventive maintenance of sewerage networks	2,952,192	60.4%	200,921,652	0.0147
Subtotal	**2,952,192**	**60.4%**	**200,921,652**	**0.0147**
1. Corrective Maintenance of Secondary Network				
D2261421 Maintenance of water connection	501,325	10.3%		501,325
M7202421 Corrective maintenance of water network	1,436,277	29.4%		1,436,277
Subtotal	**1,937,602**	**39.6%**		**1,937,602**
Total	**4,889,794**	100.0%		

Source: JICA study team, EPOF, ABC Costs – SEDAPAL, May 2010

Estimated costs in the "with" Project situation are estimated in the planning horizon, by multiplying the relevant unit costs that included the following aspects and/or items: i) projected water supply demand in the "with" project situation to get annual production , primary distribution, and secondary distribution annual costs, ii) the wastewater projected volume to get primary and secondary collection costs, and iii) the number of projected connections to get commercialization and administration costs. It must be pointed out that the number of projected water supply and sewerage connections in the "with" and "without" project situations is the same, as the project does not foresee any service coverage enlargements. Therefore, connection costs are the same and do not show any increases whatsoever.

In order to estimate operation and maintenance costs in the "with" project situation, the following assumptions have been set out:

(1) Water supply to the Project area of influence will be from the Huachipa WTP that should start operating as of 2011. This production source will interconnect to the project area through the Northern Branch (Ramal Norte), the Northern Branch supplementary works,

and the Lima Norte I project primary works5 that will start operating in 2012. The Chillón WTP and the La Atarjea WTP will be left aside and will be used in case of shortage. All 23 wells will be kept as a contingency plan in case of any water supply cuts and/or shortage at the Huachipa WTP. Pumping houses will be rehabilitated, and electromechanical and hydro-mechanical equipment will be renewed.

(2) As for the calculation of the annual costs in the project planning horizon (“with project”), it is assumed that average unit costs will be kept constant, except for the corrective maintenance in secondary networks and insurance costs which will not be incurred since the renewal and rehabilitation of water and sewerage systems; therefore, annual costs will proportionally increase to the water supply demand in the “with” project situation, however, it is expected cost will be similar to the situation “without” project, as a result of an improved secondary distribution and connection system and an improved network sectorization. This will bring about a reduction in technical losses between 40 % and 20 % which will generate more water availability. Likewise, as water consumptions are rationalized as an effect of the micrometering coverage increase via the SIAC service, it is estimated that water supply demand will decrease in the project area of influence due to reduction of losses. Updating of the technical cadastre in the facilities also work on behalf of this objective, as it will allow for gaining timely knowledge of the facilities and their location, and this will help towards applying control and preventive maintenance measures that will contribute to operation and maintenance costs savings and infrastructure preservation.

(3) Administration, commercial, meter maintenance costs will increase as new users and meters are included. These costs will be the same for both in the “with” and the “without” project situation, as these items have no substantial effects on the project implementation. It is necessary to say that the cost of commercialization and administration has been distributed proportionally to water and sewerage system in 50% each.

(4) Difference between the “with” Project and the “without” Project water supply demands lies in the volume of reclaimed water, as shown in Table 3.5.2-13; therefore, reclaimed water operation and maintenance costs will be determined by the “without” and the “with” project operation and maintenance cost differences. In this sense, operation and maintenance costs in the “with” and the “without” Project situations would be the same, if the following are included: the “with” project operation and maintenance costs, the operation and maintenance costs for reclaimed water for each component - except for the items, the network corrective maintenance, and the potable water and sewerage connections -, and the insurance costs for accidents caused by network breakages and well maintenance costs. Tables from 3.5.2-14 to 3.5.2-17 show the summary of operation, maintenance,

[5] Optimization of the Potable Water and Sewerage Networks Infrastructure: Sectorization, rehabilitation, and cadastre of the GSN – Huachipa WTP and the Chillón Drainage Area (in investment phase.)

commercialization and administration costs in situation "with" Project at market and social prices. Detail calculation of operation costs are shown in Appendix B4.

Tables 3.5.2-18 and 3.5.2-19 show the summary of total cost of operation and maintenance, including cost of commercialization and administration of the water and sewerage system at market and social prices, such as total unit cost (S/./ m3).

(5) Other additional items under operation and maintenance costs in the "with" Project situation would be the commercialization costs of reclaimed water to be distributed to in the areas close to the project area, for their billing by SEDAPAL. These costs were calculated by multiplying the unit costs of commercialization and administration, in the "without" project situation (section 3.5.1), by annual reclaimed water volume for the project horizon which is distributed to an equivalent number of connections.

Annual projected costs of commercialization at market prices are shown in Table 3.5.2-20, at market prices. It must be pointed out that the costs are additional for SEDAPAL, as a result of the project due to reclaimed water; therefore they will be used for the private evaluation of the project.

Table 3.5.2-13: Consumption, Demand "without" and "with" Project, and Reclaimed Water Volume

Year	Potable water consumption (thousands of m^3/year)	With Project		Without Project		Reclaimed water volume (thousands of m^3/year)
		Technical losses (%)	Potable water demand (thousands of m^3/year)	Technical losses (%)	Potable water demand (thousands of m^3/year)	
2009	18,870	40	31,660	40	31,660	
2010	19,689	40	32,920	40	32,920	
2011	20,399	40	33,990	40	33,990	
2012	21,052	40	34,967	40	34,967	
2013	21,645	40	35,841	40	35,841	
2014	22,841	40	37,768	40	37,768	
2015	24,030	40	34,613	40	34,613	
2016	25,253	41	42,442	25	33,694	8,748
2017	26,472	41	44,868	20	33,090	11,778
2018	27,713	42	47,373	20	34,642	12,731
2019	28,945	42	49,904	20	36,181	13,724
2020	29,312	43	50,978	20	36,640	14,337
2021	29,687	43	52,083	20	37,109	14,974
2022	30,024	44	53,140	20	37,530	15,610
2023	30,396	44	54,278	20	37,995	16,283
2024	30,758	45	55,421	20	38,448	16,973
2025	31,130	45	56,599	20	38,912	17,687
2026	31,509	46	57,814	20	39,386	18,428
2027	31,858	46	58,997	20	39,823	19,174
2028	32,189	47	60,167	20	40,237	19,930
2029	32,537	47	61,391	20	40,671	20,719
2030	32,889	48	62,646	20	41,111	21,534
2031	33,227	48	63,899	20	41,534	22,365
2032	33,556	49	65,158	20	41,945	23,213
2033	33,870	49	66,411	20	42,337	24,074
2034	34,186	50	67,695	20	42,733	24,963
2035	34,487	50	68,974	20	43,109	25,865

Source: JICA study team (same as Table 3.6.2-3)

Table 3.5.2-14: Production, distribution, commercialization, and administration costs for the "with" Project water supply system [1/]

(Nuevos Soles at market prices, as of June 2010)

Year	Water supply operation and maintenance										Commercialization and administration				Total
	Production (Chillon WTP)	Production (Huachipa WTP)	Production (La Atarjea WTP)	Well maintenance	Primary distribution	Secondary distribution	Pumping from Chillon WTP	Leakage control and cadastre	Water quality control	Total	Commercialization	Micrometer maintenance	Business management	Total	
Unit cost	**0.94**	**0.071**	**0.1892**	**20,435**	**0.0199**	**0.0300**	**0.6247**	**3.3555**	**1.5530**		**39.7746**	**0.2507**	**40.9125**		
1	-	0	8,028,191	674,366	846,496	1,272,172	-	370,633	171,537	11,363,395	4,393,358	27,691	4,519,053.29	8,940,102	20,303,497
2	-	0	8,487,108	674,366	894,884	1,344,893	-	386,984	179,105	11,967,341	4,587,187	28,913	4,718,428.22	9,334,528	21,301,869
3	-	0	8,960,888	674,366	944,840	1,419,969	-	403,459	186,730	12,590,252	4,782,466	30,144	4,919,294.11	9,731,904	22,322,155
4	-	0	9,439,716	674,366	995,328	1,495,846	-	420,049	194,408	13,219,714	4,979,129	31,383	5,121,583.93	10,132,096	23,351,810
5	-	0	9,642,734	674,366	1,016,734	1,528,017	-	425,325	196,850	13,484,026	5,041,661	31,777	5,185,905.45	10,259,344	23,743,371
6	-	0	9,851,753	674,366	1,038,773	1,561,139	-	430,405	199,201	13,755,637	5,101,876	32,157	5,247,842.27	10,381,875	24,137,511
7	-	0	10,051,662	674,366	1,059,851	1,592,817	-	435,488	201,554	14,015,738	5,162,134	32,537	5,309,824.69	10,504,495	24,520,234
8	-	47,149	10,051,662	674,366	1,082,563	1,626,950	-	440,573	203,907	14,127,170	5,222,407	32,917	5,371,822.47	10,627,146	24,754,317
9	-	150,170	10,081,225	674,366	1,105,344	1,661,187	-	445,657	206,260	14,324,209	5,282,668	33,296	5,433,806.87	10,749,771	25,073,980
10	-	278,075	9,961,921	674,366	1,128,858	1,696,524	-	450,737	208,611	14,399,093	5,342,888	33,676	5,495,750.47	10,872,315	25,271,407
11	-	386,236	9,902,268	674,366	1,153,089	1,732,941	-	455,812	210,960	14,515,673	5,403,043	34,055	5,557,625.84	10,994,724	25,510,397
12	-	514,415	9,782,964	674,366	1,176,680	1,768,395	-	460,701	213,223	14,590,743	5,460,999	34,420	5,617,240.54	11,112,660	25,703,404
13	-	641,684	9,663,660	674,366	1,200,014	1,803,462	-	465,410	215,402	14,663,998	5,516,814	34,772	5,674,652.60	11,226,239	25,890,237
14	-	772,737	9,544,355	674,366	1,224,415	1,840,135	-	469,943	217,501	14,743,453	5,570,556	35,111	5,729,932.32	11,335,600	26,079,053
15	-	883,738	9,484,703	674,366	1,249,448	1,877,756	-	474,308	219,521	14,863,840	5,622,298	35,437	5,783,154.06	11,440,889	26,304,729
16	-	994,602	9,425,051	674,366	1,274,443	1,915,319	-	478,511	221,466	14,983,759	5,672,119	35,751	5,834,400.88	11,542,271	26,526,030
17	-	1,105,885	9,365,398	674,366	1,299,555	1,953,060	-	482,559	223,340	15,104,164	5,720,102	36,054	5,883,756.56	11,639,912	26,744,076
18	1,361,714.83	1,114,475	9,305,746	674,366	1,324,550	1,990,624	903,963.08	486,459	225,144	17,387,042	5,766,330	36,345	5,931,307.22	11,733,982	29,121,025
19	2,866,765.44	1,114,475	9,246,094	674,366	1,350,158	2,029,110	1,903,078.42	490,218	226,884	19,901,150	5,810,890	36,626	5,977,142.05	11,824,658	31,725,808
20	4,367,434.53	1,114,475	9,186,442	674,366	1,375,674	2,067,456	2,899,285.12	493,844	228,562	22,407,539	5,853,869	36,897	6,021,350.23	11,912,116	34,319,655

1/ Includes reclaimed water operation and maintenance costs

Source: JICA study team and Appendix B4

Table 3.5.2-15: Collection, commercialization, and administration costs for sewerage, "with" Project 1/

(Nuevos Soles at market prices, as of June 2010)

Year	Sewerage operation and maintenance Cost					Commercialization and administration Cost				Total
	Primary collections in networks	Secondary collections in networks	Technical cadastre updating	Physical – chemical quality control	Total	Commercialization	Micrometer maintenance	Business management	Total	
Unit cost	**0.0146**	**0.0243**	**1.1639**	**0.2315**		**39.7746**	**0.2507**	**40.9125**		
1	528,240	877,972	128,557	25,569	1,560,339	4,393,358	27,691	4,519,053	8,940,102	10,500,441
2	558,436	928,159	134,229	26,698	1,647,522	4,587,187	28,913	4,718,428	9,334,528	10,982,050
3	589,610	979,972	139,943	27,834	1,737,360	4,782,466	30,144	4,919,294	9,731,904	11,469,263
4	621,116	1,032,338	145,698	28,979	1,828,130	4,979,129	31,383	5,121,584	10,132,096	11,960,227
5	634,474	1,054,540	147,528	29,343	1,865,885	5,041,661	31,777	5,185,905	10,259,344	12,125,229
6	648,228	1,077,398	149,290	29,693	1,904,609	5,101,876	32,157	5,247,842	10,381,875	12,286,483
7	661,381	1,099,261	151,053	30,044	1,941,738	5,162,134	32,537	5,309,825	10,504,495	12,446,234
8	675,554	1,122,817	152,817	30,395	1,981,582	5,222,407	32,917	5,371,822	10,627,146	12,608,728
9	689,770	1,146,445	154,580	30,745	2,021,540	5,282,668	33,296	5,433,807	10,749,771	12,771,311
10	704,443	1,170,833	156,342	31,096	2,062,714	5,342,888	33,676	5,495,750	10,872,315	12,935,029
11	719,565	1,195,965	158,102	31,446	2,105,078	5,403,043	34,055	5,557,626	10,994,724	13,099,802
12	734,286	1,220,433	159,798	31,783	2,146,300	5,460,999	34,420	5,617,241	11,112,660	13,258,960
13	748,847	1,244,635	161,432	32,108	2,187,021	5,516,814	34,772	5,674,653	11,226,239	13,413,260
14	764,074	1,269,944	163,004	32,421	2,229,443	5,570,556	35,111	5,729,932	11,335,600	13,565,043
15	779,696	1,295,907	164,518	32,722	2,272,843	5,622,298	35,437	5,783,154	11,440,889	13,713,732
16	795,293	1,321,831	165,976	33,012	2,316,112	5,672,119	35,751	5,834,401	11,542,271	13,858,383
17	810,964	1,347,878	167,380	33,291	2,359,513	5,720,102	36,054	5,883,757	11,639,912	13,999,425
18	826,561	1,373,801	168,733	33,560	2,402,656	5,766,330	36,345	5,931,307	11,733,982	14,136,638
19	842,542	1,400,362	170,037	33,819	2,446,760	5,810,890	36,626	5,977,142	11,824,658	14,271,418
20	858,464	1,426,826	171,294	34,070	2,490,655	5,853,869	36,897	6,021,350	11,912,116	14,402,770

1/ Includes wastewater volume operation and maintenance costs for reclaimed water input

Source: JICA study team and Appendix B4

Table 3.5.2-16: Production, distribution, commercialization, and administration costs for the "with" Project water supply system [1/] (Nuevos Soles at social prices, as of June 2010)

Year	Water supply operation and maintenance										Commercialization and administration				Total
	Production (Chillon WTP)	Production (Huachipa WTP)	Production (La Atarjea WTP)	Well maintenance	Primary distribution	Secondary distribution	Pumping from Chillon WTP	Leakage control and cadastre	Water quality control	Total	Commercialization	Micrometer maintenance	Business management	Total	
Unit cost	**0.7975**	**0.0613**	**0.1603**	**17,738**	**0.0206**	**0.0260**	**0.5415**	**3.3567**	**1.3480**		**34.3404**	**0.2176**	**34.7137**		
1	-	-	6,803,552	585,350	873,953	1,104,245	-	370,764	148,894	9,886,759	3,793,117	24,036	3,834,348	7,651,501	17,538,260
2	-	-	7,192,464	585,350	923,911	1,167,367	-	387,122	155,463	10,411,677	3,960,465	25,096	4,003,515	7,989,076	18,400,753
3	-	-	7,593,973	585,350	975,487	1,232,533	-	403,602	162,081	10,953,027	4,129,064	26,165	4,173,947	8,329,175	19,282,202
4	-	-	7,999,760	585,350	1,027,613	1,298,394	-	420,199	168,747	11,500,062	4,298,858	27,241	4,345,586	8,671,685	20,171,747
5	-	-	8,171,809	585,350	1,049,713	1,326,319	-	425,476	170,866	11,729,532	4,352,847	27,583	4,400,162	8,780,592	20,510,124
6	-	-	8,348,943	585,350	1,072,467	1,355,068	-	430,557	172,907	11,965,293	4,404,834	27,912	4,452,715	8,885,461	20,850,754
7	-	-	8,518,358	585,350	1,094,229	1,382,565	-	435,643	174,949	12,191,094	4,456,860	28,242	4,505,306	8,990,408	21,181,501
8	-	40,926	8,518,358	585,350	1,117,678	1,412,192	-	440,729	176,991	12,292,224	4,508,898	28,572	4,557,910	9,095,380	21,387,604
9	-	130,348	8,543,411	585,350	1,141,198	1,441,910	-	445,815	179,034	12,467,065	4,560,926	28,901	4,610,503	9,200,330	21,667,395
10	-	241,369	8,442,306	585,350	1,165,474	1,472,583	-	450,897	181,075	12,539,054	4,612,919	29,231	4,663,061	9,305,210	21,844,264
11	-	335,253	8,391,753	585,350	1,190,492	1,504,193	-	455,974	183,113	12,646,127	4,664,855	29,560	4,715,561	9,409,976	22,056,103
12	-	446,512	8,290,647	585,350	1,214,847	1,534,966	-	460,865	185,077	12,718,265	4,714,893	29,877	4,766,143	9,510,913	22,229,179
13	-	556,982	8,189,542	585,350	1,238,938	1,565,405	-	465,575	186,969	12,788,761	4,763,082	30,182	4,814,857	9,608,121	22,396,883
14	-	670,736	8,088,437	585,350	1,264,131	1,597,237	-	470,110	188,790	12,864,792	4,809,482	30,476	4,861,761	9,701,719	22,566,511
15	-	767,084	8,037,884	585,350	1,289,976	1,629,892	-	474,477	190,544	12,975,207	4,854,154	30,759	4,906,919	9,791,832	22,767,039
16	-	863,315	7,987,331	585,350	1,315,781	1,662,497	-	478,681	192,233	13,085,188	4,897,169	31,032	4,950,401	9,878,601	22,963,790
17	-	959,908	7,936,778	585,350	1,341,708	1,695,256	-	482,731	193,859	13,195,591	4,938,596	31,294	4,992,278	9,962,169	23,157,759
18	1,153,996	967,364	7,886,226	585,350	1,367,514	1,727,861	783,561	486,632	195,425	15,153,929	4,978,508	31,547	5,032,624	10,042,680	25,196,609
19	2,429,462	967,364	7,835,673	585,350	1,393,953	1,761,267	1,649,601	490,393	196,936	17,309,998	5,016,980	31,791	5,071,514	10,120,286	27,430,284
20	3,701,216	967,364	7,785,120	585,350	1,420,296	1,794,552	2,513,119	494,020	198,392	19,459,429	5,054,087	32,026	5,109,024	10,195,137	29,654,567

1/ Includes operation and maintenance costs for reclaimed water

Source: JICA study team and Appendix B4

Table 3.5.2-17: Collection, commercialization, and administration costs for sewerage, "with" Project [1/]
(Nuevos Soles at social prices, as of June 2010)

Year	Sewerage operation and maintenance Cost					Commercialization and administration Cost				Total
	Primary collections in networks	Secondary collections in networks	Technical cadastre updating	Physical – chemical quality control	Total	Commercialization	Micrometer maintenance	Business management	Total	
Unit cost	**0.0127**	**0.0211**	**1.0102**	**0.2009**		**34.3404**	**0.2176**	**34.7137**		
1	458,513	762,079	111,588	22,194	1,354,374	3,793,117	24,036	3,834,348	7,651,501	9,005,875
2	484,723	805,642	116,511	23,173	1,430,049	3,960,465	25,096	4,003,515	7,989,076	9,419,125
3	511,782	850,616	121,471	24,160	1,508,028	4,129,064	26,165	4,173,947	8,329,175	9,837,203
4	539,129	896,069	126,466	25,153	1,586,817	4,298,858	27,241	4,345,586	8,671,685	10,258,502
5	550,724	915,341	128,054	25,469	1,619,588	4,352,847	27,583	4,400,162	8,780,592	10,400,180
6	562,661	935,182	129,584	25,774	1,653,200	4,404,834	27,912	4,452,715	8,885,461	10,538,661
7	574,079	954,158	131,114	26,078	1,685,429	4,456,860	28,242	4,505,306	8,990,408	10,675,837
8	586,381	974,605	132,645	26,382	1,720,013	4,508,898	28,572	4,557,910	9,095,380	10,815,393
9	598,720	995,114	134,176	26,687	1,754,697	4,560,926	28,901	4,610,503	9,200,330	10,955,027
10	611,457	1,016,283	135,705	26,991	1,790,436	4,612,919	29,231	4,663,061	9,305,210	11,095,646
11	624,582	1,038,098	137,233	27,295	1,827,208	4,664,855	29,560	4,715,561	9,409,976	11,237,184
12	637,360	1,059,336	138,705	27,588	1,862,989	4,714,893	29,877	4,766,143	9,510,913	11,373,902
13	649,999	1,080,343	140,123	27,870	1,898,334	4,763,082	30,182	4,814,857	9,608,121	11,506,456
14	663,217	1,102,311	141,488	28,141	1,935,157	4,809,482	30,476	4,861,761	9,701,719	11,636,876
15	676,776	1,124,848	142,802	28,403	1,972,828	4,854,154	30,759	4,906,919	9,791,832	11,764,660
16	690,314	1,147,350	144,067	28,654	2,010,385	4,897,169	31,032	4,950,401	9,878,601	11,888,987
17	703,917	1,169,958	145,286	28,897	2,048,057	4,938,596	31,294	4,992,278	9,962,169	12,010,226
18	717,455	1,192,460	146,460	29,130	2,085,505	4,978,508	31,547	5,032,624	10,042,680	12,128,185
19	731,326	1,215,514	147,592	29,355	2,123,788	5,016,980	31,791	5,071,514	10,120,286	12,244,074
20	745,147	1,238,485	148,684	29,572	2,161,888	5,054,087	32,026	5,109,024	10,195,137	12,357,026

1/ Includes wastewater volume operation and maintenance costs for reclaimed water input

Source: JICA study team and Appendix B4

Table 3.5.2-18: Summary of O&M Total Cost of the Water and Sewerage System "With" and "Without" Project[1/]

(Nuevos Soles at market prices, as of June, 2010)

Year	Required produced water volume (m^3/year)	Total Cost of O&M							
		Without Project situation			Unit Cost of Production (S/./m3)	With Project situation			Unit Cost of Production (S/./m3)
		Total	Operation	Maintenance		Total	Operation	Maintenance	
1	42,442,183	36,323,611	25,446,455	10,877,156	0.85584	30,770,799	25,794,355	4,976,444	0.7250
2	44,868,310	37,864,642	26,661,981	11,202,661	0.84391	32,251,410	27,029,768	5,221,642	0.7188
3	47,373,016	39,433,714	27,896,734	11,536,979	0.83241	33,759,773	28,285,053	5,474,720	0.7126
4	49,904,411	41,017,048	29,141,739	11,875,309	0.82191	35,281,294	29,550,807	5,730,486	0.7070
5	50,977,696	41,660,501	29,582,626	12,077,876	0.81723	35,839,157	30,000,492	5,838,666	0.7030
6	52,082,704	42,304,083	30,019,162	12,284,921	0.81225	36,396,076	30,446,086	5,949,990	0.6988
7	53,139,550	42,936,876	30,447,805	12,489,071	0.80800	36,939,888	30,883,392	6,056,496	0.6951
8	54,278,285	43,513,656	30,825,689	12,687,967	0.80168	37,427,328	31,270,610	6,156,718	0.6895
9	55,420,500	43,999,266	31,127,604	12,871,661	0.79392	37,822,021	31,581,888	6,240,132	0.6825
10	56,599,435	44,454,226	31,401,441	13,052,785	0.78542	38,184,968	31,865,389	6,319,579	0.6747
11	57,814,375	44,953,078	31,708,074	13,245,004	0.77754	38,590,671	32,181,981	6,408,691	0.6675
12	58,997,172	45,402,507	31,972,740	13,429,767	0.76957	38,944,753	32,456,342	6,488,411	0.6601
13	60,167,104	45,842,883	32,227,560	13,615,323	0.76193	39,287,849	32,720,751	6,567,097	0.6530
14	61,390,576	46,283,962	32,477,530	13,806,432	0.75393	39,630,703	32,980,751	6,649,952	0.6456
15	62,645,687	46,760,323	32,751,918	14,008,405	0.74643	40,007,532	33,265,427	6,742,105	0.6386
16	63,898,878	47,230,196	33,018,160	14,212,036	0.73914	40,376,024	33,541,941	6,834,083	0.6319
17	65,157,989	47,695,065	33,277,152	14,417,912	0.73199	40,737,757	33,811,255	6,926,502	0.6252
18	66,411,179	50,317,026	35,499,382	14,817,643	0.75766	43,254,617	36,043,757	7,210,860	0.6513
19	67,695,153	53,166,013	37,924,305	15,241,708	0.78537	45,997,069	38,479,205	7,517,864	0.6795
20	68,974,471	56,002,694	40,335,959	15,666,735	0.81193	48,725,209	40,901,345	7,823,864	0.7064

1/ Including commercialization and administration cost

Source: JICA study team and Appendix B4

Table 3.5.2-19: Summary of O&M Total Cost of the Water and Sewerage System "With" and "Without" Project[1/]

(Nuevos Soles at social prices, as of June, 2010)

Year	Required produced water volume (m^3/year)	Total Cost of Operation and Maintenance of the water and sewerage system (S/.)							
		Without Project situation			Unit Cost of Production (S/./m3)	With Project situation			Unit Cost of Production (S/./m3)
		Total	Operation	Maintenance		Total	Operation	Maintenance	
1	42,442,183	31,363,977	21,955,588	9,408,388	0.739	26,544,135	22,257,566	4,286,570	0.625
2	44,868,310	32,692,164	23,003,124	9,689,041	0.729	27,819,879	23,322,363	4,497,516	0.620
3	47,373,016	34,044,386	24,067,103	9,977,283	0.719	29,119,405	24,404,163	4,715,241	0.615
4	49,904,411	35,408,883	25,139,898	10,268,985	0.710	30,430,249	25,494,969	4,935,279	0.610
5	50,977,696	35,963,231	25,519,251	10,443,979	0.705	30,910,304	25,881,959	5,028,345	0.606
6	52,082,704	36,517,566	25,894,730	10,622,836	0.701	31,389,415	26,265,300	5,124,116	0.603
7	53,139,550	37,062,724	26,263,507	10,799,217	0.697	31,857,338	26,641,596	5,215,742	0.600
8	54,278,285	37,561,536	26,590,044	10,971,491	0.692	32,278,603	26,976,235	5,302,368	0.595
9	55,420,500	37,984,270	26,853,087	11,131,183	0.685	32,622,422	27,247,405	5,375,017	0.589
10	56,599,435	38,381,627	27,092,738	11,288,889	0.678	32,939,911	27,495,444	5,444,466	0.582
11	57,814,375	38,815,856	27,359,876	11,455,980	0.671	33,293,287	27,771,226	5,522,060	0.576
12	58,997,172	39,208,411	27,591,566	11,616,845	0.665	33,603,081	28,011,332	5,591,748	0.570
13	60,167,104	39,593,108	27,814,710	11,778,398	0.658	33,903,338	28,242,801	5,660,537	0.563
14	61,390,576	39,978,416	28,033,645	11,944,770	0.651	34,203,386	28,470,441	5,732,946	0.557
15	62,645,687	40,393,122	28,272,794	12,120,328	0.645	34,531,699	28,718,520	5,813,179	0.551
16	63,898,878	40,802,197	28,504,873	12,297,325	0.639	34,852,776	28,959,515	5,893,262	0.545
17	65,157,989	41,206,929	28,730,658	12,476,270	0.632	35,167,985	29,194,259	5,973,726	0.540
18	66,411,179	43,456,043	30,632,561	12,823,482	0.654	37,324,794	31,105,079	6,219,715	0.562
19	67,695,153	45,899,272	32,707,458	13,191,815	0.678	39,674,358	33,189,110	6,485,247	0.586
20	68,974,471	48,331,910	34,770,926	13,560,984	**0.701**	42,011,593	35,261,681	6,749,911	**0.609**

1/ Including commercialization and administration cost

Source: JICA study team and Appendix B4

Table 3.5.2-20: Additional Cost of Commercialization and Administration due to Reclaimed Water

(Nuevos Soles at market prices, as of June 2010)

Year	Quantity of equivalent connections	% micro metering	Connections with meters	Commercialization (S/.) (d)			Micro measuring maintenance (S/.)	Total		
				Total	Measuring and reading	Commercialization Cost		Total	Operation	Maintenance
Unit cost				**79.125**	**6.459**	**72.666**	**0.5014**			
1	15,217	100.0%	15,217	1,204,064	98,285	1,105,779	7,630	1,211,694	1,204,064	7,630
2	21,256	100.0%	21,256	1,681,872	137,287	1,544,585	10,658	1,692,530	1,681,872	10,658
3	22,921	100.0%	22,921	1,813,641	148,043	1,665,598	11,493	1,825,133	1,813,641	11,493
4	24,640	100.0%	24,640	1,949,686	159,148	1,790,538	12,355	1,962,040	1,949,686	12,355
5	26,010	100.0%	26,010	2,058,028	167,992	1,890,036	13,041	2,071,069	2,058,028	13,041
6	27,022	100.0%	27,022	2,138,109	174,529	1,963,580	13,549	2,151,657	2,138,109	13,549
7	28,040	100.0%	28,040	2,218,651	181,103	2,037,548	14,059	2,232,710	2,218,651	14,059
8	29,076	100.0%	29,076	2,300,633	187,795	2,112,838	14,578	2,315,212	2,300,633	14,578
9	30,126	100.0%	30,126	2,383,750	194,580	2,189,170	15,105	2,398,855	2,383,750	15,105
10	31,192	100.0%	31,192	2,468,102	201,465	2,266,637	15,640	2,483,742	2,468,102	15,640
11	32,274	100.0%	32,274	2,553,668	208,450	2,345,218	16,182	2,569,850	2,553,668	16,182
12	33,360	100.0%	33,360	2,639,615	215,466	2,424,149	16,726	2,656,342	2,639,615	16,726
13	34,446	100.0%	34,446	2,725,528	222,478	2,503,050	17,271	2,742,799	2,725,528	17,271
14	35,533	100.0%	35,533	2,811,576	229,502	2,582,073	17,816	2,829,392	2,811,576	17,816
15	36,621	100.0%	36,621	2,897,655	236,529	2,661,126	18,362	2,916,016	2,897,655	18,362
16	37,708	100.0%	37,708	2,983,647	243,548	2,740,099	18,907	3,002,553	2,983,647	18,907
17	38,794	100.0%	38,794	3,069,561	250,561	2,819,000	19,451	3,089,012	3,069,561	19,451
18	39,878	100.0%	39,878	3,155,358	257,564	2,897,793	19,995	3,175,352	3,155,358	19,995
19	40,962	100.0%	40,962	3,241,127	264,566	2,976,562	20,538	3,261,666	3,241,127	20,538
20	42,044	100.0%	42,044	3,326,778	271,557	3,055,221	21,081	3,347,859	3,326,778	21,081

1/ Including commercialization and administration cost

Source: JICA study team and Appendix B4

3.5.3 Operation and Maintenance Incremental Costs

Project incremental costs are the result of the difference between the "with" and the "without" Project situation throughout the evaluation horizon. It is necessary to point out that in "with" Project cost, O&M cost is added, including commercialization and administration of reclaimed water. In this connection, incremental cost between "with" and "without" are as following: i) investment costs and ii) operation and maintenance costs represented by the savings of resources resulting from the maintenance cost decreases in the repairs of water supply network and connection caused by: a) decreased water technical losses and decreased sewerage network and connection maintenance costs and b) increased well maintenance costs and c) insurance payments for accidents on the water network. Table 3.5.3-1 and 3.5.3-2 show detailed incremental cost at market and social prices respectively. Table 3.5.3-3 and 3.5.3-4 show operation and maintenance detailed cost saving at market and social prices for the Project horizon, respectively.

In addition to the incremental costs in “with” and “without” Project situation, the distribution and commercialization costs of reclaimed water have been considered; this reclaimed water will be distributed and billed to other sectors or areas close to the project scope, as shown in Table 3.5.2-20.

Table 3.5.3-1: Operation and Maintenance Incremental Cost of the Water Supply and Sewerage System

(Nuevos Soles at market prices, as of June, 2010)

Year	Incremental Cost of O&M								
	Without Project situation			With Project situation			Incremental Cost		
	Total	Operation	Maintenance	Total	Operation	Maintenance	Total	Operation.	Maintenance
1	36,323,611	25,446,455	10,877,156	30,770,799	25,794,355	4,976,444	-5,552,812	347,900	-5,900,712
2	37,864,642	26,661,981	11,202,661	32,251,410	27,029,768	5,221,642	-5,613,232	367,787	-5,981,019
3	39,433,714	27,896,734	11,536,979	33,759,773	28,285,053	5,474,720	-5,673,941	388,318	-6,062,259
4	41,017,048	29,141,739	11,875,309	35,281,294	29,550,807	5,730,486	-5,735,754	409,068	-6,144,822
5	41,660,501	29,582,626	12,077,876	35,839,157	30,000,492	5,838,666	-5,821,344	417,866	-6,239,210
6	42,304,083	30,019,162	12,284,921	36,396,076	30,446,086	5,949,990	-5,908,008	426,924	-6,334,931
7	42,936,876	30,447,805	12,489,071	36,939,888	30,883,392	6,056,496	-5,996,989	435,587	-6,432,575
8	43,513,656	30,825,689	12,687,967	37,427,328	31,270,610	6,156,718	-6,086,327	444,921	-6,531,248
9	43,999,266	31,127,604	12,871,661	37,822,021	31,581,888	6,240,132	-6,177,245	454,284	-6,631,529
10	44,454,226	31,401,441	13,052,785	38,184,968	31,865,389	6,319,579	-6,269,259	463,947	-6,733,206
11	44,953,078	31,708,074	13,245,004	38,590,671	32,181,981	6,408,691	-6,362,407	473,906	-6,836,314
12	45,402,507	31,972,740	13,429,767	38,944,753	32,456,342	6,488,411	-6,457,754	483,602	-6,941,356
13	45,842,883	32,227,560	13,615,323	39,287,849	32,720,751	6,567,097	-6,555,034	493,192	-7,048,226
14	46,283,962	32,477,530	13,806,432	39,630,703	32,980,751	6,649,952	-6,653,259	503,221	-7,156,480
15	46,760,323	32,751,918	14,008,405	40,007,532	33,265,427	6,742,105	-6,752,792	513,509	-7,266,300
16	47,230,196	33,018,160	14,212,036	40,376,024	33,541,941	6,834,083	-6,854,172	523,781	-7,377,953
17	47,695,065	33,277,152	14,417,912	40,737,757	33,811,255	6,926,502	-6,957,308	534,102	-7,491,410
18	50,317,026	35,499,382	14,817,643	43,254,617	36,043,757	7,210,860	-7,062,409	544,375	-7,606,783
19	53,166,013	37,924,305	15,241,708	45,997,069	38,479,205	7,517,864	-7,168,944	554,899	-7,723,844
20	56,002,694	40,335,959	15,666,735	48,725,209	40,901,345	7,823,864	-7,277,485	565,386	-7,842,871

Source: JICA study team and Appendix B4

Table 3.5.3-2: Operation and Maintenance Incremental Cost of the Water Supply and Sewerage System (Nuevos Soles at social prices, as of June, 2010)

Year	Incremental Cost of O&M								
	Without Project situation			Without Project situation			Without Project situation		
	Total	Operation	Maintenance	Total	Operation	Maintenance	Total	Operation.	Maintenance
1	31,363,977	21,955,588	9,408,388	26,544,135	22,257,566	4,286,570	-4,819,841	301,977	-5,121,818
2	32,692,164	23,003,124	9,689,041	27,819,879	23,322,363	4,497,516	-4,872,286	319,239	-5,191,525
3	34,044,386	24,067,103	9,977,283	29,119,405	24,404,163	4,715,241	-4,924,981	337,060	-5,262,041
4	35,408,883	25,139,898	10,268,985	30,430,249	25,494,969	4,935,279	-4,978,635	355,071	-5,333,706
5	35,963,231	25,519,251	10,443,979	30,910,304	25,881,959	5,028,345	-5,052,927	362,708	-5,415,634
6	36,517,566	25,894,730	10,622,836	31,389,415	26,265,300	5,124,116	-5,128,151	370,570	-5,498,720
7	37,062,724	26,263,507	10,799,217	31,857,338	26,641,596	5,215,742	-5,205,386	378,089	-5,583,475
8	37,561,536	26,590,044	10,971,491	32,278,603	26,976,235	5,302,368	-5,282,932	386,191	-5,669,124
9	37,984,270	26,853,087	11,131,183	32,622,422	27,247,405	5,375,017	-5,361,849	394,318	-5,756,167
10	38,381,627	27,092,738	11,288,889	32,939,911	27,495,444	5,444,466	-5,441,716	402,706	-5,844,423
11	38,815,856	27,359,876	11,455,980	33,293,287	27,771,226	5,522,060	-5,522,569	411,351	-5,933,920
12	39,208,411	27,591,566	11,616,845	33,603,081	28,011,332	5,591,748	-5,605,331	419,766	-6,025,097
13	39,593,108	27,814,710	11,778,398	33,903,338	28,242,801	5,660,537	-5,689,770	428,090	-6,117,860
14	39,978,416	28,033,645	11,944,770	34,203,386	28,470,441	5,732,946	-5,775,029	436,796	-6,211,825
15	40,393,122	28,272,794	12,120,328	34,531,699	28,718,520	5,813,179	-5,861,423	445,726	-6,307,149
16	40,802,197	28,504,873	12,297,325	34,852,776	28,959,515	5,893,262	-5,949,421	454,642	-6,404,063
17	41,206,929	28,730,658	12,476,270	35,167,985	29,194,259	5,973,726	-6,038,943	463,601	-6,502,544
18	43,456,043	30,632,561	12,823,482	37,324,794	31,105,079	6,219,715	-6,131,249	472,517	-6,603,767
19	45,899,272	32,707,458	13,191,815	39,674,358	33,189,110	6,485,247	-6,224,915	481,653	-6,706,568
20	48,331,910	34,770,926	13,560,984	42,011,593	35,261,681	6,749,911	-6,320,317	490,755	-6,811,072

Source: JICA study team and Appendix B4

Table 3.5.3-3: Detailed Incremental Cost (Saving) of O&M of the Water Supply and Sewerage System

(Nuevos Soles at market prices, as of June, 2010)

Year	Wells maintenance	Corrective maintenance of secondary water network	Insurance by operation incidences	Corrective maintenance of secondary sewerage network	Total
1	230,366	-3,058,649	-78,181	-2,646,349	-5,552,812
2	230,366	-3,091,900	-80,323	-2,671,376	-5,613,232
3	230,366	-3,125,352	-82,523	-2,696,432	-5,673,941
4	230,366	-3,159,383	-84,784	-2,721,953	-5,735,754
5	230,366	-3,204,483	-87,107	-2,760,121	-5,821,344
6	230,366	-3,250,148	-89,493	-2,798,733	-5,908,008
7	230,366	-3,296,955	-91,945	-2,838,455	-5,996,989
8	230,366	-3,343,999	-94,464	-2,878,231	-6,086,327
9	230,366	-3,391,844	-97,052	-2,918,716	-6,177,245
10	230,366	-3,440,268	-99,710	-2,959,647	-6,269,259
11	230,366	-3,489,290	-102,442	-3,001,042	-6,362,407
12	230,366	-3,539,402	-105,248	-3,043,471	-6,457,754
13	230,366	-3,590,482	-108,132	-3,086,787	-6,555,034
14	230,366	-3,642,074	-111,094	-3,130,458	-6,653,259
15	230,366	-3,694,346	-114,137	-3,174,675	-6,752,792
16	230,366	-3,747,549	-117,264	-3,219,725	-6,854,172
17	230,366	-3,801,641	-120,477	-3,265,556	-6,957,308
18	230,366	-3,856,719	-123,777	-3,312,279	-7,062,409
19	230,366	-3,912,539	-127,168	-3,359,604	-7,168,944
20	230,366	-3,969,365	-130,652	-3,407,835	-7,277,485

Source: JICA study team and Appendix B4

Table 3.5.3-4: Detailed Incremental Cost (Saving) of Operation and Maintenance of the Water Supply and Sewerage System

(Nuevos Soles at social prices, as of June, 2010)

Year	Wells maintenance	Corrective maintenance of secondary water network	Insurance by operation incidences	Corrective maintenance of secondary sewerage network	Total
1	199,958	-2,654,907	-67,861	-2,297,031	-4,819,841
2	199,958	-2,683,769	-69,720	-2,318,754	-4,872,286
3	199,958	-2,712,806	-71,630	-2,340,503	-4,924,981
4	199,958	-2,742,345	-73,593	-2,362,655	-4,978,635
5	199,958	-2,781,491	-75,609	-2,395,785	-5,052,927
6	199,958	-2,821,129	-77,680	-2,429,300	-5,128,151
7	199,958	-2,861,757	-79,808	-2,463,779	-5,205,386
8	199,958	-2,902,591	-81,995	-2,498,305	-5,282,932
9	199,958	-2,944,120	-84,241	-2,533,445	-5,361,849
10	199,958	-2,986,153	-86,548	-2,568,973	-5,441,716
11	199,958	-3,028,703	-88,920	-2,604,904	-5,522,569
12	199,958	-3,072,201	-91,355	-2,641,733	-5,605,331
13	199,958	-3,116,538	-93,859	-2,679,331	-5,689,770
14	199,958	-3,161,320	-96,430	-2,717,237	-5,775,029
15	199,958	-3,206,693	-99,071	-2,755,618	-5,861,423
16	199,958	-3,252,873	-101,785	-2,794,721	-5,949,421
17	199,958	-3,299,824	-104,574	-2,834,503	-6,038,943
18	199,958	-3,348,711	-107,438	-2,875,058	-6,131,249
19	199,958	-3,398,355	-110,382	-2,916,136	-6,224,915
20	199,958	-3,448,869	-113,406	-2,958,001	-6,320,317

Source: JICA study team and Appendix B4

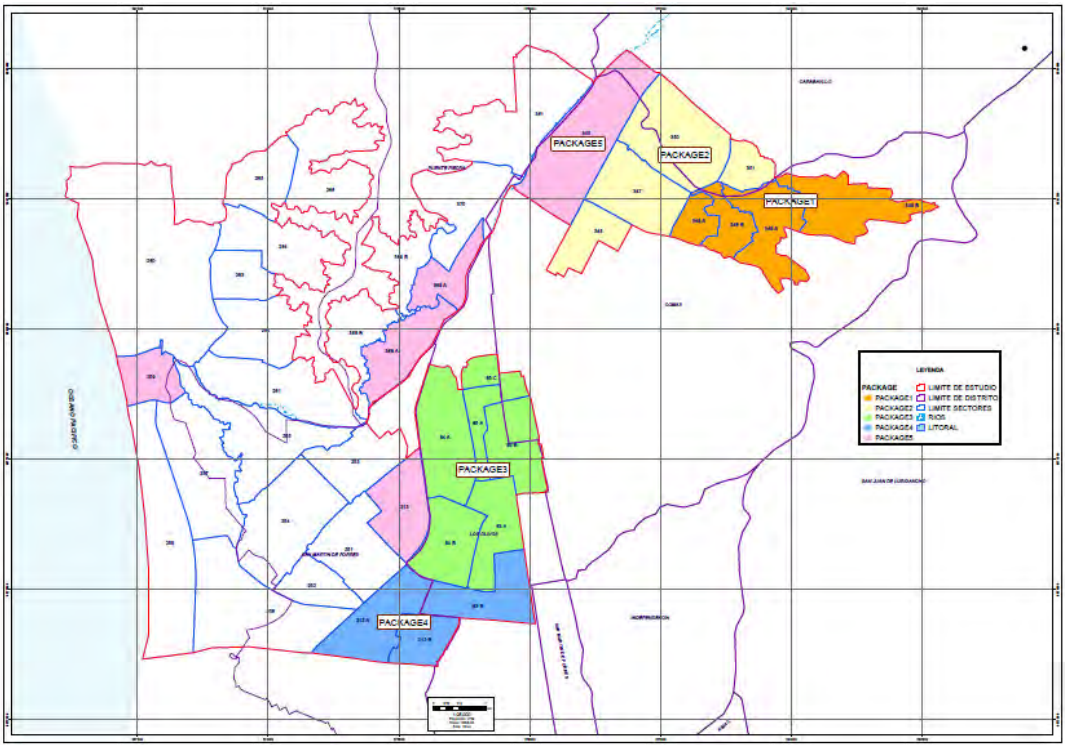
3.5.4 Project Components and Construction Packages

(1) Division of the Construction into the Packages

The Project is proposed to have the following three (3) packages based on work categories:

1. Package A: General Works: The construction of the primary network, the rehabilitation of facilities (reservoirs, pumping stations and wells) and the installation and rehabilitation of the SCADA system in facilities and pressure reducing chambers.
2. Package B: Secondary Network Works: The construction and rehabilitation of secondary networks and house connections for water supply and sewerage.
3. Package C: Procurement of O&M Equipment: The procurement of O&M equipment for the maintenance of water supply and sewerage pipes.

Also, secondary network works is proposed to divide into five (5) packages, considering the boundaries of sector and drainage area[1] as shown in Figure 3.5.5-1. Therefore, this project is divided into seven (7) packages.



Source: JICA Study Team

Figure 3.5.4-1: Packages of Secondary Network Works

The name of each package is shown in Table 3.5.4-1, along with the sectors and construction and rehabilitation works in each package area.

[1] Secondary network works of water supply and sewerage in the area should be carried out around the same time by one contractor, considering the inconvenience for residents and the application procedure of contractor. Therefore, the project area is divided by area, and this principle meets with SEDAPAL's requirement.

Table 3.5.4-1: Package List of Secondary Network Works

Package	Municipality	Sector	Drainage Area
Package B-1	Collique	348 A	ADC-2, ADC-6
		348 B	AD-AG1, AD-AG2, AD-AG4, ADC-2, ADC-4, ADC-5, ADC-6
		349 A	AD-AG4, ADC-1, ADC-2, ADC-3, ADC-4, ADC-5, ADC-6
		349 B	ADC-1, ADC-2, ADC-3
Package B-2	Comas Carabayllo	346	AD-T4, AD-T5, AD-T6
		347	AD-AG3, AD-AG4, AD-T2, AD-T4, AD-T5
		350	AD-AG1, AD-AG2, AD-AG3, AD-AG4, AD-T1, AD-T2
		351	AD-AG1
Package B-3	Los Olivos	83 A	AD-CH3, AD-N1, AD-R2
		84 A	AD-CH1, AD-CH2, AD-CH3,AD-PL1, AD-PL2
		84 B	AD-A1, AD-CH3, AD-N2, AD-PL2, AD-R2
		85 A	AD-CH1, AD-CH2, AD-CH3
		85 B	AD-CH1, AD-CH3, AD-R1
		85 C	AD-CH1, AD-R1
Package B-4	Los Olivos San Martin	83 B	AD-A1, AD-CO1, AD-N1
		212 A	AD-A1, AD-A2, AD-CO2, AD-N2
		212 B	AD-A1, AD-A2, AD-CO2
Package B-5	Comas Puente Piedra San Martin Marquez	213	(AD-CH4, AD-PL2)
		259	AD-M1
		345	(AD-CA1, AD-CA3, AD-T2)
		368 A	(PT3, PT4, PT5)
		369A	(PT4, PT6, PT7)

Note: In Sectors 213, 345, 368A, 369A, the secondary sewerage pipes had already been rehabilitated in another project. Therefore, the secondary water pipes (include house connections) should be rehabilitated in this project.

Source: JICA Study Team

And finally, these packages are reconfigured by the number of donors: JICA, KfW World Bank and SEDAPAL. JICA is expected to provide around US$ 80 million based on the commitment between MEF and JICA.

(2) Package-A: General Works

The works in Package-A include the construction works in the primary network, rehabilitation of reservoirs, pumping stations and wells, and new installations and rehabilitation of the SCADA system. All works in this package shall be completed in parallel in about two (2) years in order to distribute the water supply from the Huachipa treatment plant and sectorize the project area. The construction and rehabilitation works shall begin in October 2013, just after procurement of the contractor.

Table 3.5.4-2: Project Components of Package-A: General Works

No.	Work Items	Specification	
1	Primary Network	40.547 Km	DI Main Pipe Ø 150 mm – Ø700mm
		14 Unit	Pressure reducing valve pit
		40 Unit	Air valves
		25 Unit	Drain valves
2	Facilities	27 Reservoirs	Civil works in 27 reservoirs Equipment in 27 reservoirs
		4 Pumping Stations	Civil works in 2 pumping stations Equipment in 4 pumping stations
		23 Wells	Civil works Hydraulic and electrical equipment
3	SCADA	SCADA rehabilitation and installation in reservoirs, pumping stations, wells and pressure reducer chamber	

Source: JICA Study Team

(3) Package-B-1 to B-5: Secondary Network

The works in this package include rehabilitation and new construction of the secondary network and house connections for water supply and sewerage. All works in this package shall be completed in three (3) years. The rehabilitation and construction works shall begin in April 2014, just after procurement of the contractor, and the works of this package shall be carried out in parallel and completed by September 2016. The project component of this package is shown in Table 3.5.4-3.

Table 3.5.4-3: Project Component of Package-B: Secondary Networks

No	Works Ítems	Unit	Quantity					Total
			B-1	B-2	B-3	B-4	B-5	
1	**Water Supply**							
	Secondary Network							
1.1	Construction of new pipes (inlet lines to sectors)	Km	5.58	12.22	14.03	8.42	9.25	**49.50**
1.2	Rehabilitation of AC pipes	Km	10.08	52.50	58.10	30.38	5.85	**156.91**
1.3	Rehabilitation of other pipes (ITINTEC-FOFO-STEEL-PVC)	Km	19.51	1.09	0.03	0.30	1.18	**22.11**
								228.52
2	**Water supply accessories**							
2.1	Pressure reducing valves	Unit	1	2			2	**5**
2.2	Air valves	Unit	8	7	11	6	6	**38**
2.3	Drain valve	Unit		2	3	2	5	**12**
2.4	Sluice valves	Unit	67	140	161	115	97	**580**
2.5	Faucet valves	Unit	30	79	77	55	35	**276**
2.6	Control points	Unit	358	569	805	474	455	**2,661**
3	**Water connections**							
3.1	House connections	Unit	8,331	14,772	23,312	13,739	10,135	**70,289**
3.2	New installation of water meter	Unit	7,568	2,139			830	**10,537**
4	**Sewerage**							
4.1	Secondary network							
4.2	Trench method	Km	8.08	47.67	77.79	28.07	4.67	**166.28**
4.3	"Pipe Bursting" method	Km	3.44	20.42	33.33	12.02	2.00	**71.21**
4.4	Manhole replacement	Unit	107	404	650	209	45	**1,415**
4.5	Manhole rehabilitation	Unit	249	942	1,520	487	104	**3,302**
5	**Sewerage connections**							
5.1	House connections	Unit	1,392	9,309	16,664	5,266	1,105	**33,736**

Source: JICA Study Team

(4) Package-C: Procurement of O&M Equipments

This package is the procurement of O&M equipment for water pipes and sewerage. The procurement of this project includes O&M equipment which has limited availability, therefore the necessary procurement schedule is nine (9) months. The project component of this package is shown in Table 3.5.4-4.

Table 3.5.4-4: Project Component of Package-C: O&M Equipment

No.	Items	Quantity
1	**New team for planning of preventive maintenance**	
1)	Computer and Software	1
2)	TV inspection unit for potable water (equipment + mobile unit)	3
3)	TV inspection unit for sewerage (equipment + mobile unit)	3
2	**Hydro jet for sewerage cleaning**	
1)	Mini hydro jet with vehicle	2
2)	8.50 m3 Hydro Jet equipment	3
3)	6 m3 Hydro Jet equipment	3
4)	16 m3 capacity tank truck	3
5)	8 to 10 m3 capacity tank truck	3
6)	Nozzles 15 ° for Hydro jet	6
7)	Nozzles 35 ° for Hydro jet	6
3	**Reduction of underground water leakage**	
1)	Vehicle	2
2)	Correlator with accessories (red and blue radio)	2
3)	Wheel meter	2
4)	Acoustic Water Leak Detector	2
5)	Metal Detector	2
6)	Geophones	4
7)	Generator	2
8)	Drill	2
9)	Miscellaneous Tools	2
10)	Pre locators (Mobile)	200
11)	Data capture	2
12)	Workstation platform including CAD/GIS	2

Source: JICA Study Team

3.6 Project Benefits

3.6.1 Benefits in a "Without Project" Situation

(1) Benefits in a "Without project" situation with regard to water supply

At present, and according to the diagnosis, the population in the Project's area of influence has potable water with a good bacteriological quality that is regularly supplied through old secondary networks. These networks are operated by the Comas Service Center (C.S.) and the Callao C.S. Operation and Maintenance Teams, to the best of their ability, in order to keep a maximum continuous service, and prevent any infrastructure collapses, given the infrastructure's age, generated deficiencies, failures, and overpressures.

Measures to be implemented include pressure control to the water supply networks, in order to prevent any breakages and supply interruptions. Even under quite unsuitable conditions, the population is benefited with a supply that allows them to keep specific, and in many cases, desired, consumption levels, especially in the lower parts of the scheme. However, in the higher areas, consumption is disrupted, and some users even resort to domestic containers for water storage purposes.

Under this scenario, it is possible that the North Services Management Office (*Gerencia de Servicios Norte*, or GSN) would restrict supply in the future, in order to keep the current supply level, in view of the system's lack of capacity to supply larger volumes than expected. This means that families will have increasingly less water availability for consumption, as there is a natural population growth. In the event that service supply is not restricted, potable water physical losses[1] will be significantly increased to over 40 %; therefore, benefits in this situation are null even after Huachipa WTP starts operating.

(2) Benefits in a "Without project" situation with regard to sewerage

At present, population in the area of influence is offered a regular sewerage service through old secondary networks that are operated and maintained by the Comas Service Center (C.S.) and the Callao C.S. Operation and Maintenance Teams, to the best of their availability, in order to ensure a suitable wastewater collection and to prevent any infrastructure collapses, given the poor conditions of the pipes and manhole covers.

Major activities carried out include pipe breakage repairs and clogging cleaning, in order to attend the customer's claims for clogs and wastewater overflows. In this way, the population has an ongoing service available. However, this service is not offered under the most suitable conditions, due to infrastructure failures that pose an ongoing risk of overflows and emanations, and jeopardize public health.

[1] Technical or physical water losses currently account for 40%

3.6.2 Benefits in a "With Project" Situation

(1) Water supply

As an effect of the project implementation ("with" project situation), service continuity will be increased for those rationed sectors in the "without" project situation. These were identified in the diagnosis as sectors 348 and 349 in Comas, and Sector 259 in Callao. Average 24-hour continuity will be kept in the remaining sectors; in addition, minimum average pressure in the networks (23 m.c.a.) and water quality will be ensured for the households. In this way, potable water service in the secondary networks and the house connections will be optimized, in such a way that families will have no need to resort to unsuitable water storage measures, as they currently do.

After the project is implemented, a better potable water service will be offered to an average population of 834,547 during the Project planning period at lower operation and maintenance costs and a more efficient use of the installed capacity of the primary production and distribution infrastructure. In addition, water volumes which are currently lost will be partly reclaimed (a portion of the non-revenue water), as these losses are mainly caused by the poor conditions of the network and water connection. These reclaimed volumes will be reassigned or distributed to other population sectors.

Households with unrestricted water supply will keep similar consumption levels in the "with" project situation. Therefore, household consumptions are not restricted in terms of volume, but instead in terms of water quality and pressure, and so, the improvement in well-being accomplished would generate benefits that, when estimated in monetary terms, could be related to an increased willingness to pay by the beneficiary families.

In short, the following benefits have been identified:

- Resource savings from minor water pipes and connection repairs, as well as insurance payments for accidents in the pipelines and connections.
- Decrease in technical water loss in networks and connections (water reclamation).
- Higher water consumption in the restricted sectors.
- Postponement of water source and yield investments
- A better supply quality, continuity, and pressure to the current population, increased willingness to pay (WTP) for a better potable water service.
- Incorporation of new users

The following paragraphs explain the calculation of the benefits by the components identified in the paragraph above.

a) Resource savings in repairs

The following are events that bring about diversion of resources for repairs, as part of the operation and maintenance cost makeup in the water supply system:

- Pipe breakages;
- Connection repairs;
- Leakage at the water intake (corporation); and
- Leakage at the connection box.
- Insurance for accidents in the pipelines and connections (damage repair in the affected households).

These costs are reflected in potable water supply operation and maintenance system cost increases that, in the "with" project situation, will generate significant savings as opposed to the "without" project situation.

In that sense, these resource savings derived from the network and connection rehabilitation and/or replacement, as well as from insurance payments will be reassigned to other water supply system applications, or not used at all. For economic evaluation purposes in the Project, these cost savings will be adjusted to social price, with the market price distortions (taxes and other distortions) excluded.

b) Technical loss reductions, greater consumption, and potable water availability

The reduction or decrease in the level of technical water loss improves the water supply system's productive efficiency, as the marginal cost of the water produced that is delivered to the users is decreased, and thus, the maximum water supply that is available to the consumers is increased or even distributed to other sectors within the SEDAPAL water supply system, maintaining the same installed capacity of the Project´s primary production and distribution systems.

The proposed goal (the objective indicator) is that technical water losses are actually decreased, as the project components are set up, to 20 % (from a 40 % in a "without" project situation to a 20 % in a "with" project situation).

Impact on the production marginal costs and the maximum supply from the systems generates the following economic benefits. i) water consumption increases in restricted households and ii) a postponement in the investments or avoided costs related to marginal reductions of potable water technical losses (incremental uptake, production, supply, and distribution costs.)

c) Consumption increase

In order to estimate the benefits from the water supply consumption increases, users, who are project beneficiaries, have been identified. They are located in sectors 348 and 349 in Comas, and sector 259 in Callao. According to the current diagnosis, these users have a restricted 3- to 12- hour potable water service that is supplied with a pressure under 30 mca; in other words, they endure a strong service rationing. On the other hand, in a "with" project situation, the potable water service will be continuous (24 hours) and at higher quantities and pressures in comparison with the current situation, as shown in Table 3.6.2-1.

Benefits for these users will be based on increased potable water consumption levels. It must be pointed out that when the project becomes operative, these users will have meters that will be installed by SEDAPAL's Integrated Commercial Management System (SIAC.), whose service started in July 2010.

For the purposes of calculating the benefit, a water supply and sewerage demand function must be set up, and in this sense, at least two price points (variable or fixed tariff) and quantity (potable water consumption) must be specified. A first point is the average monthly measured consumption, as registered by a meter, for users with continuous water service under suitable pressure levels in their homes. From the information analyzed from SEDAPAL's commercial system within the project scope, an average measured consumption of residential users (one-family and multiple-family dwellings) has been stated as 15 m^3/month/connection, it is necessary to point out that 100% of these users count with sewerage connection, therefore, this consumption represents also availability of this service. Moreover, studies[2] by World Bank have demonstrated that if sewerage system is constructed then potable water consumption will increase because constraints due to waste water disposal from indoor housing will be overcamed; therefore, the benefits of more water consumption includes sewerage availability in the houses.

In this connection, users have willingness to pay for the service availability at a marginal tariff which would be the in excess tariff[3] of S/. 1. 735 per cubic meter that includes sewerage service and sales tax. It is necessary to point out that the users do not make differentiation of the costs and charges components; the real value that has willingness to be paid for one cubic meter of water is defined for calculation of economic benefits.

2 Social evaluation of public investment; alternative point of view and its adaptation to Latin America, CEPAL-Manual series N° 37.
3 Excess tariff between 10- 25 m3/mes (S/.1.023/m3 potable water tariff and S/. 0,447/m3 sewerage tariff), including 18% VAT.

Table 3.6.2-1: Consumption and Service Hours in Project Sectors

Sector	No. of Users	Without Project		With Project	
		Consumption (m^3/month) 2/	Average Service Hours (h)	Consumption (m^3/month) 3/	Average Service Hours (h)
349-A1	179	6.03	3	15.4	24
349-A2 1/				15.4	24
349-A3 1/				15.4	24
349-B1	90	6.07		15.4	24
349-B2	119	6.62		15.4	24
349-B3	178	6.61		15.4	24
349-B4 1/				15.4	24
348-A 1/			5-7	15.8	24
348-B1	10	6.15		15.8	24
348-B2	140	8.15		15.8	24
259	1,513	12.27	12	14.4	24

1/Users have no meter and are subject to rationing.
2/ Consumption with comments, restriction at year 2009 (Commercial information GSN, SEDAPAL, May 2010-Annex B7)
3/ Unit consumption for analysis of demand (See Table 3.1.2-15)
Source: JICA Study Team (Commercial information from SEDAPAL's North Services Management, May 2010)

A second point of reference for the construction of demand function would be the consumption and the price paid by those households that are not connected to SEDAPAL's water network, who obtain their supply from other alternative sources or from tank trucks. Average consumption is 4.25 m3/month at a transaction price of S/. 1.50 per container (around 0.20 cubic meters.) This information has been obtained from the socioeconomic survey in areas surrounding the project area with dwellings that are not connected to SEDAPAL's water supply network.

The two points (P, Q) that are mentioned in the paragraphs above define the demand curve that results from the following function:

$$\boxed{Q = 18.235 - 1.865\ P}$$

It must be pointed out that the saturation consumption per month with a marginal tariff of zero is 18.24 m^3/month/connection, and for a consumption that is equal to zero, the price is S/. 9,78 per cubic meter.

In addition, the economic price of water the users would be willing to pay for the service has been defined from the water demand function and the consumption values of those users with a restricted supply in the "without" project situation (3 to 12 hours), as shown in Table 3.6.2-2.

Table 3.6.2-2: Price and Consumption

Price (S/./m^3)	Q (m^3/month/Connection)	Point	User
9.78	0	A	
7.50	4.25	B	Not connected to SEDAPAL network
6.38	6.34	C	Restricted supply Sector 349
5.48	8.02	D	Restricted supply Sector 348
4.16	10.48	E	New users with a restricted supply in the future without project situation
3.20	12.27	F	Restricted supply Sector 259
1.74	15	G	Unrestricted supply
0	18.24	H	

Source: JICA Study Team

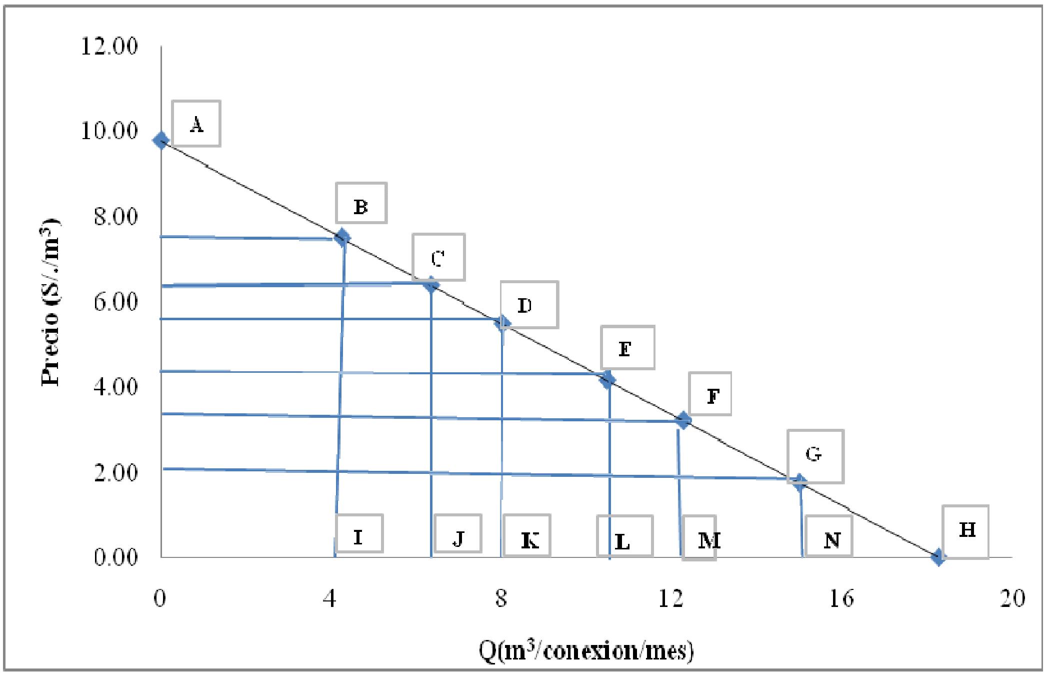
The different price points and the number of users with a restricted supply, both in the "without" and "with" project situations, will lead users to have an average consumption of 15 m^3/month at a variable tariff of S/. 1,735 per cubic meter. In this sense, unit benefits per month are calculated for the increased water consumption of those users located in sectors 348, 349, and 259, as shown in Figure 3.6.2-1.

Sector 348: Unit benefit: (15.0–8.02)*(1.735)+(15.0–8.02)*(5.48–1-735)/2= S/. 25.19 (S/. 302.3/year) connection/month. Area: KDGN.

Sector 349: Unit benefit: (15.0–6.34)*(1.735)+(15.0–6.34)*(6.38–1.735)/2= S/. 35.12 (S/. 421.4/year) connection/month. Area: KDGN.

Sector 259: Unit benefit: (15.0–12.27)*(1.735)+(15.0–12.27)*(3.20–1-735)/2= S/. 6.73 (S/. 80.8/year) connection/month. Area: MFGN.

New Users: Unit benefit: (15.0–10.48)*(1.735)+(15.0–10.48)*(4.17–1-735)/2= S/. 13.33 (S/. 159.9/año) connection/month. Area: MFGN.



Source: JICA Study Team

Figure 3.6.2-1: Demand Curve

On the other hand, new households will be connected in a natural way to the existing water supply network in all sectors within the Project scope. Due to the increasing technical losses caused by the existing old and deteriorated networks, connections, and water intakes, these new users in the "without" project situation could have a restricted water service supply that is similar to that of sectors 348, 349, and 259. Therefore, the "with" project situation ensures an ongoing 24-hour service, and so, the attributable benefits to the project will also be attributable to a higher potable water consumption. Monthly unit benefit for new users with higher water consumption levels is calculated to be S/. 13,33 connection/month (Area: LEGN). It is assumed that 13% of the new users in the "without" project situation would have a rationed water service, taking into account that at the present, the same rate of users have constraints of water services.

d) Postponement of investments or avoided costs related to marginal reductions in technical loss.

Benefits related to avoided costs associated with the decreased technical loss level at 20 % will be estimated by the calculation of the Marginal Water Value (MWV), at social price, in Soles, for every 1,000 liters or cubic meters of additional water. The Marginal Water Value or marginal cost will be an approximation of the long term average incremental cost, at social price, that is required by SEDAPAL to produce a marginal unit of water and cover the water demand in the "without" project situation.

For Marginal Water Value, it has been proposed to use the long-term Average Incremental Cost for water and sewerage calculated by SEDAPAL in its 1998 Master Plan, which has been adjusted by the JICA Study Team for June 2010 prices, with the WPI[4] for social price.

In order to update costs and water quantities a discount social rate[5] of 10% has used, resulting S/. 1,950 per cubic meter for potable water, and S/. 1,658 per cubic meter for sewerage (See Appendix B7.) It must be pointed out that the updated incremental cost at social price for water is higher than the medium term average cost (MTC) for every cubic meter of water, as calculated in SEDAPAL's tariff study[6] for the 2010-2015 period. The incremental cost for sewerage is S/. 0.856 according to the study´s calculation, which is greater than the MTC.

On the other hand, it is very likely that the current marginal or incremental potable water cost at private prices is higher than the values pointed out in the paragraphs above, in order to cover Metropolitan Lima's future demand. For example, in a private initiative project7 that involves the construction of a desalination reverse osmosis plant for the South Lima population, the cost of potable water per cubic meter to be delivered at the outlet of the reservoirs through a concession contract (take-or-pay contract) is estimated to be around US $ 1.10 per cubic meter (S/. 3.11 per cubic meter.) In this sense, marginal water value at social price adopted for the purpose of calculating the Project´s economic benefits is reasonable.

Therefore, the suggested MWV is multiplied by the volumes of net (reclaimed) water that is obtained as an output of a reduction in the technical losses of water in the "with" project situation, in order to calculate annual economic benefits at social price for the Project evaluation period. The net (reclaimed) water volume is obtained by taking away the incremental volumes of consumption from the users that would have rationing in the "without" project situation (See Appendix B7.)

It must be pointed out that benefits related to the commercial loss reductions (regularization of illegal users, effective connection measurements) were not taken into account; this is attributable to a higher level of revenue water that is linked to the utility's financial income (financial evaluation.) These activities are part of the SIAC service and other commercial measures adopted by SEDAPAL and are not to be attributable to this Project.

Table 3.6.2-3 and Figure 3.6.2-2 show the technical losses, both in the "with" and "without" project situations for the project evaluation period; these values have been calculated under available demand. The difference for these volumes is the volume of reclaimed water as a result of the project implementation.

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[4] Wholesale Price Index (WPI), INEI, Economic Information, 2010
[5] Social discount rate annex SNIP 10 – Parámetros de Evaluación.
[6] Tariff Study - SUNASS/SEDAPAL, April, 2010, Medium term median cost (MTC).
[7] "Aguas del Sur II" ("Southern Waters II") Project, accepted by the Private Investment Promotion Agency, SEDAPAL and MVCS, 2008

Another thing to consider, based on the diagnostic information of the operational system, is that technical losses will gradually increase in the "without" project situation, due to the deterioration of networks, connections, and water intakes. This will press towards a higher demand for service at the water production and distribution system levels. Technical losses will dramatically decrease in the "with" project situation, until they reach the 20 % goal for the rest of the project period.

Table 3.6.2-3: Demand Without and With Project, and Reclaimed Water Volume

Year	Potable water consumption (m^3/year)	Without Project		With Project		Higher water consumption (m^3/year) 1/	Volume of reclaimed water (m^3/year)
		Technical losses (%)	Potable water demand (m^3/year)	Technical losses (%)	Potable water demand (m^3/year) 1/		
2009	18,870,295	40.0	31,659,723	40.0	31,659,723		
2010	19,689,470	40.0	32,920,135	40.0	32,920,135		
2011	20,399,375	40.0	33,990,353	40.0	33,990,353		
2012	21,052,403	40.0	34,966,726	40.0	34,966,726		
2013	21,645,412	40.0	35,840,728	40.0	35,840,728		
2014	22,841,350	40.0	37,767,555	40.0	37,767,555		
2015	24,030,236	40.0	34,613,244	40.0	34,613,244		
2016	25,253,099	40.5	42,442,183	25.0	33,694,284	1,400,729	7,347,170
2017	26,472,303	41.0	44,868,310	20.0	33,090,379	1,402,827	10,375,105
2018	27,713,215	41.5	47,373,016	20.0	34,641,518	1,404,836	11,326,662
2019	28,944,559	42.0	49,904,411	20.0	36,180,698	1,406,752	12,316,961
2020	29,312,175	42.5	50,977,696	20.0	36,640,219	1,224,681	13,112,796
2021	29,687,141	43.0	52,082,704	20.0	37,108,926	1,221,557	13,752,220
2022	30,023,846	43.5	53,139,550	20.0	37,529,807	1,221,597	14,388,146
2023	30,395,840	44.0	54,278,285	20.0	37,994,800	1,221,596	15,061,889
2024	30,758,378	44.5	55,420,500	20.0	38,447,972	1,221,557	15,750,971
2025	31,129,689	45.0	56,599,435	20.0	38,912,111	1,221,482	16,465,842
2026	31,508,834	45.5	57,814,375	20.0	39,386,043	1,221,369	17,206,963
2027	31,858,473	46.0	58,997,172	20.0	39,823,091	1,218,385	17,955,696
2028	32,189,401	46.5	60,167,104	20.0	40,236,751	1,215,477	18,714,876
2029	32,537,005	47.0	61,390,576	20.0	40,671,257	1,212,659	19,506,660
2030	32,888,986	47.5	62,645,687	20.0	41,111,232	1,209,938	20,324,517
2031	33,227,417	48.0	63,898,878	20.0	41,534,271	1,207,325	21,157,282
2032	33,556,365	48.5	65,157,989	20.0	41,945,456	1,204,820	22,007,714
2033	33,869,701	49.0	66,411,179	20.0	42,337,127	1,202,427	22,871,626
2034	34,186,052	49.5	67,695,153	20.0	42,732,565	1,200,149	23,762,438
2035	34,487,235	50.0	68,974,471	20.0	43,109,044	1,197,987	24,667,439

1/ This is the highest water consumption in Sectors 348, 349, and 259, and for the new users having a rationed s ("without" project) service.

Source: JICA Study Team

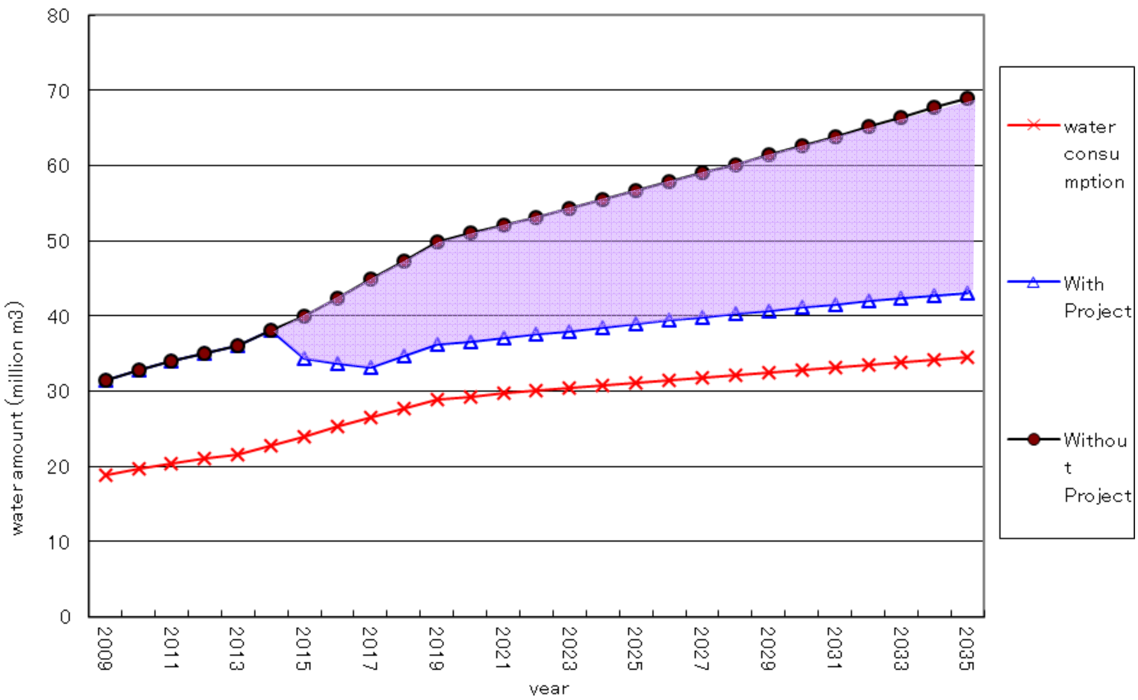


Figure 3.6.2-2: Consumption, Demand "With" and "Without" Project and Reclaimed Water Volume

e) Supply with better quality and pressure to the current population

Project execution will allow families to have a reliable and ongoing, 24-hour water supply service of suitable quality and with good network pressure, and it will keep them from storing water periodically in some cases. This group of beneficiaries includes the existing users that are connected to the system through a potable water house connection, a sewerage connection, and an operating meter, as they will actually notice the enhanced water service in terms of continuity, quantity, and quality; in this way, there will be an increased willingness to pay for an efficient, trouble-free service.

The JICA study team gathered information through a survey by sampling during the diagnosis stage regarding the families´ increased willingness to pay (additional payment for an enhanced potable water and sewerage service). The survey set out hypothetical service scenarios with the following characteristics: i) a 24-hour water supply is offered with good quantities and pressure, ii) water quality is kept under suitable conditions as a result of chlorination, iii) no foul smells should be perceived in their dwellings and surroundings (a good sewerage service), and iv) there will be no clogs or overflows around their dwellings, and there will be no pipeline collapses (sewerage service is improved.) Likewise, monetary values were given per month to various scenarios in order to gather information from households regarding their maximum willingness to pay for improved and enhanced benefits they could get from a better water and sewerage service, as this service has no explicit prices in the market, or it is linked to a variable potable water rate.

Application of this method is based on the following assumptions: the interviewed individual is involved in the project execution side effects, namely, a better potable water and sewerage service; therefore, given his / her available income, the individual maximizes this service's usefulness. The individual's behavior in a hypothetical market is equivalent to his / her behavior in a real market; the individual has been provided with full information about the benefits generated by an efficient potable water and sewerage service.

Benefits that are attributable to a better potable water and sewerage service will be calculated in monetary terms, by means of an increased willingness to pay (WTP) on a monthly basis per household.

Results of the survey carried out by the JICA study team[8] show substantial differences with regard to a willingness to pay, according to the type of access to potable water. In this sense, there is an inverse relationship between the current availability of the water and sewerage service and the willingness to pay for a better service that has resulted from the project; that is, those having continuous water and sewerage service (24-hour supply) are willing to pay less for an improvement and optimization of water and sewerage service, whereas those households lacking continuous service are willing to pay more for water and sewerage service improvement that will be a direct side effect of the Project.

In this sense, out of all households having a 24-hour water service, the median value (representing 50 % of the surveyed households) for willingness to pay is just S/. 4.49 per month, and the average willingness to pay is S/. 8.18 on a monthly basis. However, households with a restricted water supply are willing to pay more than the households that have a 24-hour water service. Indeed, the median value (representing 50 % of the surveyed households) for willingness to pay is S/. 8.54 per month, and the average willingness to pay for this group is S/. 13.57 per month.

Table 3.6.2-4: Willingness to Pay for a Better Potable Water and Sewerage Service

Type of housing	Median (S/. per month)	Average (S/. per month)
Households with 24 – hour service	4.49	8.18
Households with less than 24–hour service per day 1/	8.54	13.57

Sectors 348 and 349 (Comas)

Source: Socioeconomic survey, May, 2010 Encuesta

The average amounts for an increased willingness to pay (WTP) for a better water and sewerage service will be used for the Project´s economic evaluation, multiplying them in each case by the number of users. Results are shown in Table 3.6.2-4.

[8] Socioeconomic survey report for the project area, JICA Study Team, May, 2010 (Appendix.)

According to the survey results and present situation, 90 % of the users with no water service rationing[9] in the "without" Project situation would be willing to pay S/. 8.18 per month for a better service ("with" project), and 10% of the users with a restricted service ("without" project) would be willing to pay S/. 13.57 for a better service.

(3) Sewerage

The sewerage system will be optimized by Project execution, as the existing sewerage pipeline will maximize its capacity when secondary sewers and connections are replaced. Therefore, clogs and breakages in networks and sewerage house connections, which make for most of the claims from users in the "without" project situation, will decrease. In this way, sanitary conditions of the population will be improved, and a better sewerage service will be offered to an average population of 834,547 during the project period, at less maintenance costs and a higher operational efficiency on the part of SEDAPAL.

In short, benefits attributable to the project are as follows:

- Resource savings, due to fewer repairs and/or to replacements of sewerage pipelines and connections and network cleanings.
- A better sewerage service quality offered to the current population; therefore, an increased willingness to pay (WTP), both for this service and for the water supply service.

1) Resource savings

Significant items in the cost makeup that bring about increased operation and maintenance costs for the sewerage system in the "without" project situation include:

- Pipe clogs;
- Pipe replacements and/or repairs as a result of breakages; and
- Sewerage network cleanings.

Allotting further resources to these items in the "without" project situation generates an increase in the sewerage system's operation and maintenance costs on the part of SEDAPAL. In the "with" project situation, these items will represent resource savings that will be adjusted to social price in the economic evaluation.

2) Better quality with regard to sewerage service for the target population

The Project will offer households a reliable and permanent sewerage service that will not contribute to environmental contamination. In this sense, increased willingness to pay by families, as they perceive a better sewerage service in the "with" project situation, will come along with their increased willingness to pay for the water supply service.

(4) Summary of Benefits

Benefits calculated for the entire Project planning period are shown in Table 3.6.2-5. In compliance with the Project implementation schedule, completion of works has been foreseen

[9] 3 to 7 hours of water service

for 2015; the operation period will begin in 2016 (year 1), and its target year will be 2035 (year 20.)

It is noted that benefits for increased potable water consumption are kept consistent for users in sectors 349, 348, and 259; in addition, there is an increased willingness to pay among users in sectors 348 and 349 (Comas), as opposed to existing users in the remaining sectors, as accounted for in paragraph c). Benefits for new users increase as they connect to the water supply and sewerage system with a 24-hour ongoing service.

Major economic benefits for the project come from the reclaimed water volume that has a marginal value and will postpone investments (avoided costs) in the water supply system. These costs are shown at social price.

Economic benefits also include savings in corrective maintenance cost (repairs) that will no longer be carried out in the “with” project situation; these costs will be adjusted to social price by using the adjustment factors suggested by the National Sanitation Directorate (*Dirección Nacional de Saneamiento*, or DNS) (See Appendix B.)

Table 3.6.2-5: Economic Benefits for Water Supply and Sewerage in the Project

(Nuevos Soles to social price as of June, 2010)

Year	Users (Units)					Benefits (Nuevos Soles)							
						Increased potable water consumption		Increased willingness to pay 3/		Cost savings		Benefits per reclaimed volume of water	Total
	Total	New 1/	Sector 349 2/	Sector 348 2/	Sector 259 2/	New users	Users in 259, 348 y 349	Unrestricted users (24 – hour service)	Restricted users (less than 7 hour service)	Water supply operation and maintenance	Sewerage operation and maintenance		
2015	103,787												
2016	108,593	3,364	7,266	3,402	3,024	99,895	4,492,260	9,593,550	1,768,330	2,519,417	2,300,424	14,252,635	35,026,512
2017	113,438	3,391	7,266	3,402	3,024	100,702	4,492,260	10,021,532	1,847,218	2,550,046	2,322,240	20,157,217	41,491,215
2018	118,319	3,417	7,266	3,402	3,024	101,476	4,492,260	10,452,801	1,926,712	2,580,896	2,344,084	22,012,774	43,911,003
2019	123,236	3,442	7,266	3,402	3,024	102,214	4,492,260	10,887,205	2,006,783	2,612,300	2,366,335	23,943,879	46,410,975
2020	124,782	1,082	7,266	3,402	3,024	32,126	4,492,260	11,023,741	2,031,950	2,653,361	2,399,565	25,497,763	48,130,767
2021	126,270	1,041	7,266	3,402	3,024	30,924	4,492,260	11,155,166	2,056,175	2,694,966	2,433,184	26,744,703	49,607,378
2022	127,758	1,042	7,266	3,402	3,024	30,939	4,492,260	11,286,656	2,080,412	2,737,617	2,467,769	27,984,785	51,080,438
2023	129,246	1,042	7,266	3,402	3,024	30,939	4,492,260	11,418,145	2,104,649	2,780,528	2,502,404	29,298,613	52,627,538
2024	130,734	1,041	7,266	3,402	3,024	30,924	4,492,260	11,549,570	2,128,874	2,824,191	2,537,657	30,642,353	54,205,829
2025	132,220	1,040	7,266	3,402	3,024	30,895	4,492,260	11,680,872	2,153,076	2,868,416	2,573,301	32,036,383	55,835,201
2026	133,704	1,039	7,266	3,402	3,024	30,851	4,492,260	11,811,989	2,177,244	2,913,219	2,609,350	33,481,602	57,516,516
2027	135,133	1,000	7,266	3,402	3,024	29,703	4,492,260	11,938,225	2,200,512	2,959,030	2,646,300	34,941,696	59,207,727
2028	136,508	963	7,266	3,402	3,024	28,583	4,492,260	12,059,703	2,222,904	3,005,746	2,684,024	36,422,163	60,915,382
2029	137,831	926	7,266	3,402	3,024	27,499	4,492,260	12,176,571	2,244,445	3,052,970	2,722,059	37,966,205	62,682,010
2030	139,104	891	7,266	3,402	3,024	26,451	4,492,260	12,288,988	2,265,167	3,100,852	2,760,571	39,561,091	64,495,380
2031	140,328	857	7,266	3,402	3,024	25,445	4,492,260	12,397,129	2,285,100	3,149,611	2,799,810	41,185,049	66,334,404
2032	141,506	824	7,266	3,402	3,024	24,481	4,492,260	12,501,172	2,304,277	3,199,212	2,839,732	42,843,454	68,204,588
2033	142,639	793	7,266	3,402	3,024	23,560	4,492,260	12,601,300	2,322,734	3,250,819	2,880,430	44,528,145	70,099,248
2034	143,730	764	7,266	3,402	3,024	22,683	4,492,260	12,697,702	2,340,503	3,303,260	2,921,655	46,265,293	72,043,356
2035	144,781	736	7,266	3,402	3,024	21,851	4,492,260	12,790,567	2,357,620	3,356,646	2,963,671	48,030,108	74,012,723

1/ 13 % of the new users that would connect would have a potable water rationed service (“without” project)
2/ Users with a 3 to 7 hour - restricted water supply service
3/ For a better water supply and sewerage service
4/ 95% of accidents have been considered (payment of third party insurances), it regards to potable water service
Source: JICA Study Team and Appendix 7,

3.7 Social Evaluation (Economic Evaluation)

3.7.1 Social Evaluation Methodology

Cost – Benefit methodology is applied in order to carry out the Project´s social evaluation. Net Present Value (NPV) and Internal Rate of Return (IRR) are used as profitability indicators. A social discount rate of 10% was used for cost and benefit updating, as defined by MEF (Appendix SNIP 10 – Evaluation Parameters), as well as a minimum social performance rate for public investment projects.

In addition to the cost – effectiveness methodology, the investment per capita cost at market prices is also applied for the sewerage system (secondary networks, house connections, and box) in the Project.

As previously mentioned, the most important steps taken for social cost and benefit identification include:

1) Comparison between the “with” and “without” project situations:

   “With” project: The infrastructure optimization project (sectorization, rehabilitation and/or replace) of potable water and sewerage networks will complete the investment phase within the proposed implementation period In that sense, it shall accomplish the targeted reduction of technical water loss to 20% (objective indicator), reaching the goals of maintaining an average service continuity of twenty-four (24) hours, an average minimum pressure in the networks of 23mca, and overall water quality in the households. Likewise, sanitary conditions will be improved, as clogs are reduced in the sewerage networks.

   “Without” project: The current state of the water and sewerage infrastructure shall be maintained, with gradual deterioration of said infrastructure, service degradation with the increase of operative maintenance costs and the repair of networks and connections and the payment of disaster insurance for the networks and connections. This situation entails maintaining the current level of technical water loss. Likewise, continuous water service will be disrupted, and network pressure will decrease; therefore, a higher production of potable water will be required (new water sources, production, and distribution), and the users will perceive a decreased social well-being, as the potable water service is rationed.

2) Distinction between costs, incremental benefits (increased consumption), maintenance cost savings, insurance payments for accidents on pipes and connections, and benefits for reclaimed water volume (avoided costs related to marginal reductions in technical water loss).

3) Conversion of costs and benefits from market prices to social price was carried out, using factors suggested by the DNS (Appendix B.).

Through this procedure, an economic cash flow at social price was set up to identify net social benefits for the project evaluation period.

3.7.2 General Considerations

A list of the pre-conditions and assumptions for analysis is shown below:

1) The water supply and sewerage project evaluation period is 20 years (2016 – 2035.) The investment phase should be completed in the third quarter of 2016.

2) "Cost – Benefit" methodology is used for water supply project evaluation. "Cost – Effectiveness" methodology will be applied for the sewerage project.

3) Benefits are taken into account for the social flow, as of 2016 (the last quarter) and on a whole annual basis for the remaining years (2017 – 2035).

4) Economic benefits derived from an increased willingness to pay by the existing users are as follows: 70 % for the water supply service and 30 % from the sewerage service. This makeup will prevail at the current rates for these services.

5) All costs and benefits are expressed at social price as of June 2010, and for market price conversion to social price, factors suggested by DNS were used.

6) Water primary network infrastructure has an economic life span of 50 years. Therefore, the project will carry on generating net benefits for the next 30 years after the end of 20 years of Project planning horizon and Project evaluation period. However, in present social evaluation of the Project, future benefits have not been considered.

7) A social discount rate of 10.0 % will be used to calculate NPV.

8) Investment cost per capita (market price) is calculated for the sewerage project (secondary networks and connections), for comparison purposes with the reference value shown in Appendix SNIP 09 (Parameters and Technical Regulations for Formulation purposes – parameters of sanitation projects.)

9) Costs for future potable water and sewerage connections are not incremental to the Project. Therefore, they are not taken into account for social flow because they are not attributed to the project.

3.7.3 Results of the Social Evaluation

(1) Water supply project

Economic evaluation results are shown in Table 3.7.3-1. These results show that the water supply project is feasible from the economic point of view, based on the amounts established by the beneficiaries for the scheduled investments in the rehabilitation and replacement of water supply networks, connections, reservoirs, electromechanical and automation equipment, and primary works (supply mains and force mains to reservoirs) that are interconnected to the Ramal Norte ("Northern Branch") system that will be fed with water from the future Huachipa Water Treatment Plant.

From the net flow of the economic evaluation, a net present value (NPV) can be obtained amounting to S/. 41.5 million, as well as a 12.8% internal rate of return (IRR) that exceeds the discount rate used for the updating of total flow.

(2) Sewerage project

In order to evaluate investment rationality, the investment cost per capita was calculated; that is, the initial total investment at market prices divided by the average number of beneficiaries in the evaluation period, for purposes of comparing it to the relevant reference value provided in Appendix SNIP 09. Given that this is a network and house connection renewal project, per-capita investment costs were calculated separately for networks and connections.

Table 3.7.3-2 shows that the investment value per capita for the Project (networks and connections) is US$ 205. This value is lightly less compared to the reference value of per capita cost in Appendix SNIP 09 “Sewerage network and connection extension without primary works,” which amounts to USD $224 / inhabitant in urban areas; therefore, the proposed investment is acceptable.

Table 3.7.3-3 shows the Project social evaluation results (secondary sewer networks and connections), by using the Cost-effectiveness methodology. These results show a cost effectiveness index of S/. 283 Nuevos Soles/inhab (US$ 100/inhab.) For index specification purposes, investments and maintenance cost savings have been updated separately, by using an 10% update rate. The updated cost value (investment and cost savings) has been divided among the average benefiting population from year 1 to year 20 for the case of the networks, and among the population benefiting directly with connections, in the case of such connections. These populations are shown in Table 3.7.3-2.

Table 3.7.3-1: Economic Evaluation of Water Supply in the Project
(Nuevos Soles at social price, as of June 2010)

Year	Gross benefits				Total annual benefits	Total investment and equipment replacement 1//	Net flow
	Increased potable water consumption	Increased willingness to pay	Cost savings in O&M	By reclaimed volume of water			
2011					0	0	0
2012					0	5,809,248	-5,809,248
2013					0	21,958,200	-21,958,200
2014					0	86,068,008	-86,068,008
2015					0	95,921,801	-95,921,801
2016	1,148,039	1,988,329	629,854	3,563,159	7,329,381 2/	48,728,628	-41,399,247
2017	4,592,962	8,308,125	2,550,046	20,157,217	35,608,350	0	35,608,350
2018	4,593,736	8,665,659	2,580,896	22,012,774	37,853,065	0	37,853,065
2019	4,594,473	9,025,792	2,612,300	23,943,879	40,176,443	0	40,176,443
2020	4,524,386	9,138,984	2,653,361	25,497,763	41,814,494	0	41,814,494
2021	4,523,184	9,247,939	2,694,966	26,744,703	43,210,791	7,015,774	36,195,017
2022	4,523,199	9,356,948	2,737,617	27,984,785	44,602,548	0	44,602,548
2023	4,523,199	9,465,956	2,780,528	29,298,613	46,068,295	0	46,068,295
2024	4,523,184	9,574,911	2,824,191	30,642,353	47,564,639	0	47,564,639
2025	4,523,155	9,683,763	2,868,416	32,036,383	49,111,716	0	49,111,716
2026	4,523,111	9,792,463	2,913,219	33,481,602	50,710,396	38,766,435	11,943,961
2027	4,521,963	9,897,116	2,959,030	34,941,696	52,319,805	0	52,319,805
2028	4,520,843	9,997,825	3,005,746	36,422,163	53,946,576	0	53,946,576
2029	4,519,758	10,094,712	3,052,970	37,966,205	55,633,646	0	55,633,646
2030	4,518,711	10,187,908	3,100,852	39,561,091	57,368,563	0	57,368,563
2031	4,517,705	10,277,560	3,149,611	41,185,049	59,129,924	7,015,774	52,114,150
2032	4,516,741	10,363,815	3,199,212	42,843,454	60,923,221	0	60,923,221
2033	4,515,820	10,446,824	3,250,819	44,528,145	62,741,608	0	62,741,608
2034	4,514,943	10,526,744	3,303,260	46,265,293	64,610,239	0	64,610,239
2035	4,514,111	10,603,731	3,356,646	48,030,108	66,504,596	38,766,435	27,738,161
Net Present Value (10%)					**224,105,182**	**182,571,816**	**41,533,366**
Social Internal Rate of Return							**12.8%**

1/ Electromechanical. Meters, automation and maintenance equipment replacement. (for details refer Appendix B4)
2/ Benefits for year 2016 are related to a quarter because of starting of the project operation
Source: JICA Study Team

Table 3.7.3-2: Per Capita Investment in Sewerage Secondary Networks and Connections

Concept	Units	Networks and connections
Investment (networks)	(S/.)	125,266,795
Investment (connections)	(S/.)	52,238,962
Average beneficiary population (networks)	inhabitants	569,005
Beneficiary population (Connections)	inhabitants	144,244
S/. per capita investment (networks)	S/. inhab	220
S/. per capita investment (Conections)	S/.inhab.	362
S/. per capita total investment	S/. inhab	582
US$ per capita investment	US$/inhab	205
Per capita cost – urban area	US$inhab.	224

Source: JICA Study Team

Table 3.7.3-3: Economic Evaluation for Sewerage in the Project (Cost – Effectiveness Index)

(Nuevos Soles at social price, as of June 2010)

Year	Total population (inhab.)	Coverage (%)	Served population (hab.)	Total investment (Networks without connections)	Total investments (Connections)	Maintenance cost savings	Net flow (networks)
2010	519,661	68.60%	356,507	0	0	0	0
2011	527,994	72.10%	380,667	0	0	0	0
2012	535,676	75.59%	404,920	3,186,578	0	0	3,186,578
2013	542,762	79.08%	429,235	7,148,205	0	0	7,148,205
2014	549,299	82.58%	453,585	26,158,868	12,693,266	0	26,158,868
2015	555,337	86.07%	477,952	44,691,905	16,924,355	0	44,691,905
2016	560,914	89.55%	502,313	24,041,534	12,693,265	-2,300,424	21,741,110
2017	566,077	93.04%	526,665	0	0	-2,322,240	-2,322,240
2018	570,867	96.52%	551,001	0	0	-2,344,084	-2,344,084
2019	575,314	100.00%	575,314	0	0	-2,366,335	-2,366,335
2020	579,448	100.00%	579,448	0	0	-2,399,565	-2,399,565
2021	583,325	100.00%	583,325	0	0	-2,433,184	-2,433,184
2022	587,200	100.00%	587,200	0	0	-2,467,769	-2,467,769
2023	591,073	100.00%	591,073	0	0	-2,502,404	-2,502,404
2024	594,942	100.00%	594,942	0	0	-2,537,657	-2,537,657
2025	598,807	100.00%	598,807	0	0	-2,573,301	-2,573,301
2026	602,672	100.00%	602,672	13,078,932	0	-2,609,350	10,469,582
2027	606,496	100.00%	606,496	0	0	-2,646,300	-2,646,300
2028	610,279	100.00%	610,279	0	0	-2,684,024	-2,684,024
2029	614,025	100.00%	614,025	0	0	-2,722,059	-2,722,059
2030	617,730	100.00%	617,730	0	0	-2,760,571	-2,760,571
2031	621,399	100.00%	621,399	0	0	-2,799,810	-2,799,810
2032	625,030	100.00%	625,030	0	0	-2,839,732	-2,839,732
2033	628,623	100.00%	628,623	0	0	-2,880,430	-2,880,430
2034	632,175	100.00%	632,175	0	0	-2,921,655	-2,921,655
2035	635,696	100.00%	635,696	0	0	-2,963,671	-2,963,671
Cost Present Value (10%)				**70,038,279**	**26,343,382**	**-13,209,305**	**56,828,973**
CEI (Soles/inhab) Networks – no connection							**100**
CEI (Soles/inhab) - Connection							**183**
CEI (Soles/inhab) –Networks + Connection							**283**
CEI (US$/inhab.)							**100**
Cost per capita (US$/inhab.) 1/							**181**

1/ Revised at social price
Source: JICA Study Team

As it is compared to the relevant reference value in Appendix SNIP 09, it is noted that this CEI is also below the reference value, and this contributes to the project feasibility because of annual operation and maintenance cost savings that are generated in the social cost flow and that cause present value of costs (PVC) to decrease.

Based on both the per capita investment index and the cost-effectiveness index, it can be concluded that the sewerage (networks and connections) project is feasible from technical and economic points of view, as the results are below the reference values stated by SNIP 09.

3.8 Private Evaluation (Financial Evaluation)

Economic and financial evaluations were carried out in order to measure the impact of the Project´s investments on the economic-financial situation, under the following assumptions: i) income and incremental cost generation within the project scope, and ii) loan conditions and terms from each and every funding agency that will participate in the funding of project execution.

3.8.1 Economic Evaluation

The following assumptions were taken into account for the preparation of the financial cash flow in the evaluation period:

(1) Income

1) Income generated by the service-providing company in the ”with” project situation comes from the billing of potable water and sewerage services for a larger volume of available potable water to be supplied to other sectors close to the project scope. The larger volume of water available to SEDAPAL is the volume of water reclaimed as a result of a decrease in technical losses, both in the network and the connections; this reclaimed volume is 20 % of the total water demand for the project (water production requirement).

2) The annual calculation of reclaimed water volume is shown in Table 3.6.2-3 and Figure 3.6.2-2; this calculation is the difference in the total demand (thousands of cubic meters per year), between the “with” and “without” project situations throughout the evaluation period for the project (20 years). It is assumed that 75% of the reclaimed water will be billed to the users in other distribution areas close to the project scope, as shown in the project location map.

3) Income from reclaimed potable water and sewerage billing was multiplied by the average rate10 of S/. 2.43 / m3. This tariff was updated with the tariff increases in June 2010, as approved by SUNASS, that is 2.0 % as of 2011 and 2.0 % for 2012. This tariff is kept consistent throughout the 2016 – 2035 evaluation period.

4) Collection has a 98 % average effectiveness, and a 2 % average default.

5) Income for new future potable water and sewerage connections and their relevant billing is not incremental to the project. Therefore, it is not included in the economic flow.

6) Basic data for income calculation is shown in Table 3.8.2-1.

(2) Costs / Expenditures

[10] Average combined tariff for potable water and sewerage of S/. 2.43/m^3 as of June 2010 (including fixed charges), *Gerencia de Desarrollo e Investigación* (Development and Research Management), SEDAPAL 2010.

1) Costs in the "with" project situation have mainly considered as decreased costs in maintenance and repair of the water and sewerage network and connections. This minimizes operational corrective maintenance interventions by SEDAPAL, as well as insurance payments for any accidents caused by water networks and connections that mainly affect people's homes These costs represent cost reductions (resource savings) for the utility in terms of cash flow.

2) Reclaimed water commercialization costs have been taken into account (incremental costs), including charges for sewerage. These costs in the "with" project situation should be taken on by SEDAPAL, as a larger volume of water is required to supply areas close to the project. Calculation of commercialization costs are used, with an average unit cost of S/. 0.28 per cubic meter.

3) SUNASS input for sanitation service regulation was also taken into account. This input represents 1 % of the incremental income.

4) Project investments have been taken into account, in compliance with the works execution schedule. These investments include the preparation of the works detailed design, works supervision, and social intervention. Re-investment of equipments for control, electromechanical, water loss and collector cleaning equipment are considered too (See Appendix B4).

(3) Considerations and Evaluation Results

1) The project evaluation period is 20 years (2016-2035). The works detailed design will be prepared in 2012 and 2013; works will be executed in 2013, 2014, 2015, and 2016 (third quarter.)

2) A 3.92 % WACC was used for the economic and financial net flow updating, as calculated by SUNASS, for SEDAPAL's use in its Tariff Study during the 2010 – 2014 period. It is the JICA study team's opinion that the WACC value is a reasonable value, given the fact that project funding will cover 100 % of the investment costs without Sales Tax (VAT: Value Added Tax) to be covered by JICA and KfW. SEDAPAL will cover the VAT costs. Annual interest rate ranges for external loans granted to SEDAPAL are less than 4 %.

3) All incomes and costs are shown at prices as of June 2010.

4) All incomes and costs are shown without including Sales Tax (VAT).

5) Fixed assets (water supply and sewerage networks that are made operational by SEDAPAL after they have been incorporated to SEDAPAL), have a 50 – year depreciation period, and intangibles have a 5 – year depreciation period, according to SEDAPAL accounting practices. Therefore, by 2035 (year 20), that is, at the completion of the project evaluation period, assets will still be operative; therefore, SEDAPAL will continue raising net income (after taking away commercialization costs) for rendering sanitation services. The present value of this income (future values) is considered for the evaluation of the Project.

6) In this sense, an updated value for future net consistent income has been taken into account for the financial evaluation, throughout a 10 – year period, at a 3.92 % discount rate. This is a conservative estimation. This value is shown as an income in 2035 (year 20).

7) The project financial evaluation results, as shown in Table 3.8.2-2 show us a positive net present value (NPV) of S/. 19.7 million, and a 4.4% economic internal rate of return (EIRR)

for a 3.92 % discount rate. Therefore, the project is economically feasible to SEDAPAL.

8) At a 3.92 % discount rate, the results of the project's financial evaluation indicators claim that investments in replacement or rehabilitation of water supply and sewerage network, including investments in major water supply distribution networks, reservoir rehabilitations, and pumping station re-equipping, generate benefits or incremental income to SEDAPAL that exceed the investment costs and incremental operation and maintenance costs generated by the reclaimed water distribution and commercialization.

3.8.2 Financial Evaluation

Net flow of the economic evaluation and disbursements from the international cooperation funding agencies, such as JICA and KfW, have been taken into account for the financial evaluation. Financial conditions for loans, as well as the amounts and the debt service (interests, amortization of the principal, and commissions for non – disbursed balances), are shown in Chapter 3.15. These amounts are part of the funding flow for the Project financial evaluation during the Project evaluation period.

The Project's financial evaluation results show that SEDAPAL improves its position, resulting in a positive financial net present value (FNPV) of S/.34.4 million and a financial internal rate of return (FIRR) of 6.5%, for a 3.92 % discount rate, mainly as a result of the financial leverage generated by the good financial conditions for the bank loans, as shown in Table 3.8.2-3.

Table 3.8.2-1: Basic Data for Income Calculation, 1/2

(Nuevos Soles at market prices as of June 2010)

Data	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025
SEDAPAL average rate (S/./m3)	2.528	2.528	2.528	2.528	2.528	2.528	2.528	2.528	2.528	2.528
"Without Project" water supply demand (m3/year)	42,088,498	44,120,505	46,188,691	48,240,931	48,853,625	49,478,569	50,039,743	50,659,733	51,263,963	51,882,815
"With Project" water supply demand (m3/year)	33,814,418	33,090,379	34,641,518	36,180,698	36,640,219	37,108,926	37,529,807	37,994,800	38,447,972	38,912,111
Connections (Project) - (Units)	110,456	115,330	120,239	125,184	126,756	128,270	129,785	131,300	132,815	134,329
Water consumptions (Project) (m3/year)	25,253,099	26,472,303	27,713,215	28,944,559	29,312,175	29,687,141	30,023,846	30,395,840	30,758,378	31,129,689
Reclaimed water volume (m3//year)	8,274,080	11,030,126	11,547,173	12,060,233	12,213,406	12,369,642	12,509,936	12,664,933	12,815,991	12,970,704
Reclaimed water billing (distribution to other sectors) (S/./year)	3,922,181[1/]	20,914,542	21,894,929	22,867,757	23,158,194	23,454,437	23,720,452	24,014,347	24,300,772	24,594,128
Default (2% reclaimed water billing) (S/./year)	78,444	418,291	437,899	457,355	463,164	469,089	474,409	480,287	486,015	491,883
Income for reclaimed water (S/./year)	3,843,737	20,574,695	21,875,321	22,848,301	23,152,385	23,448,512	23,715,132	24,008,469	24,295,043	24,588,260

1/ Last quarter is taken into account

Source: JICA Study Team

Table 3.8.2-1: Basic Data for Income Calculation, 2/2

(Nuevos Soles at market prices as of June 2010)

Data	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035
SEDAPAL average rate (S/./m^3)										
"Without Project" water supply demand (m3/year)	57,814,375	58,997,172	60,167,104	61,390,576	62,645,687	63,898,878	65,157,989	66,411,179	67,695,153	68,974,471
"With Project" water supply demand (m3/year)	39,386,043	39,823,091	40,236,751	40,671,257	41,111,232	41,534,271	41,945,456	42,337,127	42,732,565	43,109,044
Connections (Project) - (Units)	135,842	137,299	138,702	140,053	141,354	142,607	143,813	144,975	146,096	147,176
Water consumptions (Project) (m3/year)	31,508,834	31,858,473	32,189,401	32,537,005	32,888,986	33,227,417	33,556,365	33,869,701	34,186,052	34,487,235
Reclaimed water volume (m3//year)	17,169,671	17,918,420	18,677,617	19,469,416	20,287,288	21,120,068	21,970,514	22,834,439	23,725,264	24,630,277
Reclaimed water billing (distribution to other sectors) (S/./year)	32,555,911	33,975,636	35,415,171	36,916,525	38,467,315	40,046,374	41,658,928	43,297,042	44,986,161	46,702,183
Default (2% reclaimed water billing) (S/./year)	651,118	679,513	708,303	738,330	769,346	800,927	833,179	865,941	899,723	934,044
Income for reclaimed water (S/./year)	32,527,806	33,947,241	35,386,381	36,886,498	38,436,300	40,014,793	41,626,677	43,264,279	44,952,379	46,667,862

Source: JICA Study Team.

Table 3.8.2-2: Economic Evaluation for the Project, 1/2

(Nuevos Soles at market prices as of June 2010)

Item	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Income					**3,395,353**	**19,277,210**	**21,368,084**	**23,244,330**	**24,762,588**	**25,981,022**	**27,186,952**
Income from water supply and sewerage (Recovered water)					3,395,353	19,277,210	21,368,084	23,244,330	24,762,588	25,981,022	27,186,952
Income future value											
Expenditures	**8,476,967**	**27,445,468**	**126,067,905**	**159,000,731**	**83,034,280**	**-3,307,855**	**-3,222,754**	**-3,136,944**	**-3,100,834**	**3,759,298**	**-3,089,093**
Investments											
- Water supply general works		3,653,271	14,613,082	10,959,810							
- Reservoir, pumping station, well rehabilitations and automation		4,725,800	18,903,201	14,177,402							
- Secondary networks and water connections			39,126,488	52,168,651	39,126,486						
- Secondary networks and sewerage connections			32,493,184	43,324,245	32,493,182						
- Equipment for Operation & Maintenance				17,586,109							
- Costs of environmental mitigation, social intervention and technical cadastre		1,716,203	6,864,810	6,864,810	5,148,609						
- Works detailed design	8,034,662	13,391,104									
- Works supervision and environmental monitoring		3,074,481	12,297,919	12,297,919	9,223,438						
- Project administration	442,305	884,610	1,769,220	1,621,785	884,610						
O&M costs											
- Operation costs											
- Maintenance and insurance costs					-4,957,868	-5,011,815	-5,066,019	-5,121,209	-5,197,629	-5,275,007	-5,354,454
- Distribution and commercialization costs (reclaimed water)					1,081,870	1,511,187	1,629,583	1,751,822	1,849,169	1,921,123	1,993,491
- Contribution to SUNASS (1.0%)					33,954	192,772	213,681	232,443	247,626	259,810	271,870
Re-investment										6,853,372	
Balance (economic flow)	**-8,476,967**	**-27,445,468**	**-126,067,905**	**-159,000,731**	**-79,638,927**	**22,585,065**	**24,590,839**	**26,381,274**	**27,863,422**	**22,221,724**	**30,276,045**

Source: JICA Study Team

Table 3.8.2-2: Economic Evaluation for the Project, 2/2
(Nuevos Soles at market prices as of June 2010)

Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Income	**28,463,022**	**29,769,029**	**31,123,539**	**32,527,806**	**33,947,241**	**35,386,381**	**36,886,498**	**38,436,300**	**40,014,793**	**41,626,677**	**43,264,279**	**44,952,379**	**142,898,185**
Income from water supply and sewerage (Recovered water)	28,463,022	29,769,029	31,123,539	32,527,806	33,947,241	35,386,381	36,886,498	38,436,300	40,014,793	41,626,677	43,264,279	44,952,379	46,667,862
Income future value													96,230,323[1/]
Expenditures	**-3,082,437**	**-3,075,872**	**-3,068,690**	**34,808,130**	**-3,054,646**	**-3,049,918**	**-3,045,302**	**3,812,043**	**-3,038,797**	**-3,037,569**	**-3,037,943**	**-3,039,118**	**34,827,148**
Investments													
- Water supply general works													
- Reservoir, pumping station, well rehabilitation and automation													
- Secondary network and water connections													
- Secondary network and sewerage connections													
- Equipment for Operation & Maintenance													
- Costs of environmental mitigation, social intervention and technical cadastre													
- Works detailed design													
- Works supervision and environmental monitoring													
- Project administration													
O&M Costs													
- Operation costs													
- Maintenance and insurance costs	-5,434,221	-5,515,397	-5,597,552	-5,680,721	-5,765,852	-5,852,709	-5,940,410	-6,029,278	-6,119,796	-6,211,882	-6,305,722	-6,400,843	-6,497,755
- Distribution and commercialization cost (reclaimed water)	2,067,153	2,141,835	2,217,627	2,294,509	2,371,733	2,448,928	2,526,243	2,603,586	2,680,851	2,758,046	2,835,136	2,912,201	2,989,160
- Contribution to SUNASS (1.0%)	284,630	297,690	311,235	325,278	339,472	353,864	368,865	384,363	400,148	416,267	432,643	449,524	466,679
Re-investment				37,869,064				6,853,372					37,869,064
Balance (Economic flow)	**31,545,459**	**32,844,901**	**34,192,229**	**-2,280,325**	**37,001,888**	**38,436,298**	**39,931,800**	**34,624,257**	**43,053,590**	**44,664,246**	**46,302,222**	**47,991,497**	**108,071,038**

1/ Updated future value of income for 10 years

ENPV (3.92%)	19,722,974
EIRR	4.4%

Source: JICA Study Team

Table 3.8.2-3: Financial Evaluation for the Project, 1/2

(Nuevos Soles at market prices as of June 2010)

Item	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Income					**3,395,353**	**19,277,210**	**21,368,084**	**23,244,330**	**24,762,588**	**25,981,022**	**27,186,952**
Income from water and sewerage (Reclaimed water)					3,395,353	19,277,210	21,368,084	23,244,330	24,762,588	25,981,022	27,186,952
Future income value											
Expenditures	**8,476,967**	**27,445,468**	**126,067,905**	**159,000,731**	**83,034,280**	**-3,307,855**	**-3,222,754**	**-3,136,944**	**-3,100,834**	**3,759,298**	**-3,089,093**
Investments											
- Water supply general works		3,653,271	14,613,082	10,959,810							
- Reservoir, pumping station, well rehabilitation and automation		4,725,800	18,903,201	14,177,402							
- Water secondary networks and connections			39,126,488	52,168,651	39,126,486						
- Sewerage secondary networks and connections			32,493,184	43,324,245	32,493,182						
- Equipment for Operation & Maintenance				17,586,109							
- Costs of environmental mitigation, social intervention and technical cadastre		1,716,203	6,864,810	6,864,810	5,148,609						
- Works detailed design	8,034,662	13,391,104									
- Works supervision and environmental monitoring	0	3,074,481	12,297,919	12,297,919	9,223,438						
- Project administration	442,305	884,610	1,769,220	1,621,785	884,610						
O&M Costs											
- Operation costs											
- Maintenance and insurance costs					-4,957,868	-5,011,815	-5,066,019	-5,121,209	-5,197,629	-5,275,007	-5,354,454
- Distribution and commercialization cost (reclaimed water)					1,081,870	1,511,187	1,629,583	1,751,822	1,849,169	1,921,123	1,993,491
- Contribution to SUNASS (1.0%)					33,954	192,772	213,681	232,443	247,626	259,810	271,870
Re-investment										6,853,372	
Balance (Economic flow)	**-8,476,967**	**-27,445,468**	**-126,067,905**	**-159,000,731**	**-79,638,927**	**22,585,065**	**24,590,839**	**26,381,274**	**27,863,422**	**22,221,724**	**30,276,045**
- JICA loan	8,257,754	15,277,561	70,175,889	88,507,996	44,820,799						
- IBRD loan		5,729,085	26,315,958	33,190,499	19,904,457						
- KfW loan		5,729,085	26,315,958	33,190,499	19,904,457						
Service debt											
- Interests (-)	3,397,342	9,358,574	9,130,503	8,678,604	8,394,240	8,094,351	7,540,211	6,965,799	26,237,147	6,370,132	5,752,178
- Amortization (-)					5,208,124	5,492,488	25,108,596	25,662,735	26,237,147	26,832,814	27,450,768
Balance (Financial flow)	**-3,616,555**	**-10,068,310**	**-12,390,601**	**-12,790,341**	**-8,611,577**	**8,998,226**	**-8,057,968**	**-6,247,260**	**-24,610,873**	**-10,981,222**	**-2,926,901**

Source: JICA Study Team.

Table 3.8.2-3: Financial Evaluation for the Project, 2/2

(Nuevos Soles at market prices as of June 2010)

Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Income	**28,463,022**	**29,769,029**	**31,123,539**	**32,527,806**	**33,947,241**	**35,386,381**	**36,886,498**	**38,436,300**	**40,014,793**	**41,626,677**	**43,264,279**	**44,952,379**	**142,898,185**
Income from water and sewerage (Reclaimed water)	28,463,022	29,769,029	31,123,539	32,527,806	33,947,241	35,386,381	36,886,498	38,436,300	40,014,793	41,626,677	43,264,279	44,952,379	46,667,862
Future income value													96,230,323[1]
Expenditures	**-3,082,437**	**-3,075,872**	**-3,068,690**	**34,808,130**	**-3,054,646**	**-3,049,918**	**-3,045,302**	**3,812,043**	**-3,038,797**	**-3,037,569**	**-3,037,943**	**-3,039,118**	**34,827,148**
Investments													
- Water supply general works													
- Reservoir, pumping station, well rehabilitation and automation													
- Water secondary networks and connections													
- Sewerage secondary networks and connections													
- Equipment for Operation & Maintenance													
- Costs of environmental mitigation, social intervention and technical cadastre													
- Works detailed design													
- Works supervision and environmental monitoring													
- Project administration													
O&M Costs													
- Operation costs													
- Maintenance and insurance costs	-5,434,221	-5,515,397	-5,597,552	-5,680,721	-5,765,852	-5,852,709	-5,940,410	-6,029,278	-6,119,796	-6,211,882	-6,305,722	-6,400,843	-6,497,755
- Distribution and commercialization cost (reclaimed water)	2,067,153	2,141,835	2,217,627	2,294,509	2,371,733	2,448,928	2,526,243	2,603,586	2,680,851	2,758,046	2,835,136	2,912,201	2,989,160
- Contribution to SUNASS (1.0%)	284,630	297,690	311,235	325,278	339,472	353,864	368,865	384,363	400,148	416,267	432,643	449,524	466,679
Re-investment				37,869,064				6,853,372					37,869,064
Balance (Economic flow)	**31,545,459**	**32,844,901**	**34,192,229**	**-2,280,325**	**37,001,888**	**38,436,298**	**39,931,800**	**34,624,257**	**43,053,590**	**44,664,246**	**46,302,222**	**47,991,497**	**108,071,038**
Disbursements													
- JICA loan													
- IBRD loan													
- KfW loan													
Service debt													
- Interests (-)	5,110,847	4,444,993	3,753,409	3,034,825	2,287,900	1,511,224	1,529,912	1,149,027	964,116	776,617	586,493	393,707	198,222
- Amortization (-)	28,092,100	28,757,953	29,449,537	30,168,122	30,915,047	12,845,696	13,025,536	13,207,893	13,392,804	13,580,303	13,770,427	13,963,213	14,158,698
Balance (Financial flow)	**-1,657,487**	**-358,045**	**989,282**	**-35,483,271**	**3,798,941**	**24,079,378**	**25,376,353**	**20,267,337**	**28,696,670**	**30,307,326**	**31,945,302**	**33,634,577**	**93,714,118**

1/ Updated future value of income for 10 years

FNPV (3.92%)	34,407,415
FEIRR	6.5%

Source: JICA Study Team.

3.9 Sensitivity Analysis

The sensitivity analysis was carried out in order to identify to what extent the uncertain factors affect the social profitability of the water and sewerage Project. The variable factors (increase or decrease) used for this purpose were: i) variation in the investment costs, ii) variation in the operation and maintenance costs, and iii) variation in the benefits.

In that sense, for the water project, the following variables are used in an independent way:

1) Decrease of the total benefits, due to a lower value of the reclaimed water in 5%, 10% and more than 15%, as well as the decrease of the maximum willingness to pay in 10%, 30%and more than 50% due to the improvement of water service and decreasing of maximum water consumption of the users with restriction of service. In this case, its exclusion doesn’t affect the project profit.

2) Increase of the investment costs by 5%, 10%, and more than 15%.

In Table 3.9-1, the results of the evaluation indicators are presented for each variation case, which a conclusion can be made that the water project is very sensitive to two factors: 1) the decrease of the recovered water with the decrease in technical losses, which strongly affects the net flow and the economic indicators; and 2) the decrease of the maximuml use of water.

Table 3.9-1: Variation 1- Decrease of Benefits

(Shown in Nuevos Soles at social prices as of June 2010)

Decrease of Reclaimed Water	NPV (S/.)	Decrease of Maximum Willingness to Pay	NPV (S/.)	Decrease of Maximum Water Use	NPV (S/.)
Base	**41,533,366**		**41,533,366**	Base	**41,533,366**
5%	34,388,604	15%	34,706,516	Exclusion	19,434,364
10%	27,243,842	30%	27,879,666	Exclusion	19,434,364
15%	20,099,080	50%	18,777,199	Exclusion	19,434,364
25%	5,809,557	75%	7,399,115	Exclusion	19,434,364
29%	-6,279	91%	3,361	Exclusion	19,434,364

Source: JICA Study Team

Results of the sensitivity analysis for the cost variations are shown in Table 3.9-2, and they show that they are sensitive to the variation in the investment costs.

Table 3.9-2: Variation 2- Increase of Costs

(Shown in Nuevos Soles at social prices as of June 2010)

Increase of investment costs	NPV (S/.)
Base	**41,533,366**
5%	32,167,158
10%	22,778,321
15%	13,366,853
22%	-17,405

Source: JICA Study Team

In the case of the sewage project, a sensitivity analysis was also carried out, so as to identify how the variation of the beneficiaries and costs affect the obtained results of the CEI (Cost-Efficiency Index) up to make equal the per-capita cost of SNIP Appendix 09 “Enlargement of sewerage networks and connections without including primary works”. It has considered to carry out the following variations in an independent way:

1) Increase of investment cost on connections by 5 %, 10%, 20% and 35.
2) Increase of investment cost on networks by 60 %, 80%, 100% and 135%.

The results of the indicators of evaluation are shown for each variation in Table 3.9-3; with the conclusion that such projects are also low sensitive to the increment of investment cost on networks..

Table 3.9-3: Variation 1- Increase of Investment Cost

(Shown in Nuevos Soles at social prices as of June 2010)

Investment Costs in Connections	**CEI S/. inhabitant**	**Investment Costs in Network**	**CEI S/. inhabitant**	**TOTAL CEI S/. inhabitant**
Base	**183**	Base	**100**	**283**
+5%	192	+60%	174	366
+10%	201	+80%	198	399
+20%	219	+100%	223	442
+35%	247	+135%	266	513 [1/]

1/ Similar to per-capita cost at social prices (Annex SNIP 09)
Source: JICA Study Team

3.10 Risk Analysis

A risk analysis was carried out so as to statistically evaluate the results of the social evaluation of the Project. This analysis was carried out using the complementary MS Excel Software called “Crystal Ball,” which allows the user to analyze the risks and uncertainties associated with the random variation of the factors identified as variables in the model, carrying out a risk analysis through a Monte Carlo simulation.

In order to carry out this analysis, the probability function must be determined for the profitability indicator, which in this case is Net Present Value (NPV). This probability function is to be determined for those changes that may take place in the variables directly related to the Project´s profitability. These variables are related to the economic benefits, investments and operation and maintenance costs. The evaluation is carried out by assigning them a probability of normal distribution in the year of occurrence around the mean value determined in the social evaluation of the project (NPV).

The hypothetical ranges were:

Benefits : +/- 30% of the mean value

Investments : +/- 30% of the mean value

Ten thousand iterations were carried out to obtain the most probable statistical behavior of the Net Present Value of the Benefits, Investments and Costs of Operation and Maintenance. The result of the Risk Analysis shows that the medium (NPV) is S/.41,226,836, with a Minimum Range at S/.-71,160,718 and a Maximum Range at S/.151,763,538, with a standard error from the mean as S/.288,534.

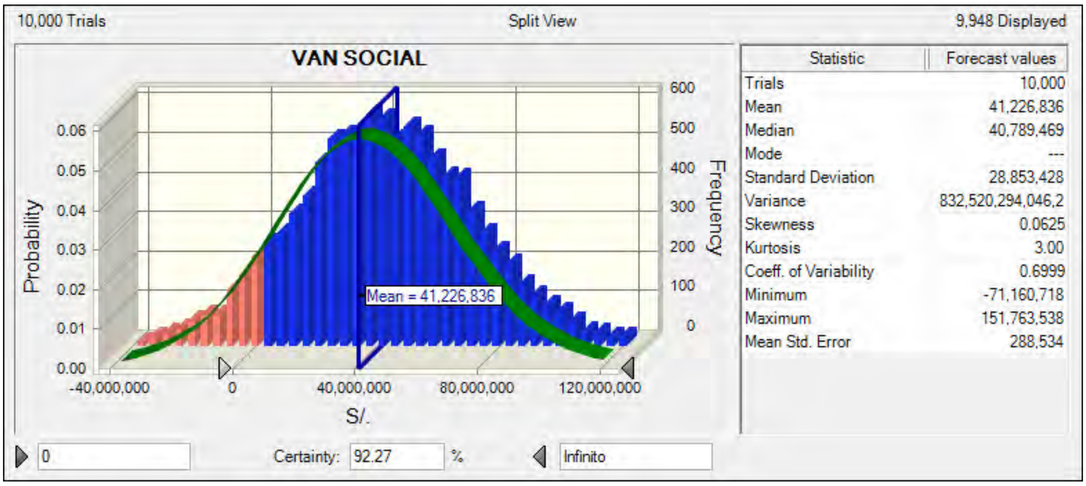
In Table 3.10-1, the main indicators of the results of the simulation are presented, such as the median, standard deviation, variance and the variability coefficient. In figures 3.10-1, N° 3.10-2 and N° 3.10-3 shows the social NPV, variable sensitivity analysis and variable correlation analysis, respectively. The results of the risk analysis performed for each of the components (benefits and investments) are presented in Appendix B6.

If a hypothesis on variation of benefits and investment would be carried out, probability of 92.27% would result and NPV would be higher or same as the estimated in the situation with project. This means that before variation in benefits and in investments (within the proposed ranges), NPV will be higher, therefore, IRR will be higher than social rate of discount of 10%.

Table 3.10.1-1: Results of the Simulation

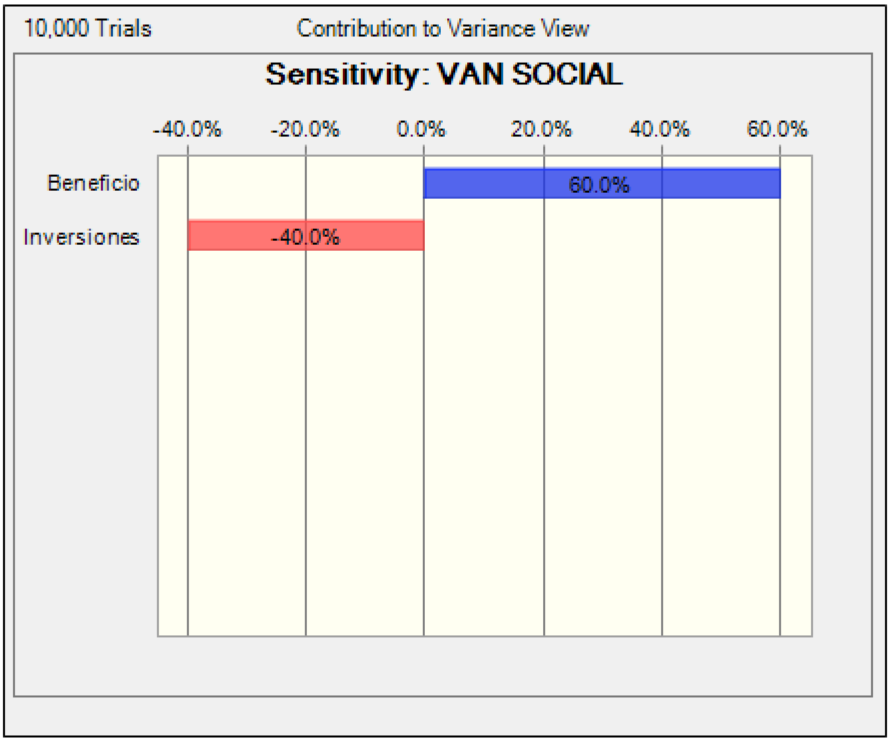
Number of Simulations	10,000
Mean value of the Simulation	41,226,836
Median	40,789,469
Mode	---
Standard Deviation of the Simulation	28,853,428
Variance of the Simulation	8.33E+14
Skewness	0.0625
Kurtosis	3.00
Variability Coefficient	0.6999
Minimum Value of the Simulation	-71,160,718
Maximum Value of the Simulation	151,763,538
Difference of Ranges	222,924,256
Standard Error of the Mean	288,534

Source: JICA Study Team



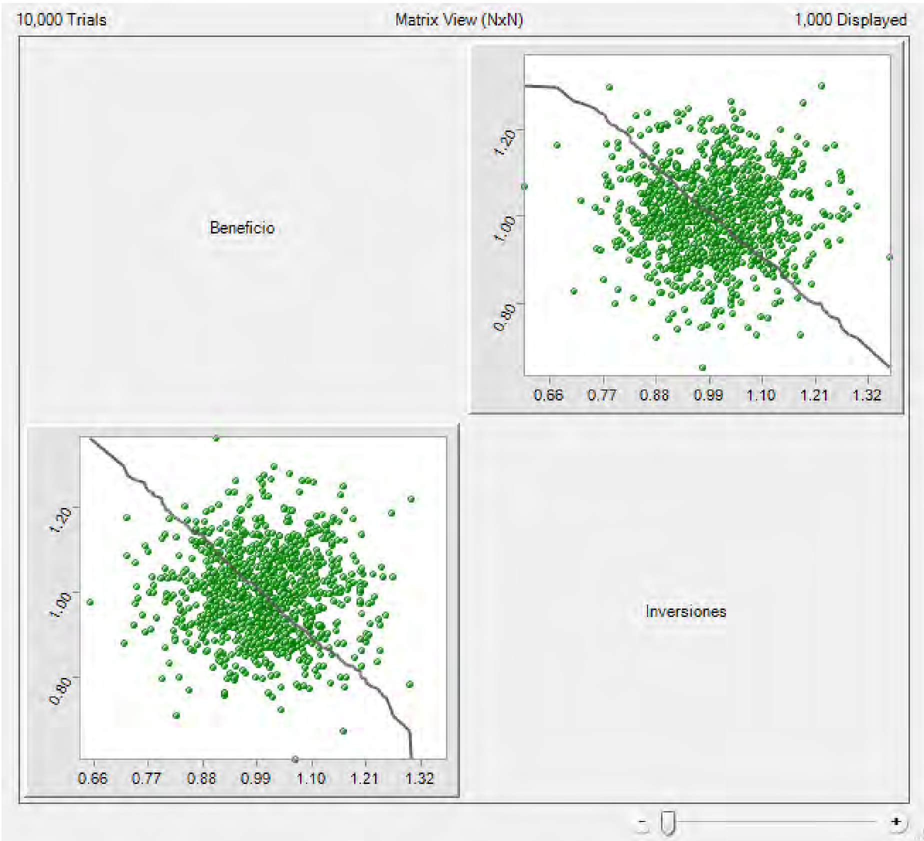
Source: JICA Study Team

Figure 3.10.1-1: Probable Distribution of the Social NPV



Source: JICA Study Team

Figure 3.10.1-2: Chart of the Sensitivity of the Variables



Source: JICA Study Team

Figure 3.10.1-3: Correlation of the Variables

3.11 Sustainability Analysis

In order to guarantee the success of the Project and achieve the desired benefits throughout the project planning period, a sustainability analysis is carried out, which is defined as the ability of a Public Investment Project to maintain the acceptable flow level of net benefits throughout its planning period. This can be expressed in quantitative and qualitative terms upon evaluation of the institutional, legal, economic, technical, environmental, and socio-cultural aspects, among others.

For this purpose, the fundamental aspects are evaluated which will assure the success of the Project. First, SEDAPAL´s capacity to carry out the subsequent stages of the project cycle: development of the technical works file, including the tendering documents, tendering of works and operation of the different actions; and second, in the medium term, the sustainability of the investments, a product of the implementation of the different actions. All of this assures a substantial improvement in the quality of water and sewerage services, which the company provides to current and future clients in the Project zone or Area (North Services Management Department).

3.11.1 Institutional Agreements Foreseen for the Project Execution

In this section, SEDAPAL´s capacity to carry out the following stages of the project cycle was evaluated, including development of the technical works file, tendering of works, implementation, and operation and maintenance for the medium term and long term.

It is SEDAPAL´s responsibility to carry out the monitoring of the feasibility study (this Study) until project viability has been obtained, and it also must ask the Ministry of Economy and Finances to manage the financing from the entities of the international funding cooperation (like, JICA, IBRD and KfW) and to provide the corresponding contracts between the Ministry of Economy and Finances, in representation of the Peruvian Government, and the cooperating organizations.

The Executing Unit for the investment stage of the project is the Sanitation Improvement Program Team in the Marginal Areas of Lima (PROMESAL: *Equipo del Programa de Mejoramiento Sanitario de las Áreas Marginales de Lima*), an office that depends functionally on the General Management Department of SEDAPAL. The Executing Unit shall have the role of technical, financial, and contractual administration of the project.

Once the contracts have been signed for loans corresponding with each funding entity, and the Agreements of Transfer of resources have been signed between the National Directorate of Public Debt (NDPD) and SEDAPAL, the Executing Unit of the Project shall execute the tendering to contract the Consultant, who will be in charge of developing the technical works file (detailed design), advising SEDAPAL in the tendering of works packages, and executing supervision of works. The legal aspects for this method of contracting are explained in Chapter 3.11.2.

For execution of the Project works in defined batches as stipulated in the Implementation Plan, national and international contracting companies will be called on through public tendering; the selected companies will sign contracts corresponding to the execution of works, and activation of the rehabilitated and renewed water and sewerage system networks, including connections, reservoirs, and water pumping stations.

In addition to the physical works, social monitoring and environmental education activities shall be developed, which shall be proposed as a result of the diagnosis of the feasibility study and the successful experiences SEDAPAL has had with other projects; the costs of these activities have been incorporated in the Project costs. These activities should be carried out through external consultancies having national specialists or specialized firms. The planning and design shall be developed in implementation stage and in a parallel with the development of the detailed design works.

The implementation of said actions will contribute to the strengthening of the commercial and operational components, of the Commercial Team and the Operation and Maintenance Team, respectively, in the Networks of the North Services Management Department. In this way, the necessary conditions will be generated for the sustainability of the project investments, especially in maintaining the level of technical loss (objective indicator of 20%) in the planning period.

The Executing Unit shall also be responsible for the activities of supervision and approval of the development of technical works files, approval of the appreciation during the execution of works, and the start of operation of the optimized installations in coordination with SEDAPAL´s offices or management departments (Projects and Works Management Department in the execution stage) and with the North Services Management Department.

The North Services Management Department shall be in charge of the operation of the project infrastructure; its objective is to render sanitation services once the facilities have been received from the contractors.

The acquisition of equipment to be used for clearing the sewers has also been included in the Project costs, as well as the equipment to be used for leak detection and the portable equipment for controlling residual chlorine. In this way, the company´s capacity will be strengthened for the operation stage of the Project.

3.11.2 Legislative Framework Necessary for Project Execution and Operation

The following documents will be applied for the investment stage of the Project: i) separate loan agreements between the Peruvian Government and JICA, IBRD, and KfW; ii) Acquisition guidelines for the ODA (Official Development Assistance) loans of JICA; iii) JICA guidelines for the employment of consultants for the ODA loans,; iv) Regulations and Procedures for the World Bank loan, and v) Regulation for the Awarding of Sales and Services Contracts in the KfW´s framework of Official Cooperation with Developing

Countries. and vi) as long as they do not oppose the regulations of the financing entities, the State Contracting Law[1] (Legislative Decree N° 1017) and its Regulations (Supreme Decree N° 184-2008-EF) and amendments. In the same way, the following shall also be applied: Law N° 27785 of the National Control System of the General Comptroller of the Republic, the Technical Regulations for Internal Control for the public sector approved by the Comptroller Resolution N° 072-98-CG, Comptroller Resolution N° 036-2001-CG from 14-03-2001, Comptroller Resolution N° 123-2000-CG from 23-06-2000 – Regulation 700-06 (Contracting and acquisition of goods and services or works), and Law N° 27444, General Administrative Procedures Law.

The legislative framework for Project operation is given by Law Nº 25965, created by the National Sanitation Services Superintendency (SUNASS: Superintendencia Nacional de Servicios de Saneamiento) and the Law N° 263338, General Sanitation Services Law; also, the Single Revised Text (TUO: *Texto Único Ordenado*) of the General Sanitation Services Law, approved by Supreme Decree Nº 023-2005-VIVIENDA (December 01, 2005), modified by Supreme Decree 010 and 024-2007-VIVIENDA, and lastly by the TUO of the Regulations enacted by Supreme Decree 031-2008-VIVIENDA from November 30, 2008.

For the Regulation of Sanitation Services, the Tariff Regulation Rules are applied which were approved by the SUNASS Advisory Board (Advisory Board Resolution N° 09-2007-SUNASS-CD and its amendments).

3.11.3 Management Capacity of the Organization in Charge of the Project during Investment and Operation Stages.

The Executing Unit of the project is PROMESAL. This Team has the technical capacity and the management capacity for the administration and supervision of development for all activities during project implementation; their activities are expected to begin once the Project Viability has been declared, and after the signing of loan contracts with the funding entities (JICA, IBRD, and KfW).

It also has the duty of administrating the loan contracts, supervision of works and services, financial operation of the loans from IBRD (International Bank for Reconstruction and Development), JICA, and others. The functional flow diagram for the team is shown in Figure 3.13-1.

In conclusion, the PROMESAL Team has the capacity to manage the Project from the investment stage until the completion of the works contract and the receiving the works for the operation and maintenance.

The Operation and Maintenance Team of the Comas Networks and the Callao Networks, both under the North Service Management Department, are currently responsible for the operation and maintenance of the networks and connections in the Project area, and once the investment

[1] Law of State Contract (*Ley de Contrataciones del Estado)*

stage is over, they shall continue to be responsible for the operation and maintenance of the secondary connections in the water and sewerage services.

As explained in the previous paragraphs, SEDAPAL, through its respective teams, has sufficient organization, experience, technical capacity, and management capacity to be able to supervise the development and execution of the project; as well as the administration of financial resources (their own and those from external loans) for the execution of the Project in the investment stage and the operation stage, guaranteeing the sustainability of said services in the medium and long term.

3.11.4 Availability of Resources and Financing

The primary source of production and distribution (supply) of water is guaranteed when the works in the Huachipa Water Treatment Plant and Lima North Main is completed for a capacity of 5 m^3/s; the plant just started operation in 2011.

The financial resources for project execution in the investment phase should be considered in the SEDAPAL Investment Budget for the years 2012, 2013, 2014, and 2015 independently of the source of funding. In the same way, SEDAPAL should include the project investments in the Master Plan for Optimization for the period from 2015 to 2019 for the purpose of including a new tariff adjustment to cover the costs of such investments, as well as the costs of operation and maintenance.

With the signing of the loan financing contracts with JICA and KfW, the Resource Transfer Agreements with the National Directorate of Public Debt (NDPD), and the completion of the additional requirements demanded by each organization; SEDAPAL assures the payment of resources for the execution of the investment phase of the project. In the same way, with the generation of resources for the investment fund[2] required by SUNASS in the current and future tariff study, it assures local compensation resources, according to the financing structure for project execution.

For the execution of the project, there are numerous international engineering consultant firms in the Peruvian market with sufficient experience in the sanitation sector in order to elaborate the technical works file; as well as international contractors for the specialized execution of sanitation works, especially the renovation of water and sewerage networks[3].

The resources required for the operation and maintenance of the rehabilitated and improved infrastructure shall be covered by the revenue collected from the water and sanitation services and the resources saved due to lower maintenance costs and payment of disaster insurance for breakages of the water supply networks.

[2] Percentage revenue for collection for water supply and sewerage, Tariff Formula, Tariff Structure and Management Goals (*Formula Tarifaria y Estructura Tarifaria y Metas de Gestión*), SEDAPAL 2010 – 2014, SUNASS 2010.
[3] "Cracking" method is the method of construction used for the renovation or replacement of sewerage networks without a trench.

3.11.5 Beneficiaries´ Capacity to Pay

The Project area is characterized as completely consolidated urban zones with basic sanitation services, whose characteristics in the "without" project situation, or the current situation, are shown in the diagnosis in Chapter 2, Section 2.5.

The JICA Study Team carried out a socio-economic study through a survey by sampling households that have continuous (24 hour) water service and those that have restricted water service (less than 12 hours). According to the results of said study, the families are willing to pay for a better service if they perceive an improvement in the water and sanitation services to be provided by SEDAPAL.

Substantial differences are observed in the maximum willingness to pay according to the type of water service. There is an inverse relationship between the provision of the water supply and sewerage service and the maximum willingness to pay for the Project. In other words, those having continuous (24 hour) water and sewerage service in the SEDAPAL network are willing to pay less for the improvement and optimization of the water and sewerage service; on the other hand, the households that do not have continuous service (i.e., interrupted service) are willing to pay more for the improvement of the water and sewerage service that will be a direct effect of the Project.

The households having water service 24 hours a day are willing to pay an average of S/. 8.18 per month. On the other hand, the families that have water service rationed by hours are willing to pay an average of S/. 13.57 per month.

In this study, the analysis was also carried out for the users´ capacity to pay for the water and sewerage service according to the parameters used by the international organizations[4]; they suggest that the amount to pay should not exceed 5% of the available income of the families benefited by the Project.

The average monthly family income according to the socio-economic survey information in the project zone is S/.2,058 soles, meaning that the average monthly estimated capacity to pay for water and sewerage service is a maximum of S/.102.90 in SEDAPAL service area, including VAT. Currently, the families are bearing fees of S/. 42.90 for water and sewerage services with an estimated consumption of 17.90 cubic meters per month (consumption of 142 L/d/inhab). This amount is less than the recommended 5% of the average family income of the families that will benefit from the project.

3.11.6 Participation of the Beneficiaries

The beneficiaries do not participate in the design or the formulation of the Project. In the execution stage, they shall participate by means within their reach, collaborating with the normal development of the construction processes and complying with the pertinent indications and recommendations, as well as participating with interest in the campaigns for

[4] Pan American Health Organization (PAHO) and Inter.-American Development Bank (INDB)

publication and in the anticipated social intervention. At the same time, they shall participate in the operation stage, making good use of the services and installations, as well as appropriately fulfilling the payment of the fees and making reports and operative complaints that help the Operation and Maintenance teams in Comas and Callao to optimize the scope of their duties.

The improvement in the quality of services shall bring about a greater interactions of the clients with the company and a greater willingness to pay in order to contribute to its development.

The above discussion ensures that the benefits generated by the Project are made sustainable over time; the Project design also considers and guarantees internal mechanisms that assure its sustainability.

3.12 Environmental Assessment

3.12.1 Introduction

The environmental assessment for a project is an important preventive tool for the protection of natural resources and social environmental conditions. It is also a management tool for integration of the environment and the project. This integration may offer advantages to both of the environment and the project. It also ensures greater social acceptance of the project. Furthermore, Principle 17 of the Rio Declaration on Environment and Development proclaims that an environmental assessment shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment. In light of this, environmental assessment of this Project has been considered.

Through the environmental assessments, it is possible to anticipate, prior to the implementation of the project, any significant environmental impacts that may arise during both the construction and operation phases. Then the remedial measures can be incorporated beforehand.

3.12.2 Legal Framework

Article No. 25 of the General Environmental Law of 2005 (*Ley General del Ambiente* N° 28611) establishes the definitions and the scope for the Environmental Impact Assessment (EIA). This law indicates that the studies should include the descriptions of the proposed activities and the foreseeable direct or indirect impacts on the natural and social environment, in short and long terms. Detailed regulations are defined by the Law of the National System of Environmental Impact Evaluation of 2008 (SNEIA: *Ley del Sistema Nacional de Evaluación de Impacto Ambiental* N° 27446).

The Ministry of the Environment (MINAM: *Ministerio del Ambiente*) has been established to formulate, manage and supervise environmental policy, in accordance with the Legislative Decree N° 1013 (*Decreto Legislativo* N° 1013: Legislative decree that approves the Law of Creation, Organization, and Function of the Ministry of the Environment.).

Under the aforementioned general laws, specific regulations are provided for each sector, and the environmental assessment study is to be performed in a way specific to the sector. Environmental Studies are examined by a governing organization within the sector.

Programs or projects that involve various sectors need to conduct environmental studies under the laws and regulations of the MINAM; the MINAM is responsible for the evaluation of the environmental studies for such multi-sector programs and/or projects.

3.12.3 Institutional Framework

SEDAPAL projects are under the jurisdiction of the Vice-Ministry of Housing and Sanitation of the Ministry of Housing, Construction, and Sanitation (*Vivienda*). The Office of the Environment (OMA: *Oficina del Medio Ambiente*) has been formed within this Ministry as the agency responsible for evaluating Environmental Assessments for the Sector; and for formulating and implementing policy guidelines, standards, plans, programs, projects, research and initiatives of the Sector.

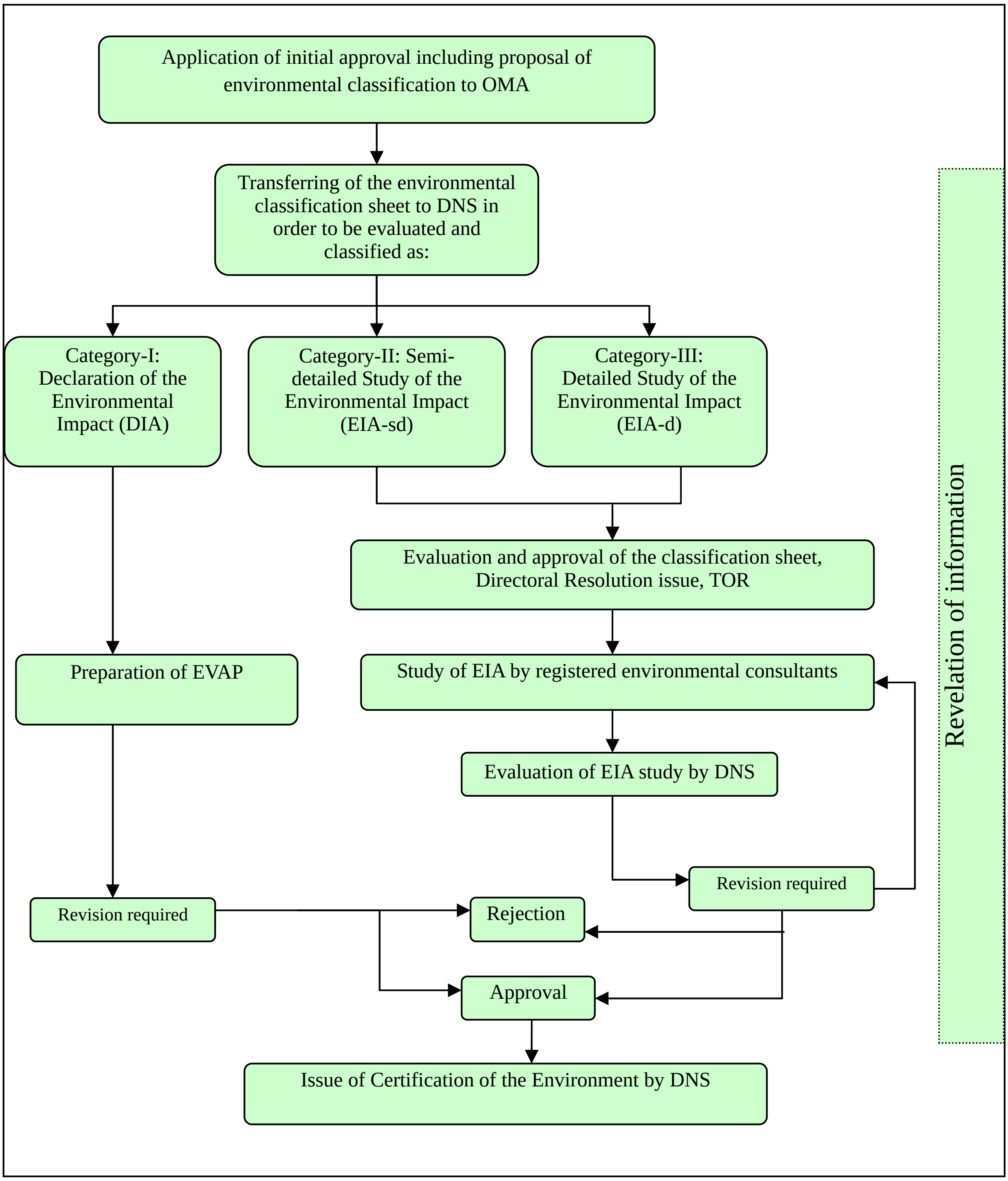
As a line organization of the Vice Ministry of Construction and Sanitation (VCS: Viceministro de Construcción y Saneamiento), the National Sanitation Authority (DNS: Dirección Nacional de Sanidad) is in charge of policies, plans, programs and norms related to the sanitation services, with the purpose of expanding the coverage and improving the service quality of water supply, sewerage, and disposal of excreta. It also reviews and approves the environmental impact studies for the Vivienda projects.

3.12.4 Environmental Assessment Procedures in Peru

Since April 29th, 2010, OMA has been transferring the environmental classification sheet to each direction for revision and approval, (procedure No.7 and 8 of TUPA), therefore, procedure to get the environmental certification is as following:

1) Submission of the application for approval of the environmental classification sheet of the project to OMA.
2) OMA transfers the environmental classification sheet of the project to the National Direction of Health (DNS).
3) DNS evaluates the environmental classification sheet and defines the classification of the project in one of the three categories:
   - Category-I: Declaration of the Environmental Impact (DIA)
   - Category-II: Semi-detailed study of the Environmental Impact (EIA-sd)
   - Category-III: Detailed Study of the Environmental Impact (EIA-d)
4) A project classified as Category-I will be given a Declaration of Environment Impact (DIA). Thereafter, the project will need no further environmental impact studies.
5) A project classified as Category-II (EIA-sd) or Category-III (EIA-d) will need further semi-detail or detail Environmental Impact Assessment (EIA) for approval.
6) EIA studies for the projects classified as Category-II or –III are to be conducted by environmental consultants, who are registered with the National Sanitation Authority (DNS) as authorized consultants.
7) Once the environmental classification sheet is revised and approved, the DNS will issue a “Directorate Resolution”, attaching the TOR of EIA for the previously classified category.

The flow chart of the procedure is shown in Figure 3.12.4-1.



Source: JICA Study Team based on the information from OMA

Figure 3.12.4-1: Evaluation Procedure for Environmental Impact

Current Status for the Project:

On behalf of the Project proponent SEDAPAL, an application was submitted to OMA on 23rd July, 2010 for initial application and environmental classification.

On October 6th, 2010, the Project has been classified as Category II and thus, is required a semi-detail EIA; moreover, TOR for the said study has been duly submitted.

On July 19th, 2011 “Favorable Environmental Opinion” was received at pre-investment level. Thus, all formalities at the pre-investment stage have been completed. As per legal procedure, a semi-detail EIA has to be done by a registered consultant during the detail design stage following approved TOR.

3.12.5 Environmental Check List

Possible impacts on the environment and its mitigation measures are evaluated by utilizing JICA checklists (list 14 for water supply and list 15 for wastewater). The checklists are given below.

Table 3.12.5-1: Environmental Check List for Water Supply

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
1	Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N/A (c) N/A (d) N/A	For the execution of the project, EIA is required according to the established norms (Law N°: 27446 and its Modifying D. Leg. N° 1078). An application has been submitted for environmental classification and the Project has been classified as Category II. Based on the classification, a TOR for the EIA study has also been approved on July 19th, 2011. A certified EIA consultant will carry out the EIA according to the TOR. The EIA will be carried out during D/D stage of the Project, same as Lima North (I) Project.
		(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained by the Local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected in the project design?	Not yet	Public consultation and disclosure of information have not yet been realized. These will be carried out in the stages of EIA execution. This approach complies with the local law.
		(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	Not yet	Alternative analysis has been carried out for technical and economic aspects. Alternative analysis for social and environmental aspects will be executed in the course of the EIA study.
2	Pollution Control	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Are any mitigating measures taken? (b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	(a) N (b) N	The Project scope does not include water treatment.
		(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	(a) N/A	The Project scope does not include water treatment plants.
		(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's regulations?	(a) N/A	The Project scope does not include water treatment plants.
		(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations, comply with the country's standards?	(a) Y	When the EIA is developed, it will consider measures in all those facilities where the noise levels surpass the standards of environmental noise quality (D.S. N°085-2003-PCM)
		(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N	The project does not increase the volume of underground water extraction, therefore subsidence is not expected.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
3	Natural Environment	(1) Protected Areas	(a) Is the project site or discharge area located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	The project is not located within protected natural areas.
		(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protective measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) N/A (d) Y	(a) The project area is in an urban area which has already been developed, so it does not impart any impacts to the biodiversity. (b) Same as above (c) Not applicable (d) The Project area already has sewerage service. Sewerage disposal will follow current practice. By 2013, a better sewerage disposal system is expected to be implemented.
		(3) Hydrology	(a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	(a) N	(a) Not expected.
4	Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensation going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document form? (f) Does the resettlement plan pay particular attention to vulnerable groups or peoples, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A (i) N/A (j) N/A	Involuntary relocation in the execution of the project is not expected.
		(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	(a) N (b) N	(a) The project generates positive impacts in the operation stage. (b) The project does not alter the amount of the water resource allocation.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
		(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) Not yet known	An initial archeological study shows existence of few sites. However, a more detailed investigation will be carried out during the EIA study.
		(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	The Project is located in an urban zone which has already been developed. If there is any impact that will be temporary in nature during project execution, it will be due to excavations and an increase in the movement of vehicles. These measures will be considered when the EIA is developed.
		(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N/A	According to the diagnosis of the population profile of the project area, there is no special ethnic minority living in the area.
		(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project do not violate the safety of other individuals involved or that of local residents?	Not yet prepared	Constructions of the Project are supposed to be carried out, following Peruvian laws regarding working environment and safety conditions. Therefore, serious impact is not expected. Measures are not prepared so far, however, proper measures will be prepared in the EIA study, which will be carried out during D/D stage.
5	Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	Not yet prepared	Major construction works of the Project are replacement/ installation of pipes and rehabilitation of small facilities, so that impact of the constructions will be limited. When the EIA is developed, measures necessary to mitigate the negative impacts will be provided in the chapter regarding environmental management.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
		(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Not yet prepared	When the EIA is developed, the environmental monitoring program will be considered in the chapter regarding environmental management.
6	Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	(a) N/A	The Project has no interaction with dams or rivers.
		Note on Using Environmental Checklist	(a) If necessary, the impacts on trans-boundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as trans-boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N/A	Although the EIA of the project is not yet developed, it can be said that there will be no impact on cross-border or global issues.

Source: JICA Study Team following JICA Reference (http://www.jica.go.jp/english/operations/social_environmental/guideline/ref.html)

Table 3.12.5-2: Environmental Checklist for Sewer Network

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
1	Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N/A (c) N/A (d) N/A	For the execution of the project, EIA is required according to the established norms (Law N°: 27446 and its Modifying D. Leg. N° 1078). At the moment, the application has been submitted for environmental classification. Based on the classification, a TOR for the EIA study will be prepared for evaluation and approval. A certified EIA consultant will then carry out the EIA according to the TOR. The EIA will be carried out during D/D stage of the Project, same as Lima North (I) Project.
		(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained by the Local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected in the project design?	Not yet	Public consultation and disclosure of information have not yet been realized. These will be carried out in the stages of EIA execution. This approach is complies with the local law.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
2		(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	Not yet	Alternative analysis has been carried out for technical and economic aspects. Alternative analysis for social and environmental aspects will be executed in the course of the EIA study.
2	Pollution Control	(1) Water Quality	(a) Do pollutants, such as SS, BOD, COD, pH contained in treated effluent from a sewage treatment plant comply with the country's effluent standards? (b) Does untreated water contain heavy metals?	(a) N/A (b) N/A	The Project scope does not include treatment facilities.
		(2) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	(a) N/A	The Project scope does not include treatment facilities.
		(3) Soil Contamination	(a) If wastes, such as sludge are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leachates from the wastes?	(a) N/A	The Project scope does not include treatment facilities.
		(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as sludge treatment facilities and pumping stations, comply with the country's standards?	(a) Y	Noise and vibration can generated during the construction period only. When the EIA is developed, it will consider measures where the noise levels surpass the standards of environmental quality of noise (D.S. N°085-2003-PCM)
		(5) Odor	(a) Are adequate control measures taken for odor sources, such as sludge treatment facilities?	(a) N/A	The Project scope does not include treatment facilities.
3	Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	The project is not located within protected natural areas.
		(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protective measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) N/A (d) Y	(a) The project area is in an urban area which has already been developed, so it does not impart any impacts to the biodiversity. (b) Same as above (c) Not applicable (d) The Project area already has sewerage service. Sewerage disposal will follow current practice. By 2013, a better sewerage disposal system is expected to be implemented.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
4	Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensation going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document form? (f) Does the resettlement plan pay particular attention to vulnerable groups or peoples, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A (i) N/A (j) N/A	Involuntary relocation in the execution of the project is not expected.
		(2) Living and Livelihood	(a) Is there a possibility that changes in land uses and water uses due to the project will adversely affect the living conditions of inhabitants? (b) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) N (b) N	(a) The project does not alter the amount of the water resource allocation. There will be no change in land use. (b) The project generates positive impacts in the operation stage.
		(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) Not yet known	An initial archeological study shows existence of few sites. However, a more detailed investigation will be carried out during the EIA study.
		(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	The Project is located in an urban zone which has already been developed. If there is any impact that will be temporary in nature during project execution, it will be due to excavations and an increase in the movement of vehicles. These measures will be considered when the EIA is developed.
		(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to lands and resources respected?	(a) N (b) N/A	According to the diagnosis of the population profile of the project area, there is no special ethnic minority living in the area.

N°	Category	Environmental Item	Main Checklist Items	Yes: Y No: N	Confirmation of Environmental Considerations
		(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project do not violate the safety of other individuals involved or that of local residents?	Not yet prepared	Constructions of the Project are supposed to be carried out, following Peruvian laws regarding working environment and safety conditions. Therefore, serious impact is not expected. Measures are not prepared so far, however, proper measures will be prepared in the EIA study, which will be carried out during D/D stage.
5	Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	Not yet prepared	Major construction works of the Project are replacement/ installation of pipes and rehabilitation of small facilities, so that impact of the constructions will be limited. When the EIA is developed, measures necessary to mitigate the negative impacts will be provided in the chapter regarding environmental management.
		(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Not prepared yet	When the EIA is developed, the environmental monitoring program will be considered in the chapter regarding environmental management.
6	Note	Note on Using Environmental Checklist	(a) If necessary, the impacts on trans-boundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as trans-boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N/A	Although the EIA of the project is not yet developed, it can be said that there will be no impact on cross-border or global issues.

Source: JICA Study Team following JICA Reference (http://www.jica.go.jp/english/operations/social_environmental/guideline/ref.html)

3.12.6 Environmental Diagnostics

The Project partially involves seven (7) districts (San Martín de Porres, Comas, Carabayllo, Los Olivos, Callao, Puente Piedra, and Ventanilla). These districts are located within the scope of Sedapal's Northern Services Management Office.

Population in the study area is 626,733, and the population in the area of influence or beneficiary population is 435,865, in the base year (2009). Served population for year "1" (2013) is projected to be 395,152, as distributed in 87,415 households.

Climate in each of the study area's districts is arid sub-tropical (hot, damp, with no regular rainfall, warm summers and mild winters.)

Geo-morphological features in the study area are the result of tectonic and plutonic processes that have been over-imposed by geodynamics processes. These processes have modeled the region's morphological features. In addition, surface soils in the study area are made up of gravel filling with sandy and / or clayey silt, or dirt filling.

Almost all of the project's geographic space has no native vegetal species, rather has small gardens, bushes, and trees in public parks and gardens, including: rubber plants, Peruvian pepper trees (Schinus molle), willows (Salix chilensis), papelillo trees, palm trees, eucalyptus trees, and sheoak trees. Some of these, among other species, are found in the riverbank hill area. Major avenues, side and central greenarea have grass (Stenotaphrum secumdatum) and some forest species that offer a landscape and ornamental look to the town.

Care and protection of parks and gardens in urban areas have found increasing interest in those towns showing high levels of environmental pollution; this is the case of Lima, and particularly, the Northern area since this area is a desert.

Given the fact that there are no natural vegetation species throughout the Project area, but only man-made gardens or parks, most commonly seen animal species are birds that are frequently seen in urban areas, and show a good tolerance to human presence and activities. These bird species include: Columbina Cruziana "Peruvian dove", Notiochelidon Cyanoleuca "Santa Rosita", Passer Domesticus "sparrow", Zenaida Asiática "Asian Dove,", and common dove. Farming areas show the presence of rodents, such as Rattus "rats"; various insects, mites, and nematodes that are phyto parasites. List of fauna species has been listed at the Ministry of Agriculture's official list of endangered and threatened fauna in Supreme Decree Nº 034-2004-AG, and it has been established that there are no endangered or threatened fauna species in the Project area.

3.12.7 Initial Environmental Assessment

As explained in Section 3.12.4, a formal EIA for the Project will be carried out during the detail design stage. A preliminary environmental assessment for the Project is carried out under this JICA Study; which can be found in Appendix B5. An archeological investigation has also been performed, which can be found in Appendix A8. A brief summary is given below.

(1) Project Components and Activities

The Project includes replacement of house connections, installation of meters and valves, construction of water main, replacement of water distribution pipes, rehabilitation of reservoirs, and replacement of sewer pipes. It is expected that the Project will reduce water loss and improve water supply and sewerage service.

Main construction activities involve digging trenches to replace old pipes and connections. Earth movers, trucks and other heavy equipments will be used during the construction stage.

It may be mentioned that some of the old pipes are made of asbestos cement, a potentially hazardous substance. Therefore, the Project proposed that appropriate on-site treatment and disposal of the asbestos cement pipes be carried out at the construction sites by a waste disposal company registered by DIGESA (See item (6) of this section).

The collected sewerage will be treated at Taboada sewerage treatment plant (capacity 14 m^3/s, equal to 1.2 million m^3/d). It is expected that the operation of this plant would start from 2013. The treatment process includes a primary sedimentation tank and deep sea outfall. The discharge point will be located at about 3,000 meters from the sea line at a depth of 13 m. It was designed following WHO guidelines and validated through mathematical diffusion modeling. The EIA of the plant has been approved by the Ministry of Housing, Ministry of Defense and the National Water Authority. DIGESA also favored the plant construction.

(2) Environmental Baseline

The environmental baseline has been investigated for physical, biological, social and cultural environment. Details can be found in supporting report Appendix B5.

(3) Environmental Impact Matrix

An impact matrix has been prepared to evaluate potential impact. A total of 18 environmental parameters were evaluated against 17 activities. The matrix is shown below.

Table 3.12.7-1: Environmental Impact Assessment Matrix

				ACTIVIDADES DEL PROYECTO - ETAPA DE CONSTRUCCIÓN																
				OBRAS GENERALES DE AGUA POTABLE				REHABIL. DE RESERVORIOS, ESTA. DE BOMBEO Y POZOS			RED SECUNDARIA Y CONEXIONES DOMICILIARIAS DE AGUA POTABLE, RESERVORIOS / SECTORES						RED SECUNDARIA Y CONEXIONES DOMICILIARIAS DE ALCANTARILLADO			
				Obras Preliminares y Provisionales	Líneas de Agua potable para obras generales	Automatización y Control	Suministro de Energía Eléctrica	Equipamiento y Rehabilitación de Reservorios	Equipamiento y Rehabilitación de Estaciones de Bombeo	Equipamiento y Rehabilitación dePozos	Mejoramiento de Redes de Agua Potable	Conexiones Domiciliarias de Agua Potable	Cámaras Reductoras de Presión	Conexiones Provisionales	Pre Localizadores de Fugas	Equipamiento Operacional	Redes de alcantarillado	Conexiones Domiciliarias de Desague	Pavimentos	EquipamientoOperacional
COMPONENTE AMBIENTAL	ABIÓTICO	SUELO	Modificación del relieve	7	4	3	5	6	6	7	4	4	3	3	3	4	5	4	4	4
			Erosión	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			Calidad del Suelo	7	5	3	5	5	4	7	5	4	4	4	3	4	5	4	6	4
			Cambio de uso de suelo	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		AGUA	Calidad de las aguas superficiales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			Calidad de aguas subterráneas	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		AIRE	Generación de partículas	4	6	3	3	7	5	7	9	3	3	4	3	4	5	3	7	4
			Generación de gases	4	6	3	3	7	5	7	5	3	3	4	3	4	5	3	7	4
			Generación de ruido	3	3	4	4	6	7	7	5	3	3	3	2	3	3	3	5	3
	BIÓTICO	FLORA	Cobertura herbácea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		FAUNA	Avifauna	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SOCIOECONÓMICO	SOCIAL	Modo de vida	3	2	1	2	3	3	3	7	4	2	4	2	3	5	5	6	3
			Seguridad y salud pública	3	5	3	2	4	3	4	9	5					4	4	6	
			Salud y Seguridad Ocupacional	3	6	3	4	6	4	6	9	5	3	3	3	3	5	5	6	3
		ECONÓMICO	Generación de empleo	+4	+5	+3	+3	+6	+5	+6	+5	+5	+4	+4	+4	+3	+5	+5	+3	+3
			Dinámica de la economía (otras actividades económicas	+2	+5	+2	+3	+6	+5	+6	+4	+3	+2	+2	+3	+3	+4	+5	+3	+3
	CULTURAL	ESTÉTICAS	Modificación del paisaje	3	3	_	_	6	7	7	3	3	3	3	2		3	3	5	_
		CULTURAL	Zonas arqueológicas	4	6	_	_	4		4	5	_	_	4	_	_	5	_	4	_

Source: JICA Study Team

(4) Analysis of Impacts

From the impact identification matrix, it is found that the most significant impacts are associated with the construction stage of the Project, while negligible negative impact is anticipated during the operational stage. These findings should be confirmed in the formal EIA study. Major impacts are briefly explained below.

1) Impacts on the Physical Environment

Landscape: Current landscape will have a negative but temporary effect, due to the excavation works, the movement of soil, the use of trucks and other heavy machinery, and the rehabilitation works of reservoirs and wells.

Soil quality: The soil quality will be affected by the excavation of ditches, soil movement, and other on-site construction works. The soil´s physical characteristics may be altered due to spills from trucks and machinery.

Air quality: The direct negative impact appears during the construction stage as a consequence of the use of machinery and motorized equipment and the movement of soil. There will be a risk of scattering of asbestos fibers during the removal of asbestos cement pipes. (See item (6) of this section for mitigation measure against this risk)

Noise and vibration: Levels of noise occurring in the construction area might be high on some occasions, affecting the homes and businesses nearby. It is important to mention that important businesses and schools are located along the principal roads, which would all potentially be affected by the increase in the noise level. Proper measures can minimize this temporary impact.

2) Impacts on the Socio-economic Environment

Living condition: The Project will improve the living condition of the habitats of the entire Project area by improving the levels of water and sewerage services. However, during the construction period, there may be temporary negative impacts on living condition due to increase of dust, noise, vibration, exhaust gas, and traffic movement.

Public Health: The Project will improve the public health condition of the inhabitants of the entire Project area by improving the levels of water and sewerage services. However, during the construction period, there may be some temporary negative impacts. Accidents can happen due to the movement of trucks and heavy equipment, and also due to inadequate or improper traffic signage.

In addition, as stated above, removal of asbestos cement pipes can give a harmful impact on public health. (See item (6) of this section for its mitigation measure)

Health and safety: Unless protective measures are taken to ensure health and safety, there is a risk of work accidents.

Employment: This is a positive impact. During the construction, skilled and unskilled labor will be required. This will help in the local economy.

3) Impacts on the Cultural Environment

Archaeological Impacts: The preliminary archaeological study has been carried out and the report can be found in Appendix A8. The Study area is dotted with many archaeological remains and JST archaeological investigation identified 50 such sites, out of them, three are not registered with the National cultural Institute (INC). The identified 50 sits are not in expected construction sites of the Project.

According to Peruvian regulation, every project needs prior approval from INC. For a new construction, the proponent must carry out a formal archaeological investigation called PEA through INC registered professional archaeologist. After reviewing the PEA, if considered appropriate, INC issues an approval certification called CIRA. A monitoring plan should be included in the PEA and that must be followed during construction. On the other hand, for rehabilitation or replacement, PEA is not required. Still, a monitoring plan has be submitted and approved by INC.

Most of expected construction sites of the Project are on routes of the pipes to be replaced and newly installed, which are in existing roads. Other expected sites are also in lands, where existing structures such as reservoirs and pumping stations locate. It has therefore a low possibility that new archaeological remains are found during the construction, and it is not supposed to take long time for the Project to receive approval from CIFA.

The proposed Project consists mainly of rehabilitation and replacement activities, thus only monitoring plan should be prepared, which should be approval by INC. The proposed Project also consists of few new constructions. Formal PEA study including monitoring plan should be prepared for the new construction.

The monitoring will be carried out under responsibility of contractors of the Project. If archaeological remains are found out, the contractor shall inform it to INC and have to take actions following instruction of INC. In such a case, the contractor has to discontinue the construction works but, as explained above, it has a low possibility to find out any new archaeological remains.

(5) Environmental Management Plan (EMP)

The Environmental Management Plan will be prepared during the formal EIA study. However, the JICA Study Team prepared a preliminary EMP as a reference, and it can be found in Appendix B5. The outcome is briefly explained here.

The preliminary EMP consists of the following:

・Prevention, Mitigation and/or Correction Program

・Monitoring Program

・Cost Estimates for implementation of EMP

The mitigation plan against the negative impacts is given in the following Table.

Table 3.12.7-2: Environmental Mitigation Plan

Environmental Impact	Mitigation Measure Proposed
1. Air pollution due to dust and exhaust gas	▪ Put a moistened canvas over the surplus soil materials stored on site before they are transported to the authorized disposal site. ▪ Adequately moisten the unpaved roadways and areas where daily Project activities may stir up dust. This moistening should take place at least twice a day, and more frequently when prevailing atmospheric conditions require it, which shall be decided and reprogrammed by the Supervisor. ▪ Perform periodic maintenance on machinery, vehicles and equipment utilized in order to guarantee it is in good condition and to reduce the emission of gases.
2. Pollution from Asbestos piping	▪ The removal, transportation and final disposal of asbestos cement piping shall be performed by a DIGESA certified agency. (refer to (6) in this section)
3. Increase in noise levels due to project activities	▪ The equipment and machinery shall have constant maintenance to ensure proper operation condition. The equipment should be used in such a time frame ensuring minimum disruption. ▪ If necessary, a sound barrier should be installed.

Environmental Impact	Mitigation Measure Proposed
4. Possible change in soil quality	▪ Implement a collection system for waste generated in each of the worksites and machine yards. ▪ Install systems to manage and dispose of grease and oils. For this, it will be necessary to comply with the established solid waste program. ▪ The soils contaminated by hydrocarbon, etc. should be removed immediately and properly disposed.
5. Public disturbances due to project activities.	▪ Inform the public about the type of machinery that will be used and the hours they will be running. ▪ Take steps to coordinate and conciliate with inhabitants living near the worksite, through the use of flyers and official reports, with relation to the activities that will take place, with a timeline that will not affect the public's normal activities. ▪ To ensure minimum disruption to vehicular and pedestrian traffic, proper traffic sign must be placed. ▪ Movement of trucks should be planned not to coincide with rush hour traffic.
6. Occupational Health and Safety risks (accidents)	▪ Follow the Occupational Health and Safety Regulations, S.D. Nº 009-2005-TR (article 20). ▪ Provide all work personnel with personal protective gear according to the activities, especially for those workers dedicated to drilling the tunnel and transporting asbestos material. ▪ Train work personnel about safety regulations for each activity to be carried out. ▪ Establish a work schedule that guarantees the performance and mental stability of personnel. ▪ Implement environmental measures proposed in the Contingency Program in the case of the occurrence of work accidents, before, during and after the event. ▪ Carry out constant inspections of the support structures and the trench interior in the zones with identified slope instabilities. ▪ Fence in the work area and do not allow access to unauthorized persons. ▪ Establish medical services and a first aid kit.
7. Improvement in local economy	▪ Maintain the policy of informing the local population about employment. ▪ Establish a rotating schedule for hiring personnel.
8. Liquid and solid waste management	▪ The final disposal of the effluents from the portable bathrooms used by the workers during Project construction shall be carried out properly. ▪ Solid waste generated should be collected and disposed properly.
9. Archeological Site	▪ Archaeological remains are not found out in expected construction sites of the Project so far. Based on the results of EIA and PEA, plan should be prepared to safeguard and implement the plan.

Source: JICA Study Team

(6) Appropriate Management of Asbestos Disposal

1) Relevant Institutions

a. Act No. 27314 (General Law on Solid Wastes)

Asbestos is identified as a hazardous material in the Act No. 27314 (General Law on Solid Wastes). The Act requires that solid wastes which include asbestos should be treated and disposed appropriately to avoid any harmful impact on public health or environment. However, the Act does not stipulate technical standards or requirements for the appropriate treatment and disposal.

b. Registration of Companies for Hazardous Solid Waste Treatment and Disposal

DIGESA is responsible for issue of license for treatment and disposal of hazardous solid wastes. Three (3) companies have the licenses so far and have been registered as authorized waste disposers. Among the three waste disposers, BEFESA is the only company in Peru which owns equipments and staff for transportation, treatment and disposal of asbestos.

Finally, procedures and criteria of the registration are not clear although the JICA Study Team conducted hearings to relevant authorities and the registered business.

2) Proposed Process in the Project

The Study Team conducted a hearing to BEFESA about their treatment and disposal process of asbestos and it was found that the process is cautious enough even comparing to common process in Japan. The process of BEFESA is as below:

1. Mechanical excavation is quite popular. However, for the works near existing asbestos cement pipes, manual excavation is carried out.
2. Water sprinkling is carried out to asbestos pipes removed. It is to keep the pipes adequately wet to prevent asbestos fibers from flying away. Joints and valves are removed from the pipelines, and asbestos pipe cutting works shall be avoided as much as possible, at construction site.
3. Removed asbestos pipes are handed over to registered disposal company.
4. The removed asbestos pipes are sent into a special air stripping device, which removes all fibers through a filter (According to United State’s Environmental Protection Agency, the air stripping is one of the most common method of asbestos treatment to avoid scatter of asbestos fibers.)
5. The air-stripped asbestos material is solidified with cement at the construction site or at disposer’s premise after transportation with protection cover of plastic sheet
6. The solidified material is disposed at landfill site.

The process above will be implemented by contractor of the construction and registered waste disposal company. The contractor may not have enough knowledge for asbestos treatment. The points to be noted for the contractor are summarized in Table 3.12.7-3.

Table 3.12.7-3: Necessary Considerations for Contractor to Asbestos Cement Pipe Removal and Dispose

Step	Necessary Actions
Preparatory Survey	Confirmation of locations of asbestos pipes with SEDAPAL staff by using facility cadastre
Work Planning	Preparation of work plan for SEDAPAL's approval, which should include the followings: - Process of the removal, treatment and disposal of asbestos cement pipes - Measures to avoid scatter of asbestos fiber - Measures to avoid exposure of workers to asbestos fiber
Education	Implementation of education for workers to be involved in the process which includes the followings: - Harmful effect which can be caused by asbestos - Measures to avoid scatter of asbestos fiber - Measures to avoid exposure of works to asbestos fiber - Usage of protective devices and clothes
Removal Work	Careful removal work considering the followings: - Removal of pipes by releasing joints but not by cutting pipe material - Use of protective devices and clothes in pipe cutting if it is inevitable - Water sprinkling on pipes during removal work to avoid scatter of asbestos fibers
Treatment and Removal	Contract with authorized business to dispose hazardous solid waste which includes asbestos

Source: JICA Study Team

In Japan, common disposal process of asbestos cement pipes is similar to the process above but does not include solidification with cement. Comparing the requirement to the asbestos disposal processes in Japan, the process in Peru will be cautious enough to avoid harmful impact on public health and environment.

(7) Cost Estimates of EMP

EMP cost estimates will be prepared during the formal EIA study. The JICA Study Team prepared a preliminary estimate, which can be found in Appendix B5. The summary is given in the following table.

Table 3.12.7-4: EMP Cost Estimates (Preliminary)

Major Items	Estimated Cost (in N. Soles)
Preventive measures	1,845,520
Waste management	79,240
Monitoring Program	1,596,870
Total	**3,521,630**

Source: JICA Study Team

3.13 Organization and Administration for Project Implementation

For the organization and management of Project implementation, the following actors participate with the roles described below:

SEDAPAL: The Executing Unit of the Project shall be PROMESAL, the Team that depends directly on the General Management Department, and shall have the duty of technical, financial, and contractual administration of the project, in internal coordination with the Line and Support Management Departments and the SEDAPAL Teams, and in external coordination with JICA and KfW for the payment of loans; as well as the National Directorate of Public Debt (NDPD), a line organization of the Ministry of Economy and Finances for the control of the payment of external loans for the execution of the project and its respective services for the corresponding debts. Figure 3.13.1-1 shows the flow chart for PROMESAL. The technical matters are supported by a committee which is composed of the existing technical teams in the headquarter and local service offices depending on the charge of each facility.

Through the Management and Selection Processes Control Team, SEDAPAL shall contract the Consultant firm for the elaboration of the technical works file (detail design) for the Project, which includes the development of the administrative basis for the tendering of work and supplies, according to the number of lots required by the Implementation Plan. In the same way, this Team shall provide public tendering for the awarding and execution of works; as well as the acquisition of goods (equipment for the operation and maintenance works). PROMESAL shall be in charge of contract administration until the acceptance of works and the delivery of supplies.

The North Services Management Team (GSN) and the Callao and Comas operation and maintenance teams shall have active responsibility in the investment phase and direct responsibility in the operation phase.

FONAFE: This entity is in charge of regulating SEDAPAL´s business activity in the pre-investment phase through the OPI FONAFE, and responsible for approving the feasibility study of the project and requesting the declaration of viability from the DGPI (*DGPI: Dirección General de Políticas de Inversiones*, or General Directorate of Investment Policies). In the investment phase, it shall give its opinion with respect to the results of the technical works file before beginning the execution of Project works.

Ministry of Economy and Finances (MEF): Through the DGPI, it shall declare project viability, and it shall give its opinion before the approval and conditions of the external debt operations with JICA, KfW and IBRD. Likewise, through the NDPD (National Directorate of Public Debt), it shall negotiate the loans with JICA, KfW and IBRD for the execution of the Project, and it shall give its opinion before the approval and conditions of the external debt operations with said organizations; later, it shall sign loan contracts for the financing of the Project with JICA, KfW and IBDR in representation of the Republic of Peru.

In the investment phase, the DGPI shall give its opinion with respect to the results of the technical works file before the beginning of execution.

During the operation phase, the NDPD shall control the payment of loans and respective debt services.

Ministry of Housing, Construction, and Sanitation: Through the OPI Vivienda, it shall give its opinion regarding the Project´s feasibility study before declaration of project viability by the DGPI. Likewise, it will ratify the legal devices for the approval of the debt operation with JICA and KfW.

In the investment phase, through the National Sanitation Directorate (*Dirección Nacional de Saneamiento,* or DNS), it shall issue the corresponding directorial resolution approving the Environmental Impact Study, whose study level shall be according to the Classification approved by said directorate.

In the operation phase, it shall regulate as appropriate in order to improve the quality of the water and sewerage services.

SUNASS: In the operation phase, it is the regulatory body for the sanitation services rendered by SEDAPAL, approving the Master Plan for Optimization and developing the Tariff Study for the approval of the Tariff Formula (adjustment or increase) and the Tariff Structure and Management Goals for the five-year period from 2015 to 2019, which shall include the project investments.

Japan International Cooperation Agency – JICA: It is an organization of the Japan's international finance and technical corporation; it is financing the development of the pre-feasibility and feasibility study of this Project. Once project viability has been declared by the authorities in the Peruvian Government, it shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of Project execution.

In the investment phase, it shall make the payments to SEDAPAL for the development of the technical file and execution of works. Likewise, before the contracts are signed for consultant, works, and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

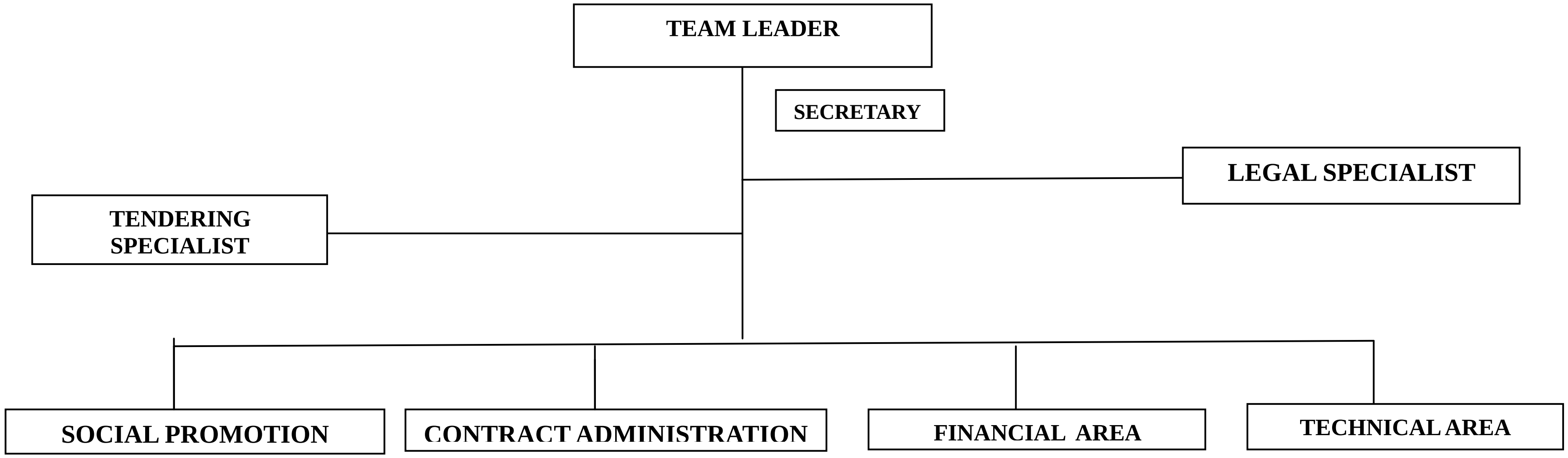
International Bank for Reconstruction and Development – IBRD: The IBRD is one of the institutions of the World Bank. Once project viability has been declared by the authorities in the Peruvian Government, it shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of project execution.

In the investment phase, it shall make the payments to SEDAPAL for the development of the technical file and execution of works. Likewise, before the contracts are signed for consultant, works, and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

Kreditanstalt Fur Wiederaufbau Bankengruppe-KfW: It is an organization of the German Government financial cooperation. Once project viability has been declared by authorities in the Peruvian Government, KfW shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of project execution.

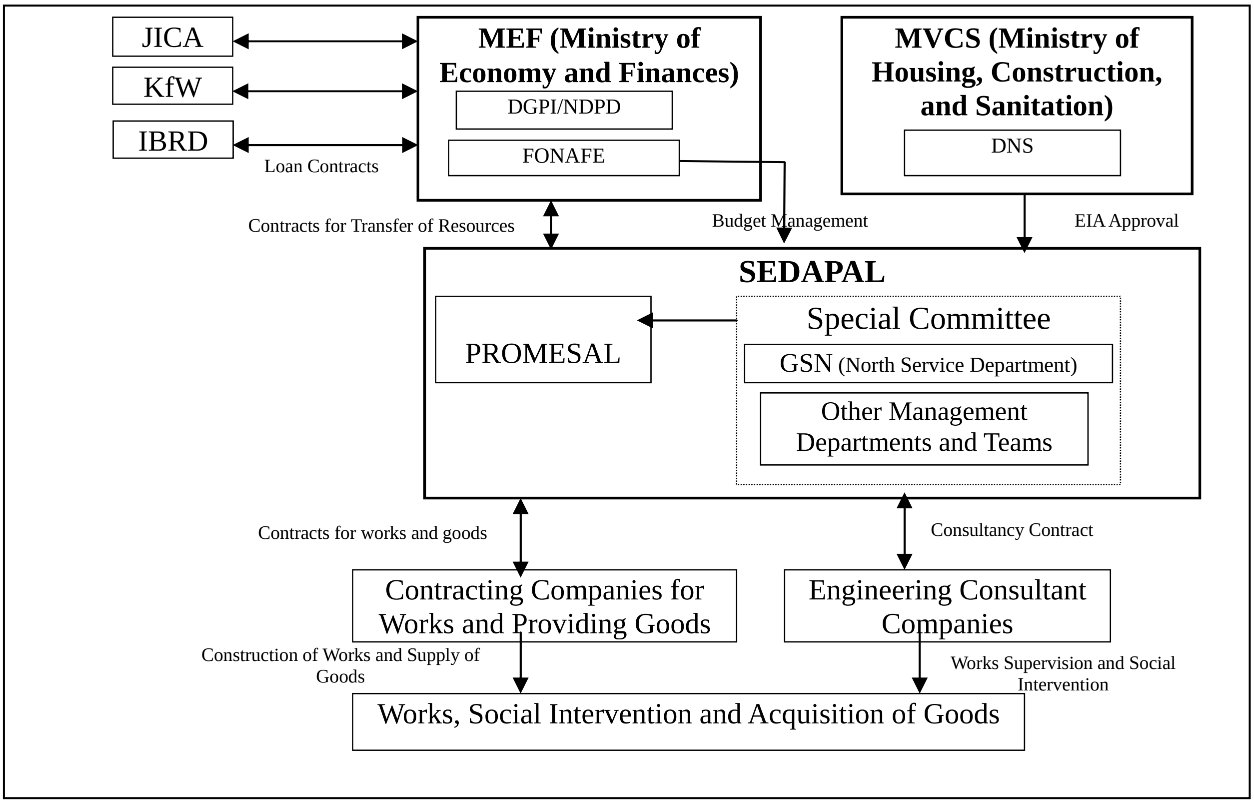
In the investment phase, it shall make the payments to SEDAPAL for the execution of works. Likewise, before the contracts are signed for works and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

Figure 3.13.1-2 and Figure 3.13.1-3 show the interrelation of the different actors in the project for the pre-investment, investment, and operation phases.



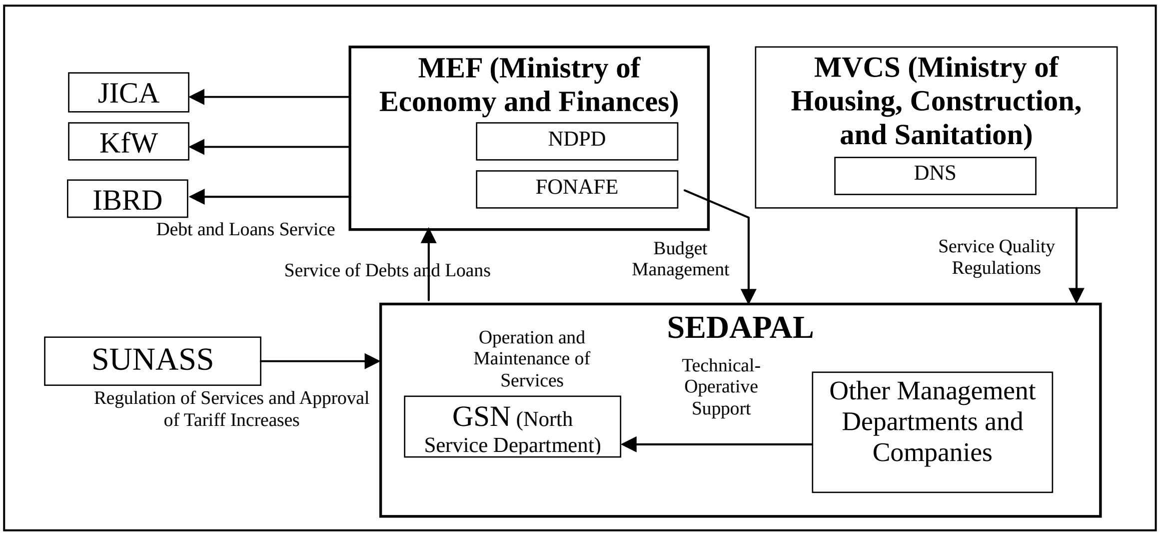
Note: Additionally, the PROMESAL Team has administrative support personnel: 3 drivers.
1/ Approved in the Directive Session No. 020-2008 from August 20, 2008.
Source: JICA Study Team

Figure 3.13.1-1: PROMESAL Flow Chart [1]



Source: JICA Study Team

Figure 3.13.1-2: Role of Actors for Project Implementation (Investment Phase)



Source: JICA Study Team

Figure 3.13.1-3: Role of Actors for Project Implementation (Operation Phase)

3.14 Implementation Plan

The Project Implementation Plan is shown in Figure 3.14.1-1. This plan includes all the pre-investment phase activities and the investment phase activities: i) engineering consultancy services, ii) selection process for works contractors and equipment supplies (pre-construction), iii) works construction and handover, and iv) Project works initial operation.

3.14.1 Pre-investment Activities

The pre-investment phase completion activities include: i) an evaluation of the feasibility study carried out by the SNIP entities (EPI SEDAPAL, OPI FONAFE, OPI VIVIENDA, and DGPI), that will lead to the Project viability, ii) a funding agreement between MEF and the international cooperating agencies that would fund the Project (JICA, IBRD, and KfW), as well as the resource transfer agreements between MEF and SEDAPAL.

It is foreseen that the feasibility study is completed and approved, and that the Project's viability is obtained in September 2011.

Organizations in charge of and/or involved in these activities are: SEDAPAL, OPI FONAFE, OPI VIVIENDA, MEF, JICA, IBRD, and KfW.

3.14.2 Consulting Services Activities

Breakdown of these activities is as follows: i) call for international consultancy firm pre-qualification and relevant short list, ii) invitation to submit technical and financial bids, iii) evaluation of bids, iv) contract awarding and subscription, with prior approval from the funding agencies.

Once the consulting contract has been subscribed, the consultancy firm will develop the following activities:

1. Development of the Detailed Design study[1] of the Works and equipments for Packages A, C, and B, including a TV camera inspection through the sewerage networks. Detailed Design study completion and approval for packages A and C is scheduled for March, 2013, and for package B, for September, 2013. This period includes the presentation of Form SNIP-15 to OPI-FONAFE and DGPI[2].
2. Preparation of pre-qualification and Works tender and equipment procurement for Packages A, C, and B.
3. Assistance to SEDAPAL in the Works bidding and equipment procurement process (answering to queries, bid evaluations, contract negotiations)
4. Works supervision during the construction, as well as environmental monitoring, social intervention, and the updating of the technical cadastre of the facilities (the consultancy firm(s) will prepare the as-built drawings for the works.)

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1 It includes: descriptive of Project, technical specifications, works execution drawings, quantifications, works budget, works budget determination date, reference value, Price analysis, appraised Works progress calendar, polynomial formulas, topography, soil study, geological study, environmental impact study, archaeological remains study, and other studies.
2 Consistency report between D/D and F/S (Article 24.2, SNIP directive (R.D N° 003-2011-EF/68.01)

Organizations in charge and/or involved in these activities are: SEDAPAL, JICA, IBRD, and KfW, the consulting firm hired by SEDAPAL, and the contractor(s) hired by SEDAPAL.

3.14.3 Pre-construction activities

Pre-construction activities include the following: i) preparation of the Works technical file, preparation of the pre-qualification, Works bidding, and equipment purchase documents, ii) call to public tender for works and equipment in Packages A, C, and B, iii) bid evaluations, iv) granting and subscription of works and equipment procurement contracts, with prior approval from the funding agencies

Pre-construction activities must be completed for Packages A and C in November 2013, and for Package B, in June 2014.

Implementation Schedule

	ITEM	Months	2010–2016 (I, II, III, IV)
1	**Feasibility study and SNIP evaluation**	10	Apr – Feb
		7	Set
2	**Financial agreement**	6	Apr – Set
	1) Submission of official application (SEDAPAL, MEF)	-	
	2) Evaluation for financing (JICA, BIRF y KfW)	3	
	3) Exchange of letters	-	
	4) Loan agreement (JICA, KfW, BIRF)	-	
3	**Consulting services**	6	Jun
	1) Pre-qualification	1.5	
	2) Preparation works and field sightseeing	1.5	
	3) Preparation of proposal	1.5	
	4) Evaluation of proposal	1	
	5) Awarding and sign of contract	0.5	
	6) Execution of consultant services (detail design and supervision of works)	54	
4	**Works of lot A and C**	22	Dec
	1) Preparation of detail design document for construction and equipment and registration of format SNIP-15	10	
	2) Pre-qualification	3	
	3) Preparation of bidding documents	2	
	4) Bidding period	2	
	5) Evaluation of bidding	1	
	6) Acceptance of bidding evaluation from financial entities side	1	
	7) Negotiation of contracts	1	
	8) Acceptance of contract by financial entities side	1	
	9) Sign of construction contract	1	
	10) Execution of construction lot A and C, liquidation and acceptance of the works	24	
5	**Works of lot B**	29	Jun
	1) Preparation of detail design document for construction and equipment and registration of format SNIP-15	16	
	2) Pre-qualification	3	
	3) Preparation of bidding documents	2	
	4) Bidding period	2	
	5) Evaluation of bidding	2	
	6) Acceptance of bidding evaluation from financial entities side	1	
	7) Negotiation of contracts	1	
	8) Acceptance of contract by financial entities side	1	
	9) Sign of construction contract	1	
	10) Execution of construction lot B, liquidation and acceptance of the works	30	
5	**Inicio de Operación de los lotes A y B**		
	1) Works of lot A		
	2) Works of lot B		

1/ Includes preparation of consistency report (Form SNIP -15)

Source: JICA Study Team

Figure 3.14.3-1: Planned Schedule of Pre-Construction Stage

3.14.4 Construction activities

Construction period for this Project is estimated as 36 months, it is expected to start from December 2013, and should be completed by the end of December 2016, as shown in Table 3.14.4-1. It includes as-built drawing submitting activities, and the completion of the relevant contracts. The Project construction works is divided into two (2) packages, A and B.

Organizations in charge and/or involved in these activities are: SEDAPAL, JICA, IBRD, and KfW, the works construction companies, the equipment suppliers, and the consulting firm hired by SEDAPAL.

Table 3.14.4-1: Duration of Works Construction and Equipment Supply

Package	Duration	Start	End
Package-A: General Works Primary Networks, Reservoirs, Pumping Stations, Wells and SCADA system	24 months	Jan 2013	Dec 2015
Package-B-1 to B-5: Water supply and sewerage secondary Networks	30 months	Jul 2014	Dec 2016
Package-C: Procurement of O&M Equipment	9 months	Jan 2013	Dec 2014

Source: JICA Study Team

The Project construction works is divided into two (2) packages, A and B. Duration of each pipeline installation work that represents a critical aspect of the Project is calculated based on the assumptions, as shown in Table 3.14.6-1.

3.14.5 Operations Startup Activities

Operations startup for the Project Works to be carried out by the Comas and Callao Network Operation and Maintenance Teams is foreseen for December 2015, for Package A Works, and December 2016, for Package B Works.

3.14.6 Physical and financial goals

Table 3.5.2-5 shows the Project investment schedule, and Table 3.14.6-2 and 3.14.6-3 shows the physical and financial progress by Project packages and intangibles, during the implementation period.

Table 3.14.6-1: Condition of Pipe Installation and Rehabilitation Works

<table>
<tr><th>Package</th><th>Work item</th><th>Quantity</th><th>Work rate
Parties
Years</th><th>Remarks</th></tr>
<tr><td>A</td><td>Primary networks</td><td>40.55 km</td><td>12.0m/day
× 6 parties
× 1.8 years</td><td>• Average depth is 2.0m.
• Average diameter is φ250mm.
• The Primary Network consists of 24 lines. Therefore, construction work will be carried out in parallel.</td></tr>
<tr><td rowspan="4">B</td><td>Secondary network for water supply</td><td>228 km</td><td>6.7 m/day
×14 parties
× 3.0 years</td><td rowspan="2">• Average depth is 1.5m.
• Average diameter is φ125mm.
• The secondary pipes will be installed and rehabilitated area-wide. Therefore, the construction duration can be shortened by mobilization many construction parties.
The house connection works will be carried out in parallel with the secondary network works.</td></tr>
<tr><td>House connections for water supply</td><td>70,289 units</td><td>2 onnections /day
×45 parties
× 3.0 years</td></tr>
<tr><td>Secondary collection pipes for sewerage</td><td>237.49 km</td><td>12.6 m/day
×21 parties
× 2.9 years</td><td rowspan="2">• Average depth is 2.0m.
• Average diameter is φ200mm.
• The secondary pipes will be rehabilitated area-wide. Therefore, the construction duration can be shortened by mobilization many construction parties.
• The house connection works will be carried out in parallel with the secondary network works.</td></tr>
<tr><td>House connections for sewerage</td><td>33,736 units</td><td>3 connections /day
×19 parties
× 2.5 years</td></tr>
</table>

Source: JICA Study Team

Table 3.14.6-2: Physical and Financial Progress of the Project Components
(Nuevos Soles as of June 2010)

Ítem	Description	Total	2012	2013	2014	2015	2016
	Package A						
1	General Works of Water Supply	34,486,873		4,310,860	17,243,437	12,932,576	
2	Rehabilitation of reservoirs, pumping stations, wells and automation	44,611,555		5,576,444	22,305,777	16,729,334	
	Package B						
3	Secondary networks and water connections	153,897,517			46,169,256	61,559,008	46,169,253
4	Secondary networks and sewerage connections	127,806,521			38,341,957	51,122,609	38,341,955
	Package C						
5	Equipment for O&M	20,751,609				20,751,609	
	Intangibles						
6	Cost of environment mitigation, social intervention and technical cadastre	24,301,429		2,025,119	8,100,476	8,100,476	6,075,358
7	D/D for construction and EIA	25,282,404	9,480,901	15,801,503			
8	SV and environmental monitoring	43,534,634		3,627,887	14,511,545	14,511,545	10,883,657
9	Business (Project) Management	6,610,985	521,920	1,043,840	2,087,680	1,913,706	1,043,839
	Total	**481,283,527**	**10,002,821**	**32,385,653**	**148,760,128**	**187,620,862**	**102,514,063**

Source: JICA Study Team

Table 3.14.6-3: Physical Progress of the Project Components 1/

Ítem	Description	Total	Unit	2012	2013	2014	2015	2016
	Package A							
1	**General Works of Water Supply**							
1.1	Primary Network of Pipes for Water Supply (trench method)	40,547	m		5,068	20,274	15,205	
2	Rehabilitation of reservoirs, pumping stations, wells and automation							
2.1	Equipment and rehabilitation of reservoirs	27	Unidad		3	13	10	
2.2	Equipment and rehabilitation of pumping stations	4	Unidad		1	2	1	
2.3	Equipment and rehabilitation of wells	23	Unidad		3	11	9	
2.4	Automation and control – water supply	Global	%		12%	50%	38%	
	Package B							
3	**Secondary networks and water connections**							
3.1	Rehabilitation of secondary network of water supply (trench method)	228,520	m			68,560	91,414	68,546
3.2	Rehabilitation of house connections – water supply	70,289	Unidad			21,087	28,116	21,087
3.3	Provisional connections of water supply	Global	%			30%	40%	30%
3.4	Suplí and installation of micrometers	10,537	Unidad			3,161	4,215	3,161
4	**Secondary networks and sewerage connections**							
4.1	Rehabilitation of secondary network of sewerage (trench method)	166,280	m			49,950	66,600	49,730
4.2	Rehabilitation of secondary network of sewerage (trenchless method)	71,210	m			21,402	28,536	21,272
4.3	Rehabilitation of house connections – sewerage	33,736	Unidad			10,121	13,494	10,121
4.4	Provisional connections of sewerage	Global	%			30%	40%	30%
	Package C							
5	**Equipment for O&M**	Global	%				100%	
	Intangibles							
6	**Cost of environment mitigation, social intervention and technical cadastre**	Global	%		8%	33%	33%	25%
7	**D/D for construction and EIA**	Global	%	37%	63%			
8	**SV and environmental monitoring**	Global	%		8%	33%	33%	25%
9	**Business (Project) Management**	Global	%	8%	16%	32%	29%	16%

1/ of the most representative components of construction

Source: JICA Study Team

3.15 Funding Plan

Funding for Project execution foresees the use of resources from the Japanese Government financial cooperation through JICA, the International Bank for Reconstruction and Development (IBRD), and the German Government financial cooperation through the KfW Bankengruppe. These agencies are to come to agreements with SEDAPAL and the Peruvian Government (PG). These resources will be mainly used for general works execution, reservoir, pumping station and well rehabilitations, secondary network and potable water connection replacements, as well as secondary sewerage network connection replacements. Likewise, consultancy services will also be used for technical file or detailed design preparations and advice during tendering processes, works supervision and liquidation, as well as technical cadastre preparation, social intervention activities, and equipment supply to strengthen the Comas and Callao Operation and Maintenance Teams in SEDAPAL's North Services Management Office, all of which are foreseen in the project costs.

The following paragraphs describe the financial conditions for the JICA, IBRD, and KfW loans that have already been agreed upon or subscribed by SEDAPAL for other projects. It is foreseen that the final funding conditions with all agencies will be defined by SEDAPAL and Ministry of Economy and Finances (MEF) once the Project has been approved as feasible by MEF's General Directorate of Multi-Annual Programs in the Public Sector (*Dirección General de Políticas de Inversiones,* DGPI.)

3.15.1 JICA Funding

JICA defines the upper limits (in percentages) for project funding specific for a country, based on that country's gross national income per capita. In the case of Peru, up to 85% of the total project cost can be funded by JICA, unless JICA's funding amount for this project should exceed the part to be normally provided by JICA's funding.

In principle, non-eligible items for JICA funding include: any type of taxes, land purchase or compensation costs, and administration costs incurred by the project executing unit (SEDAPAL in this case).

Financial conditions for a JICA loan would be as follows:

- Interest rate: 1.40 % annual.
- Commission charges: 0.10 % annual.
  (for undisbursed balances)
- Charges for outlay period extensions: 0.20% of the undisbursed amount multiplied by the number of years.
- Debt repayment period: 18 years
- Grace period: 6 years

3.15.2 IBRD Funding

The International Bank for Reconstruction and Development (IBRD) is one of the World Bank group institutions. At present, its mission focuses on fighting against poverty through project fundings in countries with medium income levels and poor countries with a credit standing.

In general, non-eligible items for IBRD funding include: any types of taxes for the execution of the project components.

Financial conditions for an IBRD loan would be as follows:

- Interest rate: LIBOR (6 months) + fixed spread.
- Commission charges: 0.35 % annual (with a 0.50 % discount).
  (for undisbursed balances)
- Debt repayment period: 10 years
- Grace period: 5 years

3.15.3 KfW Funding

The German funding cooperation agency aims at funding investments in developing countries within the economic scope, in social infrastructure, for struggle against poverty, and for environmental protection. These investments are funded through loans under favorable conditions, as well as non-refundable contributions (donations, grants) with funds from the federal budget, and , supplemented with KfW´s own funds.

Generally, non-eligible items for KfW funding include: any type of taxes for the execution of project components.

Financial conditions for a KfW loan would be as follows:

- Interest rate: 5.46 % annual.
- Commission charges: 0.25 % annual.
  (for undisbursed balances)
- Debt repayment period: 12 years
- Grace period: 3 years.

3.15.4 Project Funding Scheme

Based on the considerations previously mentioned, the proposed funding scheme for the Project is shown in Table 3.15.4-1. It is noted that 82.6% of the project total cost will be funded with resources from JICA, IBRD, and KfW, and the remaining 17.4% will be funded with SEDAPAL's own resources (i.e., internal fund generation from the tariffs). In addition, Table 3.15.4-2 shows the funding makeup by agencies, with JICA accounting for 47.2%, which is equal to a loan amounting to 80.0 million US Dollars (7,264.1 million Yens), IBRD accounting for 17.7%, which is equal to 30 million US Dollars, KfW accounting for 17.7%, which is equal to 30 million US Dollars (24.6 million Euros); the remaining would be covered with SEDAPAL's own resources. Average exchange rates[1] for the currencies used are effective as of June 30th, 2010.

[1] Exchange rate for purchase – sale of 1 USD = S/. 2,838 = Yen 90,80 = Euros 0,819, Bank and Insurance Companies Superintendent's Office (SBS) – Perú, June, 2010.

Table 3.15.4-1: Project Funding Scheme by Source
(Currencies as of June 2010)

Source	2012		2013		2014		2015		2016		Total	
	Nuevos Soles	USD	Nuevos Soles	USD	Nuevos Soles	USD	Nuevos Soles	USD	Nuevos Soles	USD	Total	USD
Own Resources	1,745,067	614,893	5,649,920	1,990,811	25,952,322	9,144,581	32,731,869	11,533,428	17,884,348	6,301,744	83,963,527	29,585,457
External loan	8,257,754	2,909,709	26,735,732	9,420,624	122,807,806	43,272,659	154,888,994	54,576,812	84,629,714	29,820,195	397,320,000	140,000,000
Total	**10,002,821**	**3,524,602**	**32,385,653**	**11,411,435**	**148,760,128**	**52,417,240**	**187,620,862**	**66,110,240**	**102,514,063**	**36,121,939**	**481,283,527**	**169,585,457**

Source: JICA Study Team

Table 3.15.4-2: Project Funding Scheme by Cooperation Agency Sources
(Currencies as of June 2010)

Fuente	2012		2013		2014		2015		2016		Total	
	USD	%	USD	%	USD	%	USD	%	USD	%	USD	%
SEDAPAL	614,893	17.4%	1,990,811	17.4%	9,144,581	17.4%	11,533,428	17.4%	6,301,744	17.4%	29,585,457	17.4%
JICA	2,909,709	82.6%	5,383,214	47.2%	24,727,234	47.2%	31,186,750	47.2%	15,793,094	43.7%	80,000,000	47.2%
BIRF			2,018,705	17.7%	9,272,713	17.7%	11,695,031	17.7%	7,013,551	19.4%	30,000,000	17.7%
KfW			2,018,705	17.7%	9,272,713	17.7%	11,695,031	17.7%	7,013,551	19.4%	30,000,000	17.7%
Total	**3,524,602**	**100%**	**11,411,435**	**100%**	**52,417,240**	**100%**	**66,110,240**	**100%**	**36,121,939**	**100%**	**169,585,457**	**100%**

Source: JICA Study Team

3.15.5 Debt Service for Loans

Table 3.15.5-1, Table 3.15.5-2, and Table 3.15.5-3 show the debt service for JICA, IBRD, and KfW loans, respectively, in US Dollars. The JICA loan amortization is paid off around year 2035, and the IBRD and the KfW loan amortizations are paid off in 2027. These estimations are used as a reference for the Project's financial analysis.

Table 3.15.5- 1: JICA Loan Debt Service
(US Dollars as of June 2010)

Year	Outlays	Debit Balance	Commission for non-disbursed balances	Amortization	Intereset	Total payment installment
2012	3,367,174	80,000,000	76,633	0	1,120,000	1,196,633
2013	5,744,720	80,000,000	70,888	0	1,120,000	1,190,888
2014	24,431,153	80,000,000	46,457	0	1,120,000	1,166,457
2015	30,979,640	80,000,000		0	1,120,000	1,120,000
2016		80,000,000		0	1,120,000	1,120,000
2017		80,000,000		0	1,120,000	1,120,000
2018		80,000,000		3,938,816	1,120,000	5,058,816
2019		76,061,184		3,993,959	1,064,857	5,058,816
2020		72,067,225		4,049,875	1,008,941	5,058,816
2021		68,017,350		4,106,573	952,243	5,058,816
2022		63,910,777		4,164,065	894,751	5,058,816
2023		59,746,711		4,222,362	836,454	5,058,816
2024		55,524,349		4,281,475	777,341	5,058,816
2025		51,242,874		4,341,416	717,400	5,058,816
2026		46,901,459		4,402,196	656,620	5,058,816
2027		42,499,263		4,463,826	594,990	5,058,816
2028		38,035,437		4,526,320	532,496	5,058,816
2029		33,509,117		4,589,688	469,128	5,058,816
2030		28,919,428		4,653,944	404,872	5,058,816
2031		24,265,484		4,719,099	339,717	5,058,816
2032		19,546,385		4,785,167	273,649	5,058,816
2033		14,761,219		4,852,159	206,657	5,058,816
2034		9,909,060		4,920,089	138,727	5,058,816
2035		4,988,970		4,988,970	69,846	5,058,816

Source: JICA Study Team

Table 3.15.5-2: IBRD Loan Debt Service
(US American Dollars as of June 2010)

Year	Outlays	Debit balance	Commission for non – disbursed balances	Amortization	Interest	Total payment installment
2012						
2013	2,154,270	30,000,000	97,460		300,000	397,460
2014	9,161,682	30,000,000	65,394	0	300,000	365,394
2015	11,617,365	30,000,000	24,733	0	300,000	324,733
2016	7,066,682	30,000,000		0	300,000	397,460
2017		30,000,000		0	300,000	300,000
2018		30,000,000		2,867,462	300,000	3,167,462
2019		27,132,538		2,896,137	271,325	3,167,462
2020		24,236,401		2,925,098	242,364	3,167,462
2021		21,311,302		2,954,349	213,113	3,167,462
2022		18,356,953		2,983,893	183,570	3,167,462
2023		15,373,060		3,013,732	153,731	3,167,462
2024		12,359,329		3,043,869	123,593	3,167,462
2025		9,315,460		3,074,308	93,155	3,167,462
2026		6,241,152		3,105,051	62,412	3,167,462
2027		3,136,101		3,136,101	31,361	3,167,462

1/ 0.5 % Libor and 0.5 % fixed spread were considered

Source: JICA Study Team

Table 3.15.5-3: KfW Loan Debt Service
(US American Dollars as of June 2010)

Year	Outlays	Debit balance	Commission for non – disbursed balances	Amortization	Interest	Total payment installment
2012						
2013	2,154,270	30,000,000	69,614	0	1,638,000	1,707,614
2014	9,161,682	30,000,000	46,710	0	1,638,000	1,684,710
2015	11,617,365	30,000,000	17,667	0	1,638,000	1,638,000
2016	7,066,682	30,000,000		1,835,139	1,638,000	3,473,139
2017		28,164,861		1,935,338	1,537,801	3,473,139
2018		26,229,523		2,041,007	1,432,132	3,473,139
2019		24,188,517		2,152,446	1,320,693	3,473,139
2020		22,036,071		2,269,970	1,203,169	3,473,139
2021		19,766,101		2,393,910	1,079,229	3,473,139
2022		17,372,191		2,524,617	948,522	3,473,139
2023		14,847,574		2,662,461	810,678	3,473,139
2024		12,185,112		2,807,832	665,307	3,473,139
2025		9,377,281		2,961,139	512,000	3,473,139
2026		6,416,141		3,122,818	350,321	3,473,139
2027		3,293,324		3,293,324	179,815	3,473,139

Source: JICA Study Team

3.16 Log Frame

The Log Frame matrix shows a consistency between the Project goal and the solution that is being set out; in addition, it shows results indicators that will allow for measuring the Project impact.

Table 3.16.1-1: Log Frame Matrix

	Narrative Summary of Objectives	Objectively verifiable indicators	Means of Verification	Assumptions
END	To improve quality of life for population in the Project's area of influence	By year 5, 100 % of the population are content with the water supply and sewerage service quality offered by SEDAPAL	Project impact evaluation survey	No social problems in the areas around SEDAPAL's scope
PURPOSE	To successfully offer a suitable water supply, sewerage, and operational management service in the project's area of influence	By year 2 after implementation, total number of claims (both commercial and operative) have an 80 % decrease in the area of influence.	SEDAPAL Statistical Annual Report.	No external factors (disasters) that affect / deteriorate the infrastructure
COMPONENTS	Water supply service improvement	• Technical or physical losses show up to a 25 % decrease in operation year 1, and up to a 20 % decrease during the remaining years of the project horizon (2035) • Service continuity is on a 24-hour basis and with sufficient pressure for all sectors by operation year 1. • Operative claims for breakages and water leakage have an 80 % decrease by operation year 2 of the Project	Annual report from the Leakage Control and Reduction Team, the Commercial Management Team, and the Network Operation and Maintenance Team in Callao and Comas	Operative budgets are allotted for water network operation, and system is interconnected to the Huachipa WTP distribution system
	Wastewater collection service improvement	Clogs in networks and connections decrease down to 0.5 interventions per km by year 5 of the Project implementation. Operative claims for clogs and overflows have an 80 % decrease by year 5 of the Project implementation.	Annual report from the Network Operation and Maintenance Team in Callao and Comas	Budgets for Project operation are available, and primary collection and wastewater final disposal systems show no operational problems
	The North Services Management (GSN) develops an efficient water supply and sewerage service management in the project's area of influence	By year 1 of Project operation, the North Services Management has 100 % budgeted resources and maintenance equipment to develop a suitable preventative maintenance management. In this way, the Leakage Control and Reduction Team carries out all water leakage detection and control actions.	SEDAPAL Statistical Annual Report	Economic resources and staff available for Project operation
ACTIVITIES	General works and rehabilitation for reservoirs, pumping stations, and Wells	• Installation of DI primary distribution pipes, DN 150 mm to DN 700 mm, 40.55 Km and 107 pressure reducing valves, air valves, purge valves and sluice valves. • Cost: S/. 34.5 million.	Works appraisal and liquidation report	Economic resources available for Project execution
	Rehabilitation for reservoirs, pumping stations, and Wells	Civil, hydraulic Works, equipment and rehabilitation for pumping stations, including automation and hydraulic equipment for 27 reservoirs, 4 pumping stations and 23 wells. Cost: S/. 32.5million	Works appraisal and liquidation report	Economic resources are available for Project execution
	Potable water supply system rehabilitation (secondary networks, connection, and meters)	• Rehabilitation of 179.02 Km of pipes, installation of inlet to sector pipes pf 49.50 Km of, DN 100 mm to DN 400 mm, 228.52 km, including pressure reducing valves, air valves, drain valves and hydrants. • Renewal of 70,289 connections	Works appraisal and liquidation report	Economic resources are available for Project execution.

		• Installation of 10,537 new meters Cost: S/. 153.9 million		
	Automation and Control System	• Automation and control – potable water Cost: S/. 12.1 million	Valuation and liquidation of works	Available economic resources for the execution of the project
	Wastewater collection system rehabilitation (sewerage secondary networks and house connections).	• Rehabilitation and/or renewal of existing sewerage networks in 237.49 Km, PVC, DN 200 to DN 400 mm: 166.28 km (trench) and 71.21 km PVC (trench- less). • 3,302 new manholes installation and 1,415 manholes rehabilitation • Renewal of 33,736 connections Cost: S/. 127.8million	Works appraisal and liquidation report.	Economic resources are available for Project execution.
	Water supply and sewerage operation and maintenance team	• Procurement of 2 mini hydro jet equipments, with vehicle, 6 hydro jet equipments, 6 m3 to 8 m3 with a tank truck for sewerage cleaning • Procurement of 3 mobile equipment for TV camera inspection to sewerage networks. • Water supply leakage detection equipment: 2 leakage location correlators, 4 geophones, and 200 mobile pre-locators and an equipped vehicle • Computer equipment. Cost: S/. 20.8million	Equipment Reception (Handover) and Contract liquidation report.	Economic resources are available for Project procurement of equipment
	Environmental mitigation, social intervention, and facility cadastre	• Mitigation measures during Works construction phase. • Environmental monitoring and follow-up during construction . • Archaeological monitoring during construction • Social awareness raising to population during Works execution. • Technical cadastre to facilities, includes as-built drawings Cost: S/. 24.3 million	Monthly report on environmental monitoring, archaeological remains, and social intervention programs. As-built drawings, records, and descriptive memory.	Economic resources are available for Project execution. Population and municipalities participate actively.
	a) Technical file includes environmental and archaeological remains studies. **b) Works supervision and environmental monitoring and follow-up.** **c) Project management.**	• Detailed design studies for works, includes EIA and CIRA. Cost: S/. 25.0 million • Supervision of works and environmental monitoring • Social monitoring Cost: S/. 43.9 millones • Project administration, technical, and financial management Cost: S/. 6.6 million	Approval reports of detailed design studies for Works and procurement of equipment Works supervision approval report Project management report	Economic resources are available for Project execution The Executing Unit continues as an entity depending on General Management Office

Source: JICA Study Team

3.17 Project Baseline

Major indicators to be used to set up the baseline that will measure the project's impact are shown in Table 3.17.1-1

Table 3.17.1-1: Baseline for Project Impact Evaluation

Nº	Indicator	Unit	Year 2009	Year 2016
1	Total population			
	Study area	Inhabitants	625,310	710,328
	Project's area of influence	Inhabitants	614,830	695,200
2	Served population			
	Study Area	Inhabitants	398,590	629,425
	Influence Area	Inhabitants	398,570	621,749
3	Water supply coverage			
	Study area	%	64	89
	Influence Area	%	64	89
4	Sewerage coverage	%	—	89
5	Service continuity	hours/day	3 – 24	24
6	Non Revenue Water (NRW)	%	50	25
	Technical losses		40	20
7	Water pressure	m.c.a.	< 40	10－30
8	Sectors			
	Project's area of influence	Units	24 1/	32
9	Existing Water supply secondary networks	km	773.45	
	Rehabilitation and / or renewal	km		228.52
10	Incidents in the water supply network	km/year	0.43	
11	Secondary collector networks			
	Existing	km	651.56	
	Rehabilitation and / or renewal	km		237.92
12	Water supply connections			
	Existing	Units	77,573	
	Rehabilitation and / or renewal	Units		70,289
13	Sewerage connections			
	Existing	Units	62,407	
	Rehabilitation and / or renewal	Units		34,441
14	Breakages in the sewerage network	km/year	0.6	

1/ Four (4) sectors have no water networks

Source: JICA study team