STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
IN
THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU
JAPAN INTERNATIONAL COOPERATION AGENCY

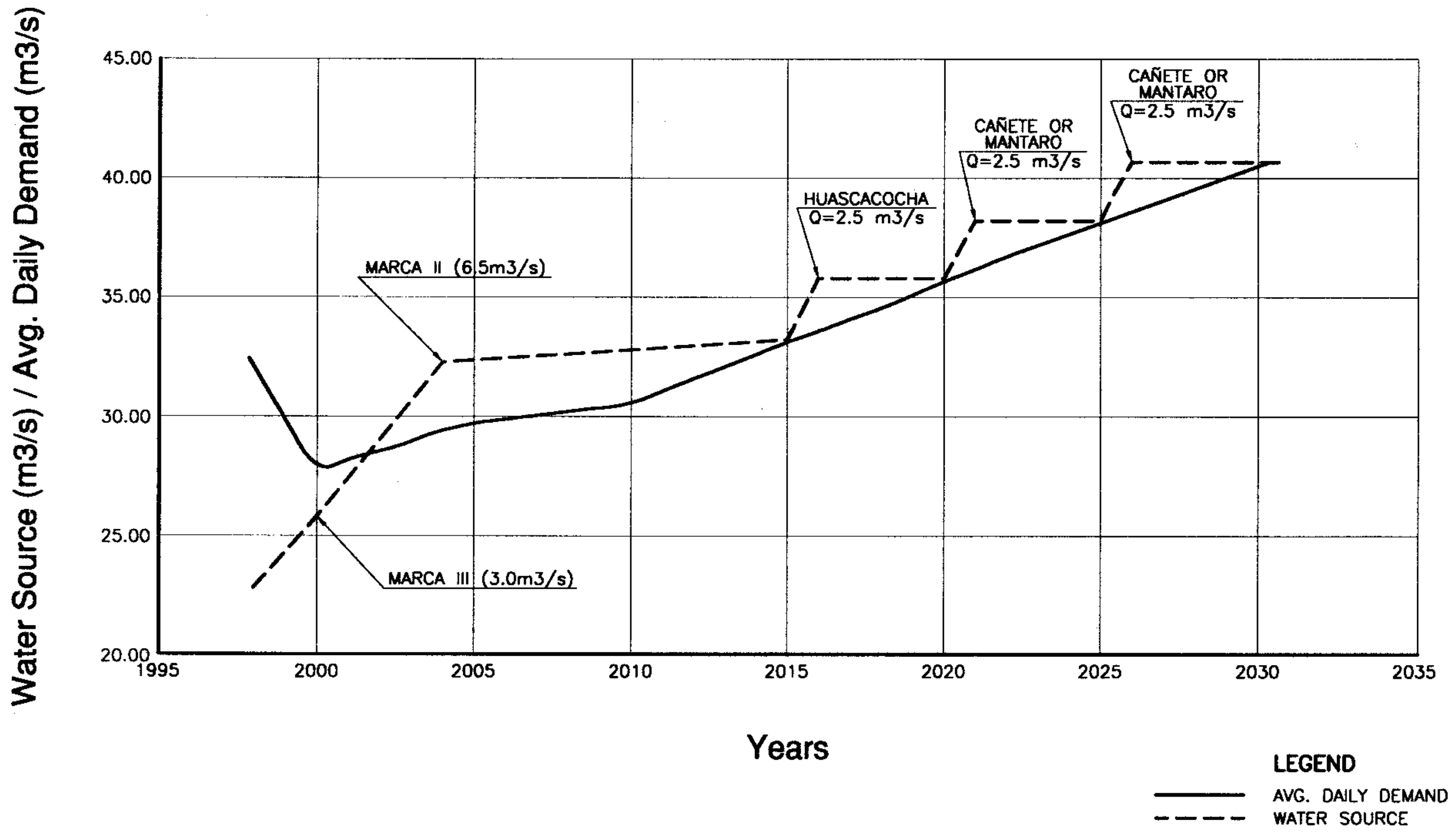
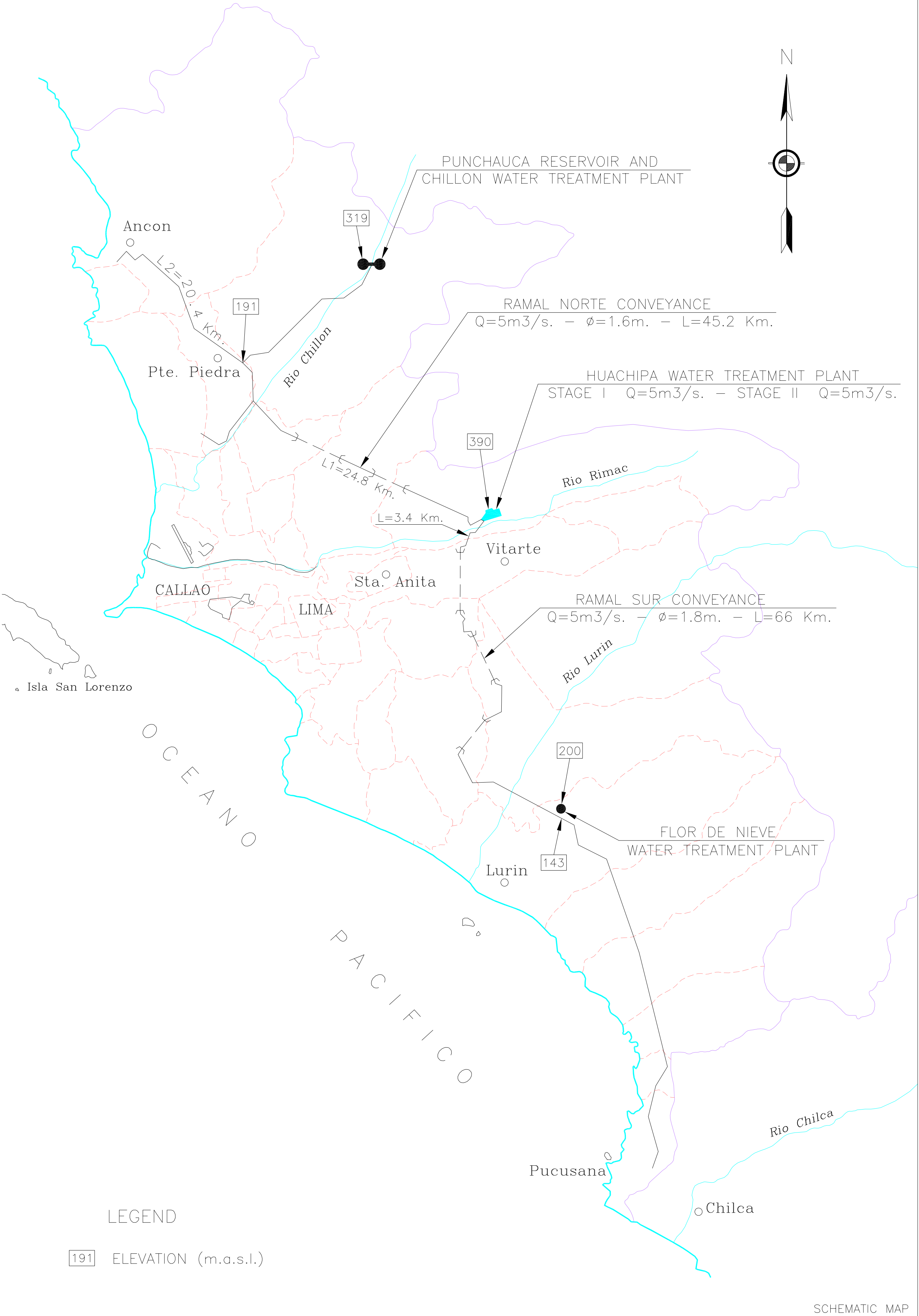


Figure 4.3.8
Water Demand - Supply Balance for Metropolitan Lima Water Supply System, Period 1998 - 2030



STUDY ON INTEGRATED WATER RESOURCES DEVELEMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU	Figure 4.3.9 SEDAPAL COMMITTED PROJECT FOR CONSTRUCTION AT SHORT TERM
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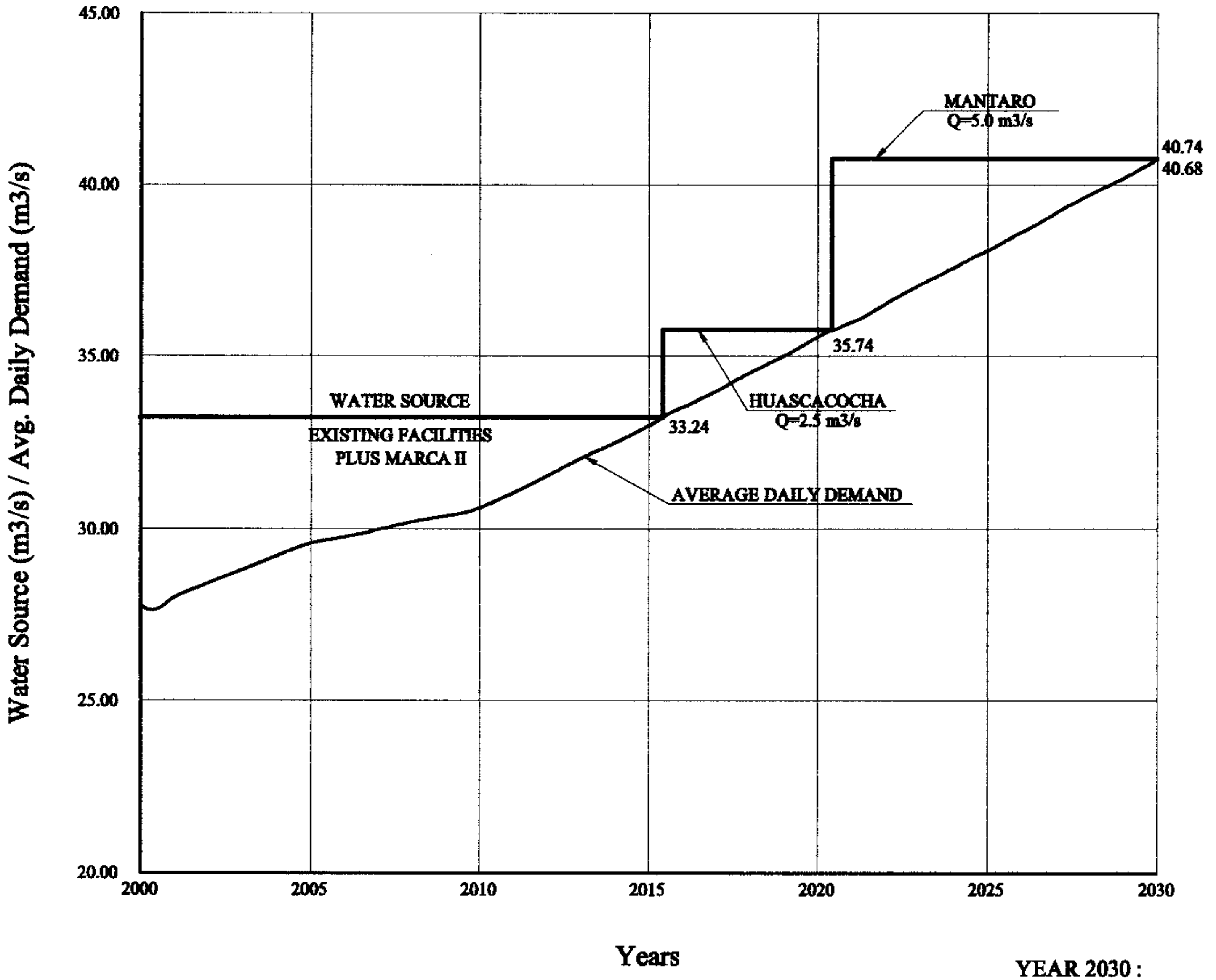
STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
IN
THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

THE JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.10

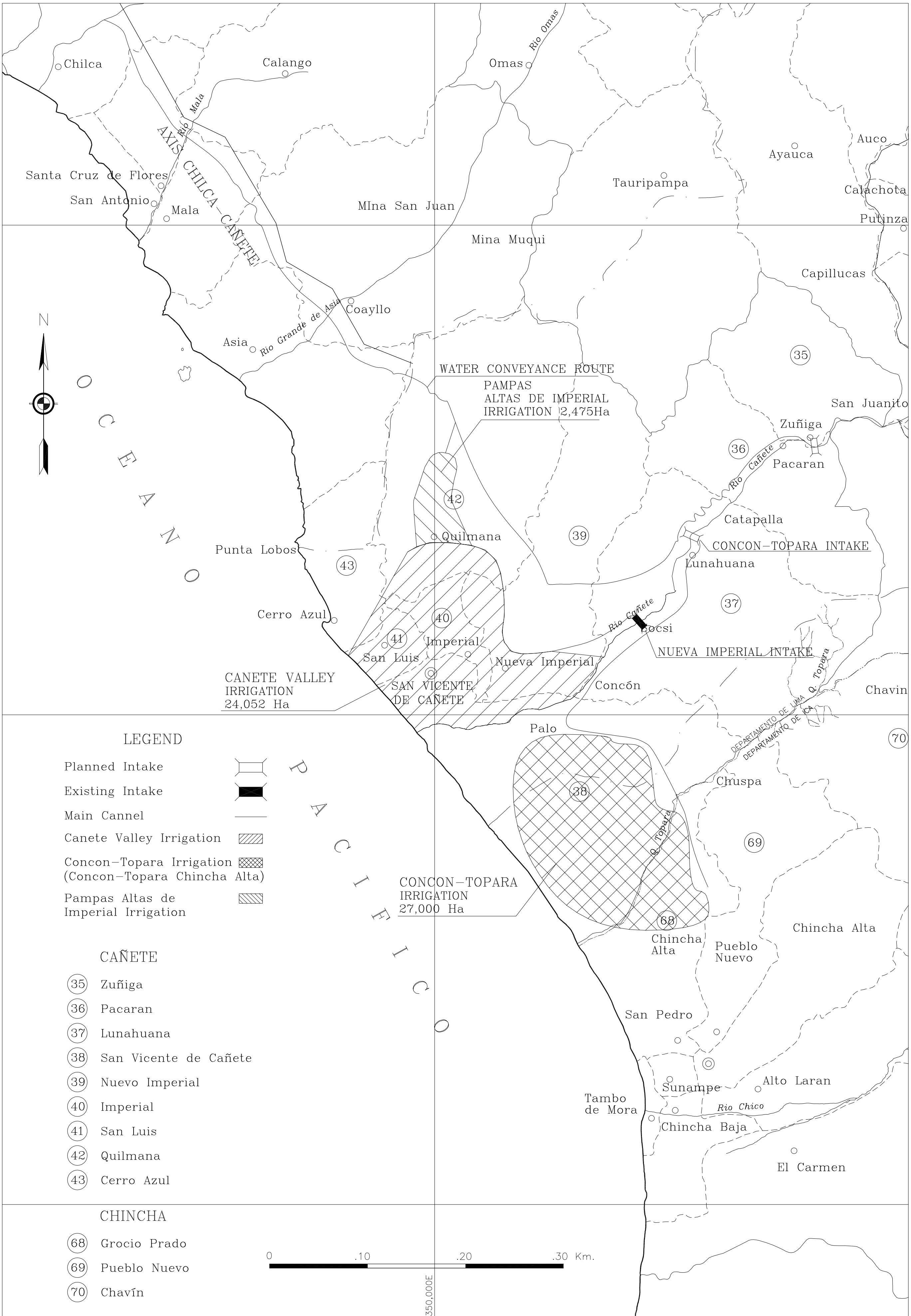
Demand – Supply Balance and Proposed Expansion System for Metropolitan Lima Water Supply System



YEAR 2030 :

WATER SOURCE : 40.74m3/s

AVERAGE DAILY DEMAND : 40.68m3/s



STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

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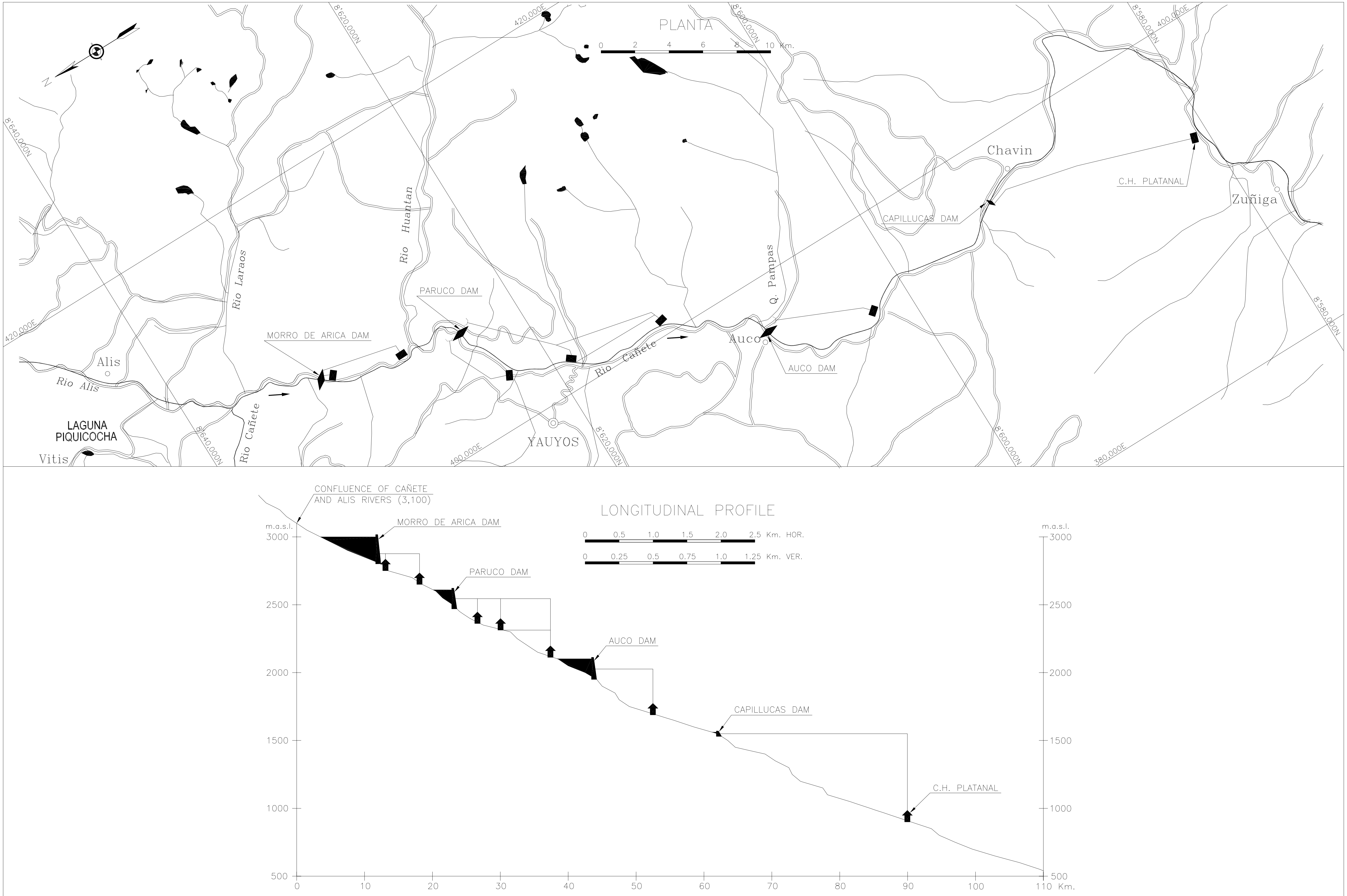
Figure.4.3.11

Map on Irrigation Areas



STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU	Figure 4.3.12
JAPAN INTERNATIONAL COOPERATION AGENCY	Alternatives for Hydropower Development

CHAPTER 5 ECONOMIC AND FINANCIAL EVALUATION AND IMPLEMENTATION SCHEDULE

5.1 Preliminary Design and Cost Estimate

5.1.1 Preliminary Design

Preliminary design was prepared for the engineering works including dams and water conveyance facilities. Location of the works is shown in Figure 4.2.2. For comparison with project cost of alternative D/I water conveyance scheme (the Mantaro - Carispaccha scheme) to the Cañete scheme, the Study team reviewed the Mantaro - Carispaccha scheme of the SEDAPAL M/P. Location of the schemes is shown in Figure 5.1.1.

(1) Dam

In the Cañete River basin, a private cement company, Cemantos Lima S.A. has already conducted some design works for dam and hydroelectric power, which are called “El Platanal Project”. In this project, it is planned to construct one earth fill dam (Paucarcocha dam), one RCC dam with hydroelectric power plant (Morro de Arica dam, recently the dam type was changed to arch dam) and one intake dam with hydroelectric power plant (Capillucas intake dam, concrete gravity type). Typical features are shown in Figures 5.1.2, 5.1.3 and 5.1.5. On the other hand, the Study team assumed additional dam sites (Auco and San Jeromino dams, both RCC type) for the purpose to enhance regulation capacity of the river runoff and carried out preliminary design as shown in Figures 5.1.4 and 5.1.6. Location of the dams is seen in Figure 4.2.2.

(2) Cañete D/I Water Conveyance

Preliminary design for the facilities of the Cañete D/I water conveyance scheme (Mountain Route-1, total length: 206 km) was carried out for the purpose to review the existing design and preliminary cost estimate in a pre-feasibility study by SEDAPAL in 1995. Zuñiga intake dam is shown in Figure 5.1.7. Figure 5.1.8 illustrates main facilities of the water conveyance system to be composed of the following elements:

i)	Open channel	:	125 km
ii)	Pipe line (D=1.6m)	:	53 km
iii)	Siphons (D=1.6m)	:	8 km
iv)	Tunnels	:	18 km
v)	Drop	:	2 km
	Total		206 km

Two alternative mountain and coastal routes of the conveyance system were examined as shown in Figures 4.2.2 and 5.1.9, and the original Mountain Route-1 was selected for the study in this stage (see Section 5.1.2 (2), 2).

(3) Mantaro - Carispaccha Water Conveyance

Location of facilities for Mantaro - Carispaccha scheme in Stage-1 and Stage-2 are shown in Figure 5.1.10. System diagram for Mantaro - Carispaccha scheme in Stage-1 is shown in Figure 5.1.11. Main structures of the scheme are shown in Figures 5.1.12 and 5.1.13.

5.1.2 Preliminary Cost Estimate

(1) Methodology

Existing reports related to the Study listed below were collected for the purpose to review the design, cost data and information including engineer's cost estimates and unit prices:

a) Pre-Feasibility Study on Cañete River Basin for Water Supply to Lima City 1995, SEDAPAL
b) Pomacocha – Rio Balanco Water Transfer Detailed Study (MARCA-II) 1998, SEDAPAL
c) Marcapomacocha Water Transfer Detailed Study (MARCA-III) 1997, SEDAPAL
d) Feasibility Study on Optimization of Rimac River Basin, between Moyopampa and La Atarjea, and the Environmental Impact Study, 1997, SEDAPAL
e) Feasibility Study on Cañete River Hydroelectric Power Project "EL PLATANAL" 1998, Cementos Lima S.A.
f) Feasibility Study on EL PLATANAL Hydroelectric Power Plant 1987, Electroperu S.A.

Cost estimate in this study was made in consideration of the following findings summarized from the collected reports:

a) Unit prices of major component of works were assumed with reference to the records of international bids for schemes of hydroelectric power and water supply development.
b) For dam and/or hydroelectric power scheme, simple conventional cost estimate equations were adopted to estimate project component cost including direct and indirect costs with input of principal dimensions of the project facilities and assumed unit prices.

c) For water conveyance schemes, work quantities were reviewed by a design method of the Study Team based on the preliminary design by SEDAPAL Pre-F/S, 1995.

d) For irrigation scheme, project component cost was worked out as a product of command area and unit price per irrigation area that was gauged with reference to the current cost data of similar schemes in Peru and other countries.

e) Costs of mobilization works and unmeasured factor were assumed as follows.
- Mobilization works: 10% of total amount of civil works
- Unmeasured factor: 5% of total amount of civil works

f) In-direct Costs are assumed as follows.
- Administration & Engineering Services: 10% of total direct cost
- Physical Contingency: 10% of total direct cost
- Price Contingency 3% of total direct cost

g) Annual operation and maintenance cost for this study is adopted as follows.
- Open channel: 1.0% of direct cost
- Pumping station: 2.0% of direct cost
- Tunnel: 0.1% of direct cost
- Access road: 0.5% of direct cost
- Pipeline & Siphon: 0.2% of direct cost
- Dam 0.5% of direct cost
- other Facilities 0.5% of direct cost

(2) Project Cost of CANETE Scheme

Main project features and corresponding total project cost are set out below.

1) Dam and hydroelectric power

For preliminary cost estimate of the dams and hydroelectric power schemes, preliminary design was prepared for each dam (Paucarcocha dam, Morro de Arica dam, Auco dam, Capillucas dam, San Jerónimo dam), as shown in Figures 5.1.2, 5.1.3, 5.1.4, 5.1.5 and 5.1.6 by reviewing the existing data and information given by SEDAPAL and Cementos Lima. The total project cost is summarized as follows:

Name of Dam	Paucarcocha	Morro de Arica		Auco	Capillucas	San Jerónimo
		High Dam	Low Dam			
Dam Type	Center Core Earthfill Dam	RCC Dam	RCC Dam	RCC Dam	Concrete Gravity Dam	RCC Dam
Dam Vol (m^3)	405,000m^3	2,499,400m^3	1,805,000m^3	6,934,500m^3	76,500m^3	6,635,500m^3
Dam Height from the Bottom (m)	30m	259m	232m	230m	37m	235m
Active Storage Vol.(mcm)	55mcm	245mcm	205mcm	300mcm	-	250mcm

Total Cost (US$ Million)						
Only Dam Constriction	16	196	143	535	-	513
Dam & Hydro electric power (Install Capa. MW)	-	239 (50MW)	184 (46MW)	591 (47MW)	164 (200MW)	555 (42MW)

2) D/I water conveyance

Route	Mountain Route			Coastal Route *	
	Proposed (Route-1)	Alternative	Proposed (Rotue-2)		
Length of Water Conveyance (km)	206km	172km	206km	165km	
Water Supply to Lima (m^3/sec)	5.0 m^3/sec	5.0 m^3/sec	10.0 m^3/sec	5.0 m^3/sec	10.0 m^3/sec
Diameter & Line of Steel Pipe	D=1.6m x 1line	D=1.6m x 1line	D=1.6m x 2lines	D=1.8m x 1line D=1.6m x 1line	D=1.8m x 2lines D=1.6m x 2lines
Total Cost (US$ million)	295	365	453	436	732

* 1 Pumping station will be installed on Coastal route.

For preliminary cost estimate, preliminary design was prepared for each water conveyance route as shown in Figures 5.1.7 and 5.1.8 by reviewing the design of SEDAPAL Pre-F/S.

It is noted that comparison of alternatives of water conveyance system, the 206 km long mountain route with gravity conveyance (Mountain Route-1) and the 165 km long coastal route with combination of gravity and pumping up, showed the mountain route to be in advantage in cost and operation reliability.

Mountain Route-2 (Figure 5.1.9) is more costly compared with the proposed Mountain Route-1, though Route-2 is safer against natural disasters such as land sliding because the main component is pipelines and tunnels instead of open channels.

3) Irrigation

Region	Valle de Cañete	Pampas Altas de Imperial	Pampas de Concón-Topará & Chincha Alta	Total
Irrigation Area (ha)	24,052 ha	2,475 ha	27,000 ha	53,527 ha
Irrigation Water (m^3/sec)	22.3 m^3/sec	1.7 m^3/sec	19.5 m^3/sec	43.5 m^3/sec
Total Cost (US$ million)	13	5	147	164

4) Cost estimate for alternative scenarios and cases

Tables 5.1.1 (1/3), (2/3), and (3/3) present summary of costs including construction and O/M for each case of Water Resources Development Scenarios discussed in the foregoing Section 4.2 (see Table 4.2.3).

(3) Project Cost of Mantaro - Carispaccha Scheme

Review result indicated that the cost estimate for the Mantaro - Carispaccha D/I water conveyance scheme of the SEDAPAL M/P is reasonable. The estimate is 339 million US$ for construction (6.6 million US$ for O/M cost) in the case of water supply of 5.0 m^3/s to Lima.

(4) Unit Development Cost of Water

Unit development cost of water is estimated as summarized below in terms of unit dam facilities cost (per 1 m^3 of active storage) and unit conveyance facilities cost (per 1 m^3 of water conveyance) to compare investment efficiency of prospective alternative dams and water conveyance systems.

1) Unit development cost of dam and hydroelectric power

Name of Dam	Paucarcocha	Morro dde Arca		Auco	Capillucas	San Jerónimo
		High Dam	Low Dam			
Dam Type	Center Core Earthfill Dam	RCC Dam	RCC Dam	RCC Dam	Concrete Gravity Dam	RCC Dam
Active Storage Vol.(mcm)	55 mcm	245 mcm	205 mcm	300 mcm	-	250 mcm
Unit Dam Facilities Cost (US$ / Active Storage Vol. 1.0 m^3)						
Only Dam Constriction	0.3	0.8	0.7	1.8	-	2.1
Dam & Hydro-electric power (Install Capa. MW)	-	1.0 (50 MW)	0.9 (46 MW)	2.0 (47 MW)	- (200 MW)	2.2 (42 MW)

2) Unit development cost of Cañete water conveyance system

(US$ Million)

Route	Mountain Route			Coastal Route *	
	Route-1 (A)	Route-2	Route-1 (B)		
Length of Water Conveyance (km)	206 km	172 km	206 km	165 km	
Water Supply to Lima (m^3/sec)	5.0 m^3/sec	5.0 m^3/sec	10.0 m^3/sec	5.0 m^3/sec	10.0 m^3/sec
Unit Conveyance Facilities Cost (US$ million/ Water Supply to Lima 1.0 m^3/sec)					
Unit Cost of Water Development	59.0	73.1	45.3	87.2	73.2

5.2 Water Resources Development Projects

5.2.1 Description of Project Components

Alternative seven cases are selected for water resources development scenarios of the Cañete River based on the alternative plan study in the foregoing Section 4.3.1. (See description of alternative cases in Table 4.3.1 and its system diagram in Figures 4.3.1 – 4.3.4. Among the scenarios and subsequent cases, the Scenario-3/Case 3.3 indicates the most reasonable IRRs and NPVs in economic and financial evaluation done in the succeeding Section 5.2.2. This development option aims to implement projects including engineering works for 1) D/I water supply to Lima South Cone, to Canete basin and to Concón-Topará, 2) agriculture (irrigation) in Cañete valley and Concón-Topará, and 3) hydropower at Morro de Arica and El Platanal, with construction of storages dams at Paucarcocha (glacial lake) and Morro de Arica (middle reach).

(1) D/I Water Supply

1) To Lima

Five (5) m^3/s of D/I raw water is planned to be conveyed to the south of Lima metropolitan area, with construction of storage dams (at Paucarcocha and Morro de Arica), an intake dam (at Zuniga), and a 200 km long conveyance canal-pipeline system. The two storage dams have multiple functions and will be implemented for the purposes of hydropower (Morro de Arica and El Platanal) and agricultural (Concón-Topará) development prior to the implementation of other works.

2) To Cañete basin

Cañete basin will require 0.87 m^3/s of potable water in 2030, in addition to the current demand at 0.96 m^3/s (see Figure 4.3.3). Current demand is supplied by groundwater with wells. Supply to the additional demand is assumed to be surface water, since groundwater potential has not yet to be gauged at accurate level. If the proposed groundwater investigation in the coming feasibility study reveals the amount to be at appreciable level, a part of surface water supply source may be replaced with groundwater.

3) To Concón-Topará

Agricultural development in Concón-Topará will require 0.15 m^3/s potable water to the residential people in the farmland. Since the farmland area is dry and does not have any reliable own water sources, the water will be brought from the Cañete River to the demand area through the irrigation canal (11.1 m^3/s for irrigation, see Figure 4.3.4). Agricultural development (construction of primary irrigation system) is being promoted by the private firm, Cementos Lima.

(2) Agriculture (Irrigation)

1) Cañete Valley

This is the existing agricultural land in the Cañete River basin with an area of about 24,000 ha and irrigation demand at about 10.8 m^3/s (see Figure 4.3.4). Rehabilitation and improvement of the irrigation facilities are going on with a co-finance by OECF (JBIC) and World Bank (see Section 4.3.3). It is assumed that all activities will be completed by 2004.

2) Concón-Topará

Cementos Lima is proceeding 27,000 ha agricultural development in the area Concón-Topará, by providing 11.1 m^3/s irrigation water from Cañete River (see Figure 4.3.4). This aims to enjoy an integrated effect of the hydropower development, which constructs relatively large storage dams for the natural runoff regulation, thus yielding new firm water.

(3) Hydropower

1) Morro de Arica

Two storage dams, Paucarcocha and Morro de Arica planned hydropower generation as well as for other water use purposes. About 30 m high Paucarcocha dam will dam up an existing glacial lake (named Laguna Paucarcocha) to attain an active storage of 55 MCM, which aims solely to contribute to the runoff regulation (see Figure 4.3.4). About 260 m high Morro de Arica dam with an active storage of 245 MCM will have main role of runoff regulation. A hydropower plant of 50MW is to be installed on the dam to take advantage of the high gravity head of the reservoir. Cementos Lima is proceeding implementation activities to be ready for operation in 2007.

2) El Platanal

In the downstream of the Morro de Arica dam, located is El Platanal power plant which is composed of an intake dam at Capillucas, a headrace tunnel and 220 a MW power station.

5.2.2 Economic and Financial Evaluation of Schemes in the Cañete River

(1) Scenarios Subject to Economic and Financial Evaluation

The economic and financial evaluation is made on three different scenarios consisting of seven different cases of development (Refer to Table 4.3.1) which have been formulated in relation with development of water resources in the Cañete River.

(2) Evaluation Methodology

The economic evaluation intends to sound the project viability from the standpoint of the national economy by use of a normative method of cost-benefit analysis that is commonly applied for evaluation of similar projects in Peru under finance of the World Bank, Inter-American Development Bank (IDB), etc. The internal rate of return (IRR) is calculated on the basis of cash flow consists of projects costs and benefits during the project life. It constitutes the primary indicator for assessment of each alternative, and apart from the IRR, the net present value (NPV) is also calculated so as to estimate the magnitude of project's incremental benefits.

(3) Components of Project Costs and Benefits

1) Benefits

The quantifiable benefits attributable to integrated development of water resources in the Cañete River are as briefly explained hereinafter:

Sectors	Anticipated Quantifiable Benefits
D/I water supply to Lima:	The direct benefits of D/I water supply to Lima stem from the amount of newly served water to population. For the present master plan, supply of only raw water from the Cañete River to southern district of Lima with amount of 5 m^3/s is considered.

Hydroelectric power generation:	For the purpose of economic evaluation, two alternatives for expansion of the National Interconnected System are prepared; one is what is called “With Project” situation, which envisages development of hydroelectric power stations at El Platanal and at Morro de Arica and the other is “Without Project” situation, in which electric demand to satisfy an expansion of the National Interconnected System is proposed with installation of one additional gas turbine (300 MW) to substitute for hydroelectric power generation. The benefits stem from electric power generation are thus expressed as an alternative energy cost the capital and running costs for installation and operation and maintenance of this additional gas turbin, which is obtained as the balance of investment and running costs for thermal power generation between “Without Project” and “With Project”.
Irrigation :	Benefits accrued to development of new irrigation system are expressed as net surplus of crop production (production value minus production cost) to cover the whole beneficial area by an irrigation system and those from improvement of existing irrigation districts are the balance of net surplus of crop production between “Without” project situation and “With” project situation.

2) Costs

The cost for different scenarios consist of direct costs (capital cost and recurrent cost for construction, operation and maintenance of engineering works) and indirect costs (administration cost, engineering services and physical and price contingencies). Direct costs, in turn, are represented by development of dam (Paucarcocha, Morro de Arica, & San Jerónimo) and installation of facilities required for utmost production of anticipated benefits mentioned above. Meanwhile, indirect costs are composed of: administration and engineering services (10% of direct costs), physical contingency (10% of direct cost) and price contingency (3 % of the sum of the costs for direct costs, administration and engineering services and physical contingency).

(4) Valuation of Costs and Benefits

1) Benefits

D/I water supply to Lima

SEDAPAL’s tariffs are based on a marginal cost expressed at net present value of capital and recurrent cost. According to SEDAPAL’s M/P capital and recurrent costs expressed at market price were converted to economic price with a conversion factor of 0.64 on average. Thus economic and financial values of “raw water” to be used for estimating project’s benefit are determined as follows.

Year	Unit value of raw water (US$/m^3)	
	Market Price	Economic Price
2005	0.288	0.184
2006 – 2019	0.321	0.205
2020 – 2035	0.953	0.610

Raw water to be produced under the present master plan is 157.68 MCM/year (5 m^3/s), which is to be conveyed to Lima with an efficiency of 95%, equivalent to 149.78 MCM/year or 299.59 MCM/year. Then, an annual amount of project’s benefits are obtained as given in the table below.

Year	Anticipated Benefits for 5 m^3/s (US$/year)	
	Market Price	Economic Price
2005	43,136,640	27,559,520
2006 – 2019	48,079,380	30,704,900
2020 – 2035	142,740,340	91,365,800

Hydroelectric power generation

Benefits accrued to hydroelectric power development enterprise consist of investment cost for installation of one additional gas turbine with capacity of 300 W (150 million US$), fixed operation and maintenance cost of this equipment (2.6 million US$/year) and variable cost – cost of fuel consumption (31.9 million US$/year) for operation of equipment (Refer to the Section 5.2.2 (3) 1)).

Irrigation

The conversion of market price of agricultural commodities and farm inputs (seeds, plants, fertilizers, agro-chemicals, farm machinery and labor force, etc.) into economic price has been made in pursuance to the guideline (“Actualización de los Precios de Eficiencia para los Estudios de Factibilidad de Subproyectos de Riego y Drenaje”) prepared by Ministry of Agriculture for Irrigation Subsector Program.

As a consequence, farm gate price and crop budget calculated at market price in the Section 4.3.4 have been expressed in economic price to obtain net agricultural benefits at economic price (efficiency price). Net agricultural benefits calculated both market and economic prices at maturation stage of agricultural production for respective irrigation project is as given hereinafter.

Irrigation Projects	Net Agricultural Benefits (US$/year)	
	Market Price	Economic Price
Valle de Cañete	4,512,000	7,580,000
Concon-Topara	66,384,000	78,333,000
Pampas Altas de Imperial	3,027,000	3,663,000

2) Costs

Following similar procedure employed in estimating economic price of benefits, capital and recurrent costs for construction, operation and maintenance of infrastructure have been converted from market price to economic price with use of the different conversion factors, and the total sum of capital and recurrent costs for development of infrastructure for each alternatives of infrastructure have been expressed in both market and economic prices in the following manner:

Unit: Million of US$

Alternatives	Capital Cost (Total)		Recurrent Cost (Yearly)	
	Market Price	Economic Price	Market Price	Economic Price
Case 1.1	655.53	544.09	2.17	1.69
Case 1.2	889.30	738.12	2.85	2.22
Case 2.1	595.40	494.18	4.84	3.78
Case 2.2	475.49	394.66	3.63	2.83
Case 3.1	1,392.49	1,155.77	7.64	5.96
Case 3.2	841.11	698.12	4.70	3.67
Case 3.3	902.48	749.06	6.29	4.91

(5) Build-up of Costs and Benefits for Respective Development Scenarios

So as to calculate IRR and NPV, the cash flow is forged in accordance with the principles as given hereinafter:

1) Benefits

- D/I water supply to Lima: It is presumed that raw water from the Cañete would be conveyed to south of Lima starting in 2010 until 2039. In compliance with the Section 5.2.3. (4) 1), benefits are estimated at constant value of US$ 48,079,30 at market price and US$ 30,704,900 at economic price for the period 2010 – 2019 and US$ 142,740,340 at market price and US$ 91,365,800 at economic price for the period 2020 – 2039.
- Hydropower generation: Installation of one additional gas turbine is required in the fourth year (year 2003) from start of the project, and running cost for operation and maintenance of the equipment is scheduled from the fifth year (year 2004) onward. Durable life of gas turbine is set as 15 years, so replacement of the equipment is required in the 20^{th} year (year 2019). Hence, benefits attributable to hydroelectric power

generation are estimated in line with this installation schedule.

- Irrigation development: Benefits attributable to new irrigation system installation and improvement of the existing irrigation system are generally produced shortly after operation of new and improved systems, namely from 2005 onward. Nevertheless, it should be noted that non-traditional and permanent crops proposed in the new agricultural development projects would undergo transitional period until attaining planned target yields. In line with this assumption, agricultural full benefits are attained in the 5th year for Cañete Valley and in the 7th year for both Pampas Altas de Imperial and Concon-Topara.

2) Costs

Capital cost for development facilities and plants is allocated during the five years, in which initial two years are assigned for design and preparation of development works, meanwhile major construction works are scheduled to be executed during the latter three years. Operation and maintenance costs are assigned for time horizon of 30 years after starting the operation. In this cash flow, residual values are taken into account for civil works and equipment whose durable period still remains at the expiration of the project life.

(6) Evaluation Results

The economic and financial IRRs and NPVs for respective development scenarios are as summarized in the following table. For calculating the NPV, a discount rate of 12% was applied referring to prevailing practice in Peru.

Scenarios/ Alternatives	IRR (%)		NPV at 12% (Million US$)	
	Financial	Economic	Financial	Economic
Case 1.1	17.1	14.2	156.1	56.4
Case 1.2	17.2	11.2	260.0	- 24.8
Case 2.1	15.6	16.9	118.0	148.6
Case 2.2	15.8	15.9	87.8	81.5
Case 3.1	12.6	13.0	36.7	46.5
Case 3.2	15.0	14.3	137.3	83.8
Case 3.3	16.1	16.4	208.3	184.7

The above indicators show that all alternatives except for the Case 1.2 have been assessed to be both economically and financially feasible for their implementation bearing in mind that their IRRs outstrip the opportunity cost of capital in Peru, which is considered to be around 12%.

It should be noted herewith that above IRRs and NPVs are underestimated actually because benefits accrued to maintenance flow (4.3 m^3/s or 1.0 m^3/s) do not make up part of tangible benefits due to their being intractable in quantification. It is thus considered that benefits stem from an integrated water resources development of the Cañete River Basin are considerably larger than quantified ones, even though intangible socio-economic secondary benefits such as public health effect owing to supply of piped domestic water, generation of job opportunity, development of agriculture-based industry, increase in trading of commodities and services, etc. should not taken into account.

5.3 Economic and Financial Analysis of Mantaro-Carispacha Scheme

5.3.1 Introduction

As mentioned in Section 4.3.3, SEDAPAL has conducted a master plan study on Lima & Callao Water Supply and Sewerage Systems (SEDAPAL M/P) with time horizon up to 2030. In this master plan, four alternative plans comprising Cañete River scheme have been forged with respect to capturing and conveyance of raw water to Lima & Callao; in these alternative plans, Cañete River scheme is competing with Mantaro - Carispacha scheme within long-term implementation schedule of water supply system. In this context, it is worthy to review economic evaluation of these two schemes exposed in SEDAPAL's master plan with input of updated information on capital and recurrent cost as well as with more refined engineering consideration.

5.3.2 Comparison of Cañete Scheme with Mantaro-Carispacha Scheme

For the sake of present comparison, engineering works and cost for both schemes cover regulation, intake and conveyance of raw water to specifined water treatment plants as briefly described hereinafter:

<u>Cañete scheme</u>: River water is to be regulated by raising a new dam at Paucarcocha and construction of a new dam at Morro de Arica and to be withdrawn at Zuñiga with construction of an intake to covey to Lima through open channel and pipe line.

<u>Mantaro-Carispacha scheme</u>: Rive water is to be traversed from the Mantaro River and to be pumped from Carispacha lake and conveyed to Lima through Marcapomacocha-Marca III System to the Rimac River.

On the other hand, the comparison between Cañete and Mantaro – Carispacha schemes from economic viewpoint have been made at first on the following assumptions:

1) Cañete S/P (single purpose) the water resources in the former scheme should be newly developed for exclusive use of D/I water supply to Lima.
2) Cañete D/P (dual purpose) – the same comparison is to be made on

condition that water resources of the Cañete River should be developed for dual, Case 1.1.

3) Cañete M/P-1 (multipurpose) - D/I water supply to Lima, hydroelectric power generation and irrigation to Concon-Topara – full scale with minimum maintenance flow 1.0 m^3/s and development of groundwater, Case 3.3.

4) Cañete M/P-2 (multipurpose) - D/I water supply to Lima, hydroelectric power generation and irrigation to Concon-Topara – full scale with minimum maintenance flow 4.3 m^3/s, Case 3.1.

See Table 4.3.1 for definition of Case 1.1, Case 3.1 and Case 3.3

The economic evaluation on the two schemes is be made on the basis of the following conditions, namely:

Design production amount for respective scheme:

- Design raw water production : 5 m^3/s for both Cañete and Mantaro schemes
- Electric power generation: 270 MW (Assumed for simplification)
- Irrigation for Concon-topara: 10 m^3/s for the Case 3.1 and Case 3.3
- Minimum maintenance flow: Cañete – 4.3 m^3/s for the Case 3.1 and 1.0 m^3/s for the Case 3.3; Mantaro – Carispacha (Rimac) – Not considered

Scope of cost estimation

Capital cost for water intake, regulation, conveyance works and groundwater development including temporary and related facilities and recurrent cost for their operation and maintenance. Cost for administrative and engineering services and physical and price contingencies are also taken into account.

Cost allocation of dam construction to D/I water supply

In so far as the cases of dual purpose and multi-purpose are concerned, cost to be allocated to the sector of the D/I water supply to Lima has been determined in line with the methodology named as "Separable Cost – Remaining Benefits (SCRB) Method", which is the method recommended for general use in allocating costs of multi-purpose river basin projects in the United State of America and is world-widely used by a number of development agencies (See Attachment of the Sector Report on Socio Economy and Finance for its reference). Consequently, cost allocation to D/I water supply has been determined as given below:]

- Dual purpose: 50%
- Multi-purpose: 26% (Case 3.1) and 22% (Case 3.3)

Parameter for evaluation

Net present value (NPV) of capital and recurrent costs expressed in market price is employed. Discount rate used for calculating NPV is at 12%, referring to other similar projects of SEDAPAL. Construction period is assumed to be 5 years including study and design stage and the project life is assumed to be 30 years after commencement of operation.

The result of cost comparison at NPV is as resumed in the tables below.

Cañete Scheme (Single Purpose) vs. Mantaro-Carispacha Scheme

Unit: Million US$

Schemes		Cañete (S/P)	Mantaro-Carispacha
Water Conveyance System	Total Capital Cost	294.97	217.95
	Annual Recurrent Cost	0.84	6.18
	Total Cost at NPV	204.32	176.30
Dam	Capital Cost	142.91	n.a.
	Annual Recurrent Cost	0.53	n.a.
	Total Cost at NPV	99.54	n.a.
Integrated Engineering Works	Cost Summary at NPV	303.86	176.30

Remarks: The project cost of the Mantaro-Carispacha water transfer was reviewed and modified by the same cost estimate criteria of the Study Team.

Cañete Scheme (Dual and Multiple Purposes) vs. Mantaro-Carispacha Scheme

Unit: Milion US$

Schemes		Cañete			Mantaro-Carispacha
		D/P (Case 1.1)	M/P-1 (Case 3.3)	M/P-2 (Case 3.1)	
Water Conveyance System	Total Capital Cost	294.97	294.97	294.97	217.95
	Annual Recurrent Cost	0.84	0.84	0.84	6.18
	Total Cost at NPV	204.32	204.32	204.32	176.30
Dam	Capital Cost	71.46	46.60	184.36	n.a.
	Annual Recurrent Cost	0.27	0.17	0.69	n.a.
	Total Cost at NPV	49.77	32.42	128.45	n.a.
Ground Water	Capital Cost	n.a.	2.66	n.a.	n.a.
	Annual Recurrent Cost	n.a.	0.13	n.a.	n.a.
	Total Cost at NPV	n.a.	2.42	n.a.	n.a.
Integrated Engineering Works	Cost Summary at NPV	254.09	239.16	332.77	176.30

As above comparison indicates, it is judged that any case of the Cañete scheme is economically disadvantageous than the Mantaro-Carispacha scheme. Therefore, it is advised that the priority for implementation of water supply project to Lima should be given to the Mantaro-Caprispacha Scheme in ahead of the Cañete Scheme.

5.4 Implementation Schedule

The implementation schedule for development in the Cañete river basin is shown in Figure 5.4.1. SEDAPAL has suspended implementation of the D/I water supply conveyance to Lima (5 m^3/s). Implementation schedule of the D/I water supply in and around the Cañete river basin, rehabilitation of existing irrigation facilities and the Integrated El PLATANAL project is summarized as follows:

- Expansion of D/I water supply in Cañete river basin (0.87 m^3/s) will be carried out step by step to meet the demand growth by use of groundwater and/or surface water. D/I water supply to Concón-Topará (0.15 m^3/s) will be implemented over the period from 2003 to 2007 together with the implementation of the irrigation development therein.
- On-going rehabilitation of the existing Valle de Cañete irrigation system (24,000 ha) is assumed to be completed by 2004. Concón-Topará development (27,000 ha) is assumed to be realized over the period from 2003 to 2011.
- Hydropower development including Morro de Arica (dam and 50 MW power plant) and El Platanal (220 MW power plant) is planned to be realized over the period from 2003 to 2006.

Among the above, a private firm, Cementos Lima is carrying out the implementation of both the hydroelectric power (both Morro de Arica and El Platanal) and irrigation (Concón-Topará) with the construction of the Morro de Arica dam. Rehabilitation and improvement of the irrigation system for the existing agricultural land at the Valle de Cañete is being implemented with co-finance by OECF (now JBIC) of Japan and the World Bank.

Table 5.1.1 Preliminary Cost Estimate for Water Resources Development Scenarios and Alternative Cases (1/3)

(US$ Million)

Facilities Plan	Scenario-1			
	Case 1.1 *		Case 1.2	
	Construction Cost	O/M Cost	Construction Cost	O/M Cost
1 Dam only				
1) Paucarcocha dam (Earthfill)	-	-	15.72	0.03
2) San Jeronimo-1 (RCC)	-	-	-	-
3) Morro de Arica-1 (High, RCC)	-	-	196.08	0.72
4) Morro de Arica-2 (Low, RCC)	142.91	0.53	-	-
2 Hydroelectric Power Station only				
1) Morro de Arica-1 (High, RCC)	-	-	42.51	0.09
2) Morro de Arica-2 (Low, RCC)	40.74	0.08	-	-
3) Capillucas *(Hydroelectric Power Station + Intake Dam)	164.04	0.47	164.04	0.47
3 Water Conveyance (Mountain route)				
1) 5.0 m3/sec to LIMA	294.97	0.84	-	-
2) 10.0 m3/sec to LIMA	-	-	453.37	1.20
4 Irrigation Facilities				
1) Canete Valley (CV)	12.87	0.26	12.87	0.26
2) Altas de Inperial (CLC)	-	-	4.71	0.09
3) Concon - Topara & Chincha Alta-1 (CTP-Full scale)	-	-	-	-
4) Concon - Topara & Chincha Alta-2 (CTP-Half scale)	-	-	-	-
Total	**655.53**	**2.17**	**889.30**	**2.85**

Note: O/M Cost: Operation and Maintenance Cost

Table 5.1.1 Preliminary Cost Estimate for Water Resources Development Scenarios and Alternative Cases (2/3)

(US$ Million)

Facilities Plan	Scenario-2			
	Case 2.1 *		Case 2.2	
	Construction Cost	O/M Cost	Construction Cost	O/M Cost
1 Dam only				
1) Paucarcocha dam (Earthfill)	15.72	0.03	-	-
2) San Jeronimo-1 (RCC)	-	-	-	-
3) Morro de Arica-1 (High, RCC)	196.08	0.72	-	-
4) Morro de Arica-2 (Low, RCC)	-	-	142.91	0.53
2 Hydroelectric Power Station only				
1) Morro de Arica-1 (High, RCC)	42.51	0.09	-	-
2) Morro de Arica-2 (Low, RCC)	-	-	40.74	0.08
3) Capillucas *(Hydroelectric Power Station + Intake Dam)	164.04	0.47	164.04	0.47
3 Water Conveyance (Mountain route)				
1) 5.0 m3/sec to LIMA	-	-	-	-
2) 10.0 m3/sec to LIMA	-	-	-	-
4 Irrigation Facilities				
1) Canete Valley (CV)	12.87	0.26	12.87	0.26
2) Altas de Inperial (CLC)	-	-	-	-
3) Concon - Topara & Chincha Alta-1 (CTP-Full scale)	164.18	3.28	-	-
4) Concon - Topara & Chincha Alta-2 (CTP-Half scale)	-	-	114.93	2.30
Total	**595.40**	**4.84**	**475.49**	**3.63**

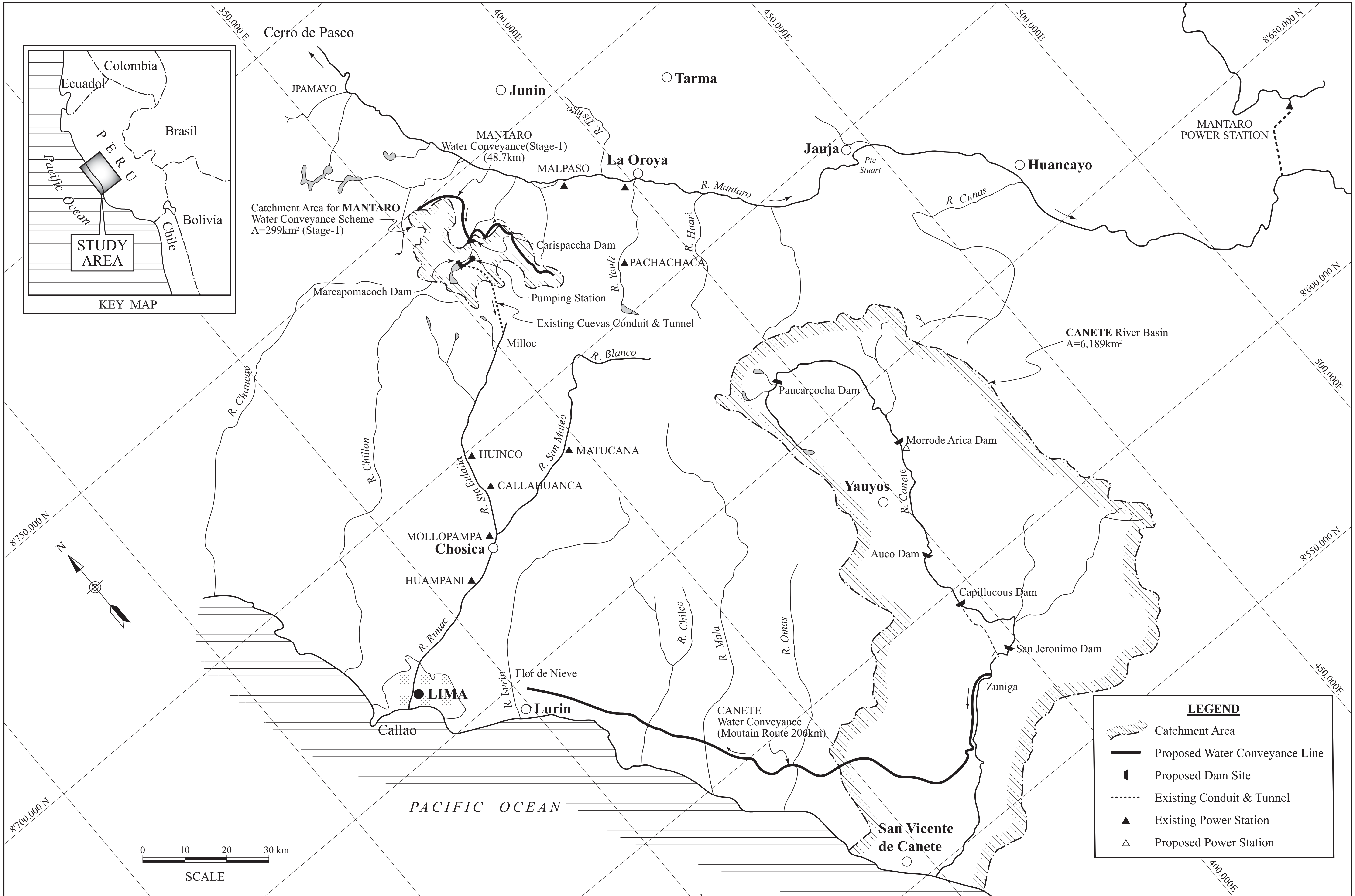
Note: O/M Cost: Operation and Maintenance Cost

Table 5.1.1 Preliminary Cost Estimate for Water Resources Development Scenarios and Alternative Cases (3/3)

(US$ Million)

Facilities Plan	Scenario-3					
	Case 3.1 *		Case 3.2		Case 3.3	
	Construction Cost	O/M Cost	Construction Cost	O/M Cost	Construction Cost	O/M Cost
1 Dam only						
1) Paucarcocha dam (Earthfill)	-	-	15.72	0.03	15.72	0.03
2) San Jeronimo-1 (RCC)	513.13	1.89	-	-	-	-
3) Morro de Arica-1 (High, RCC)	196.08	0.72	196.08	0.72	196.08	0.72
4) Morro de Arica-2 (Low, RCC)	-	-	-	-	-	-
2 Hydroelectric Power Station only						
1) Morro de Arica-1 (High, RCC)	42.51	0.09	42.51	0.09	42.51	0.09
2) Morro de Arica-2 (Low, RCC)	-	-	-	-	-	-
3) Capillucas *(Hydroelectric Power Station + Intake Dam)	164.04	0.47	164.04	0.47	164.04	0.47
3 Water Conveyance (Mountain route)						
1) 5.0 m3/sec to LIMA	294.97	0.84	294.97	0.84	294.97	0.84
2) 10.0 m3/sec to LIMA	-	-	-	-	-	-
4 Irrigation Facilities						
1) Canete Valley (CV)	12.87	0.26	12.87	0.26	12.87	0.26
2) Altas de Inperial (CLC)	4.71	0.09	-	-	-	-
3) Concon - Topara & Chincha Alta-1 (CTP-Full scale)	164.18	3.28	-	-	164.18	3.28
4) Concon - Topara & Chincha Alta-2 (CTP-Half scale)	-	-	114.93	2.30	-	-
Total	**1,392.49**	**7.64**	**841.11**	**4.70**	**890.37**	**5.68**

Note: O/M Cost: Operation and Maintenance Cost



STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
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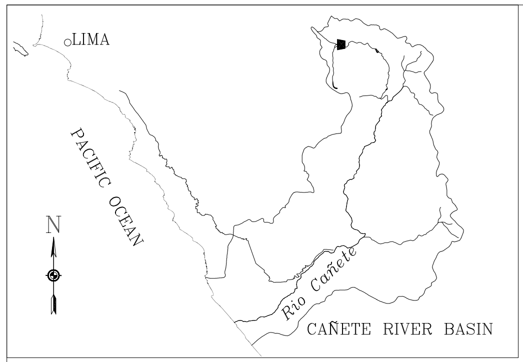
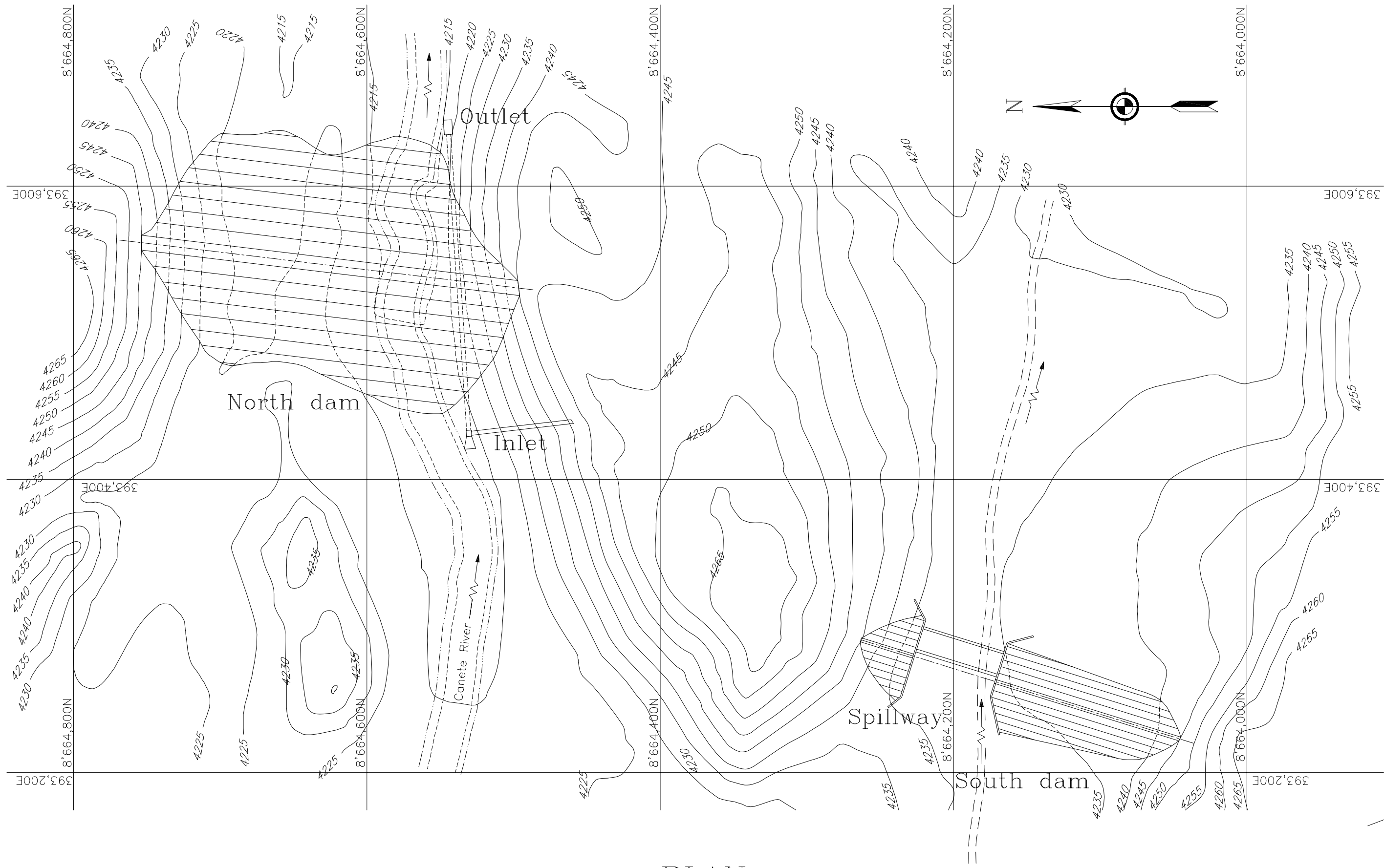
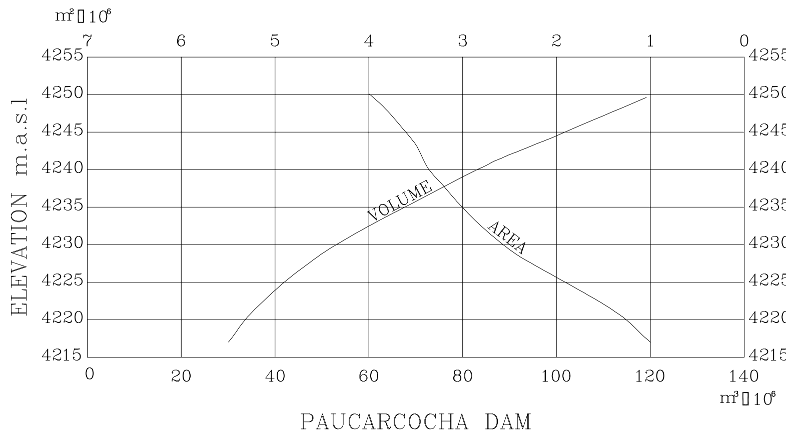
Figure 5.1.1
Location of CANETE Scheme and MANTARO Scheme



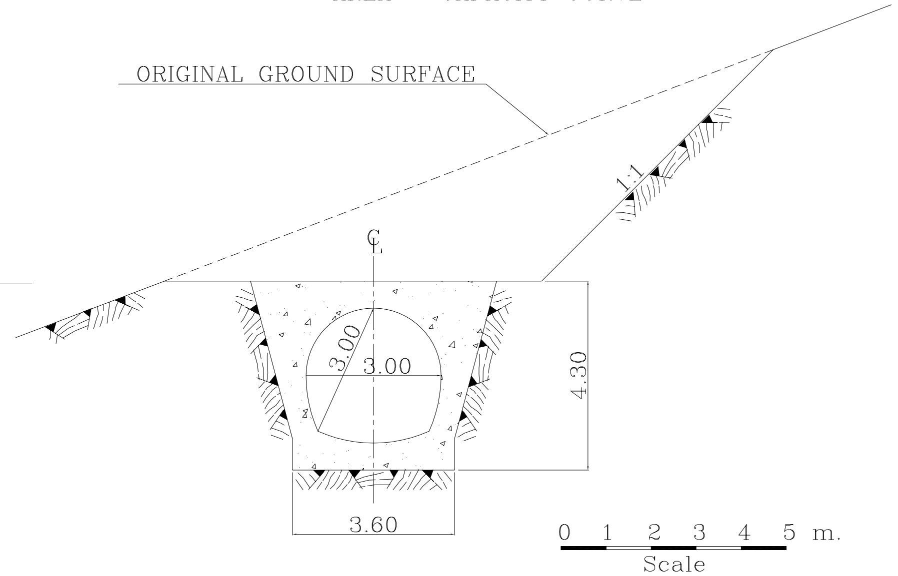
KEY MAP



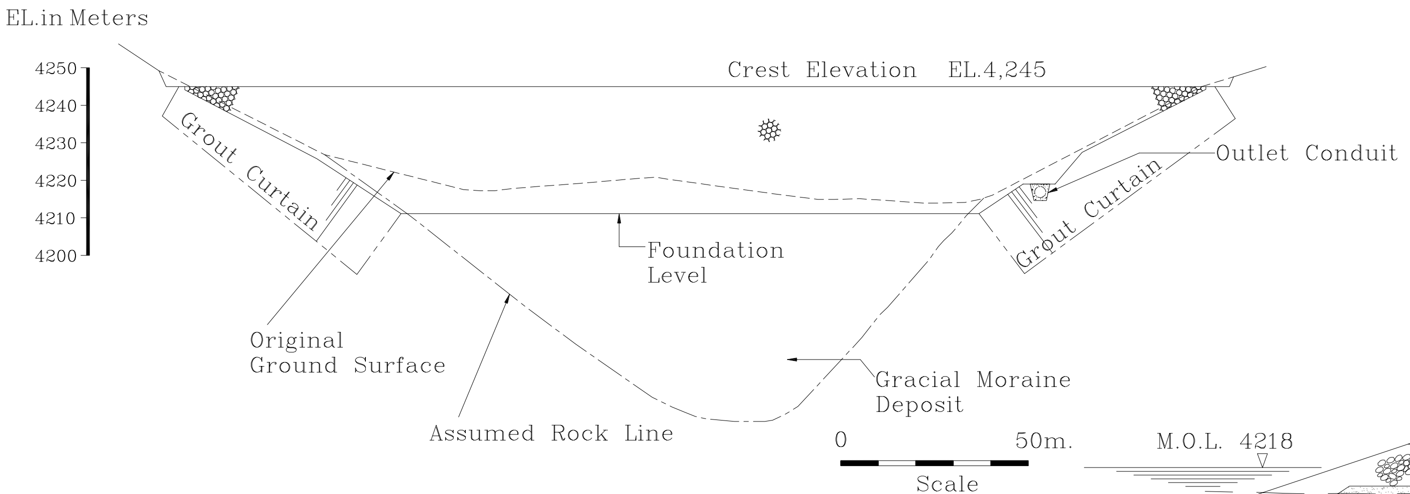
PLAN



PAUCARCOCHA DAM
AREA - CAPACITY CURVE



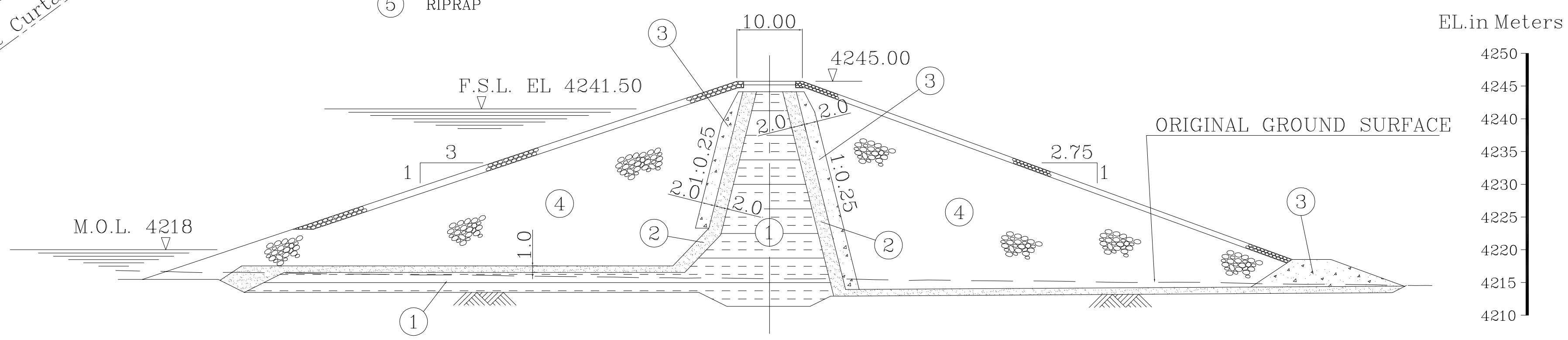
SECTION OF DIVERSION CONDUIT



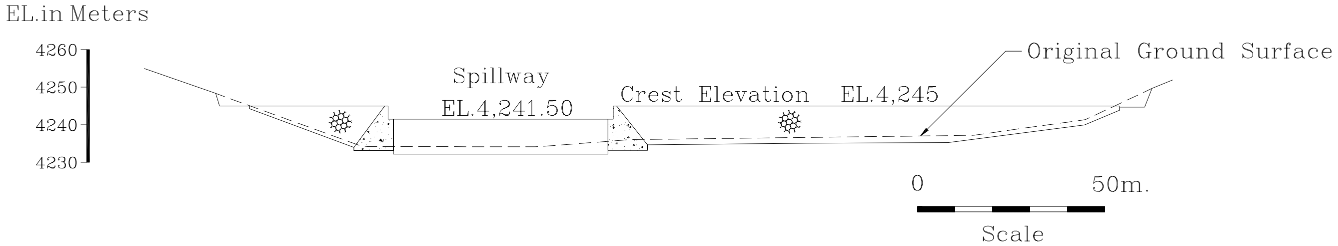
UPSTREAM ELEVATION OF NORTH DAM

LEGEND

1. IMPERVIOUS CORE
2. FINE FILTER
3. COURSE FILTER
4. PERVIOUS GRANULAR FILL
5. RIPRAP

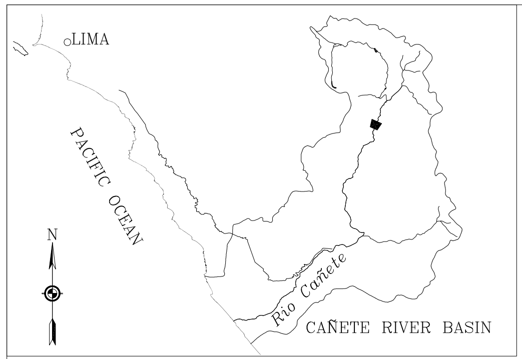


TYPICAL SECTION OF NORTH DAM

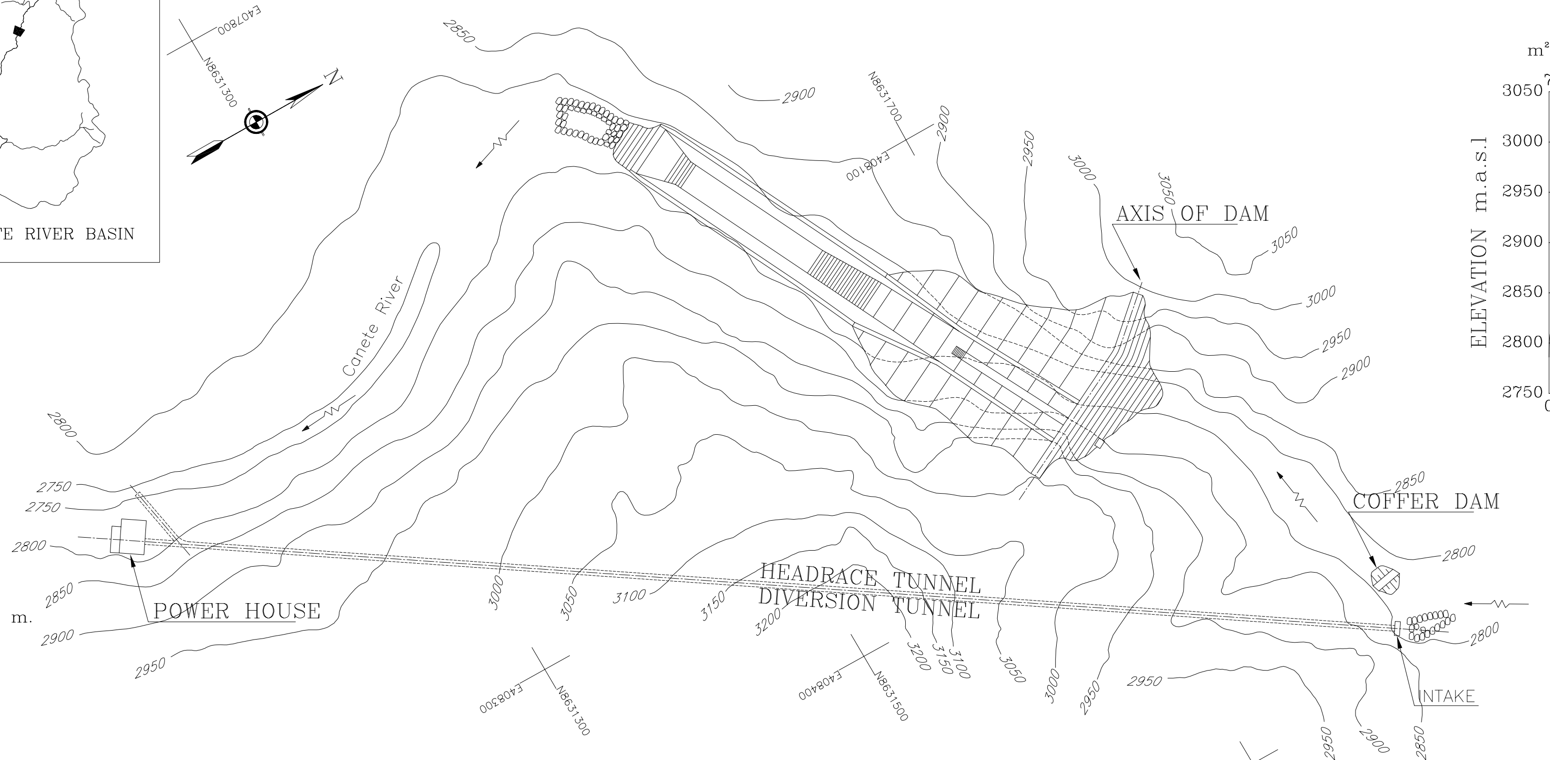


UPSTREAM ELEVATION OF SORTH DAM

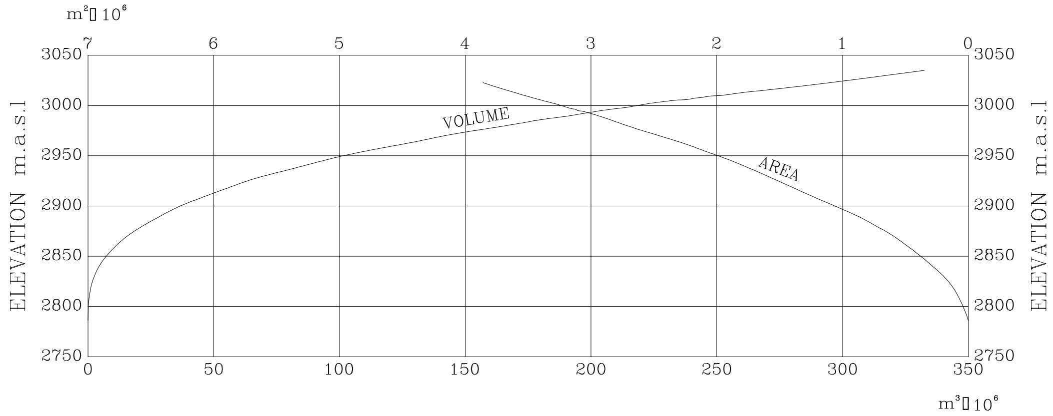
STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT THE CA□ETE RIVER BASIN IN THE REPUBLIC OF PERU JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 5.1.2 PAUCARCOCHA DAM (EARTHFILL DAM)



KEY MAP

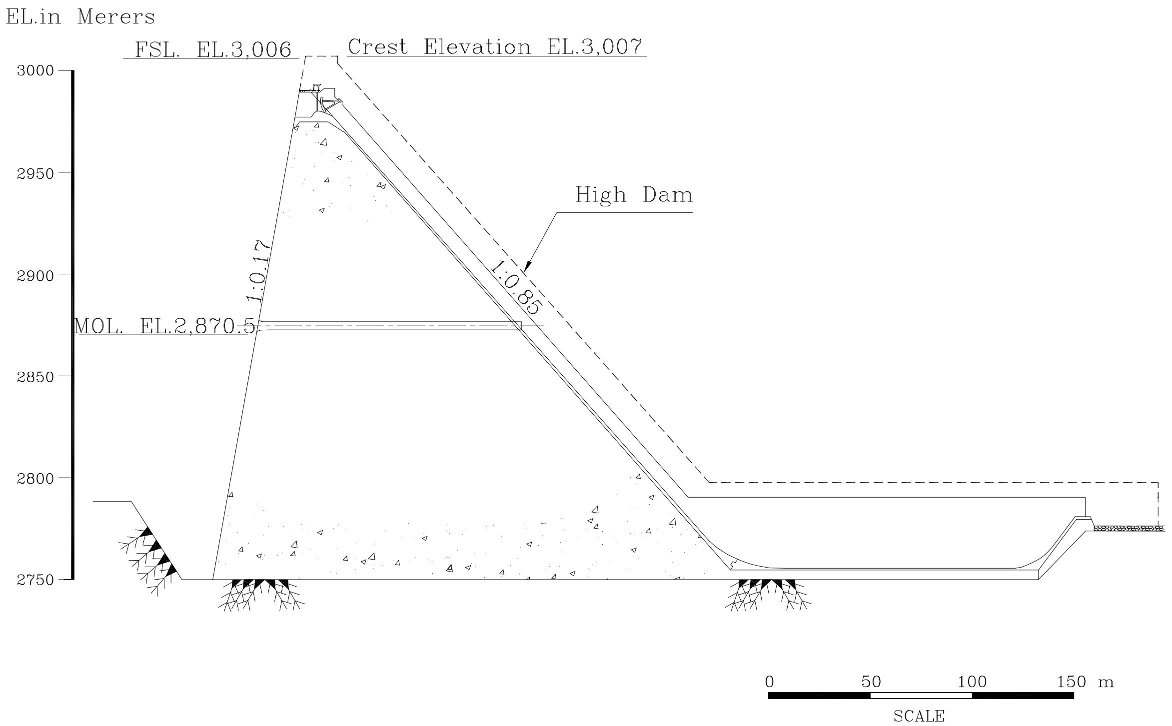


PLAN

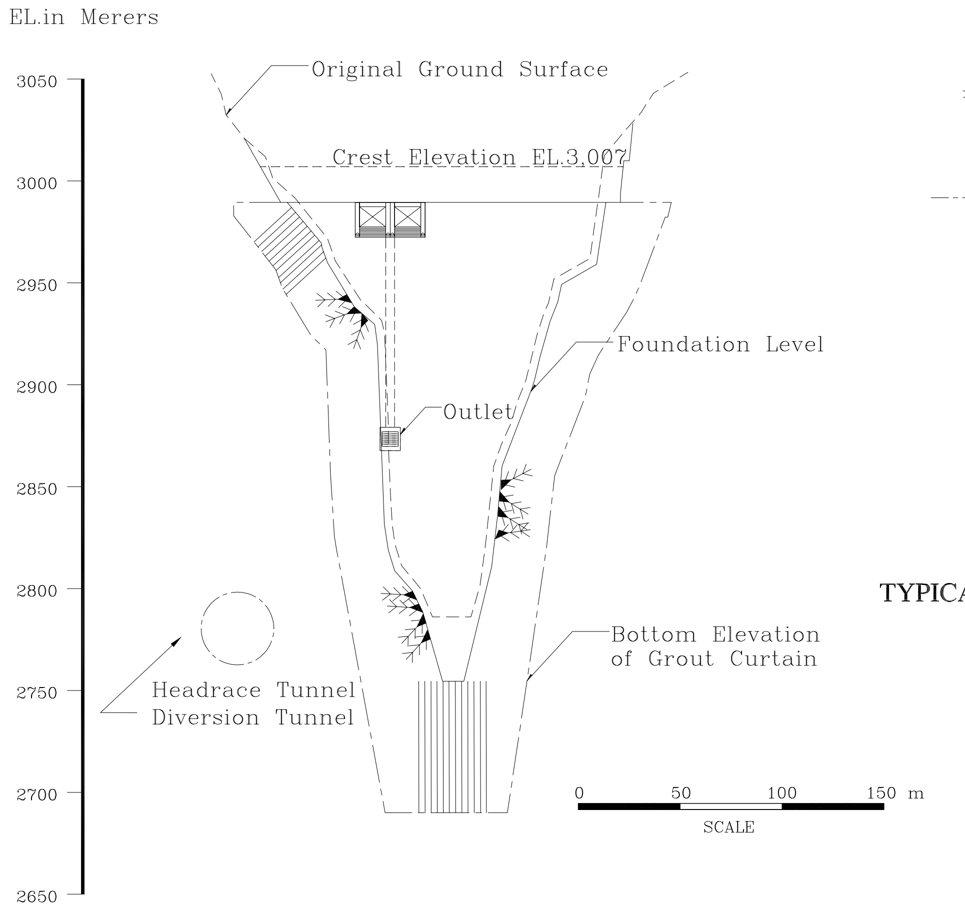


MORRO DE ARICA DAM

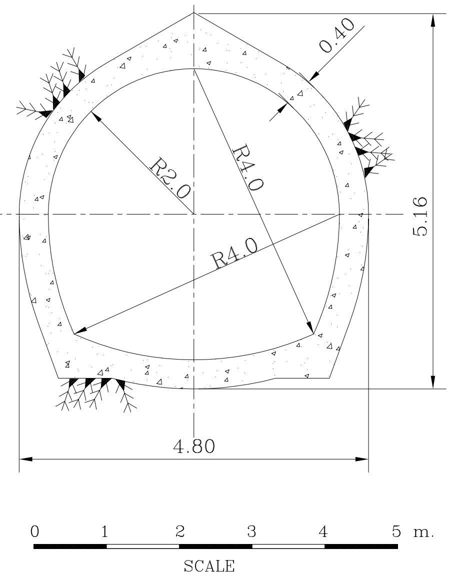
AREA-CAPACITY CURVE



TYPICAL CROSS SECTION OF DAM



UPSTREAM ELEVATION



TYPICAL SECTION OF HEADRACE TUNNEL

Notes:
1) Original design prepared by ARPL TECHNOLOGIA INDUSTRIAL S.A.
2) Crest Elevation(EL.3,007), FSL(EL.3,006), MOL(EL.2,870.5) for high dam are proposed by the JICA Study Team.

STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU	Figure 5.1.3 MORRO DE ARICA DAM (RCC DAM)
JAPAN INTERNATIONAL COOPERATION AGENCY	