FINAL REPORT

VOLUME III SUPPORTING REPORT

G. WATER RESOURCES DEVELOPMENT AND

RIVER MANAGEMENT

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

FINAL REPORT
VOLUME III
SUPPORTING REPORT

G: Water Resources Development Plan

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Chapter 1 Water Resources Development Plan

1.1 Principal Approaches of Water Resources Development

1.1.1 Development Scenario

The integrated water resources development master plan for the Cañete River basin covers multivarious sectoral development plans, domestic and industrial (D&I) water supply, irrigation, hydroelectric power and other water uses for both areas inside and outside the river basin. Water demand outside the Cañete River basin includes the D/I water conveyance to the south of Lima metropolitan area and the water diversion to the Concón-Topará irrigation project located south of the river basin.

The master plan will be formulated for three development scenarios.

Scenario-1 : First priority on the D/I water supply, in particular, high weight on the water conveyance to the south of Lima metropolitan area .

Scenario-2 : High weight on the irrigation (agriculture) development,

Scenario-3 : Equal weight on the D/I water supply and, the irrigation (agriculture) development.

Scenario-1 aims to achieve a policy to provide sufficient domestic and industrial water to the population in the Cañete River and the Lima metropolitan area for the national and regional social welfare and sanitation. Scenario-2 aims to achieve a policy to maximize the region's economic account by agricultural development and to increase job opportunity and per capita income for poverty alleviation in the Study area. Scenario-3 aims to achieve a policy to develop the water resources to the maximum extend in order to fulfil both requirements of Scenario-1 and Scenario-2.

In these scenarios hydroelectric power generation is treated as in-stream water use while D/I and irrigation water use is treated as consumptive water use.

1.1.2 Plan Formulation in PHASE I (M/P)

The foregoing scenarios have been being planned leading to the master plan with the overall workflow illustrated in Figure 1.1:

1. **Water Resources Potential Analysis;** is to gauge exploitable water sources consisting of surface water (river runoff) and groundwater. Groundwater is excluded from the succeeding quantitative analysis in this Study stage because reliable data were not available.

2. **Water Demand & Supply Balance Analysis;** is to estimate development requirement of water source. Alternative water resources development plans are formulated based on the results of water demand and supply

balance analysis, by taking into consideration development scenarios, potential storage dams, water demand projection (2030) and other constraints.

3. **Screening Criteria and Sectoral Development Plan Analysis;** is to establish bases to prepare implementation schedule of integrated water resources development projects, based on the above alternative development plans, taking into consideration assessment of sectoral development plans and screening criteria including policy of water uses, examination of cost & benefit and other relevant issues.

4. **Assessment of Water Resources Management;** is to assess overall aspects from implementation stage to O/M stage including initial environmental examination (IEE) for the Cañete River basin and surrounding influential areas, review of and recommendations on the current status of management and institutions for the development and management of the water resources.

As a conclusion of the Study, a list of alternatives for the feasibility study in PHASE II is prepared, and preferred options are delineated among alternatives.

1.2 Water Balance Analysis

1.2.1 Analysis Cases and Assumed Conditions

(1) Analysis Model

Water demand and supply balance analysis was done by the use of HEC-5 mathematical model (from Hydrology Engineering Center, USA). Simulation of the reservoir operation to fulfill the deficit (balance of demand and available discharge) and to determine the reservoir storage capacity of prospective dam projects was also performed by the use of HEC-5. The basin model for the water balance analysis and the reservoir operation are illustrated in Figure 1.2. The balance point was assumed at the Socsi station.

(2) Water Demand and Discharge Data

Present and future water demand for water supply and irrigation was estimated on monthly basis. Monthly discharge record at five stations (Tanta, Aguas Calientes, Tinto de Alis, Chavin, and Socsi) from January 1986 to December 1997 (12 years) were compiled from the daily discharge and were used for the natural inflow of the water demand and supply balance analysis. Missing data were interpolated from other stations based on a correlation analysis.

(3) Analysis Cases and Assumed Conditions

Water demand and supply balance were analyzed for the following conditions:

1) Without structural measures

Natural flow condition without flow regulation is assumed at the Socsi station. Present (1999) and future water demand (2030) were projected for two sectors, domestic and industrial water supply and irrigation for both inside and outside the Cañete Rive basin.

2) With structural measures

The same natural flow and future water demand were assumed, but flow regulation were provided by single operation or combined operation of prospective 4 reservoirs, Morro de Arica, Paucarcocha, Auco and San Jeronimo. The future water demand was adjusted with seasonal variation depending on case. The active storage capacity of the three reservoirs was changed from low dams to high dams depending on the quantity of water demand. Reservoir operation rule was also adjusted depending on case.

Assumed conditions for main cases of analysis are summarized below.

<u>Without Structural Measures</u>

Case 1: Present Condition

a) Discharge; natural condition
b) D/I Water Supply Demand; 1999 domestic water in Cañete River basin (CB)
c) Irrigation Water Demand; 1999 Cañete valley irrigation water (CV)

Case 2-5: Water Demand in 2030 Without Structural Measures (Dams)

a) Discharge; natural condition
b) D/I Water Supply Demand; combination of 2030 domestic water in Cañete River basin (CB = average 1.09 - 3.37 m^3/s) and Conveyance to Lima (L10 = average 10.0 m^3/s or L5 = average 5.0 m^3/s)
c) Irrigation Water Demand; combination of 2030 Cañete valley irrigation water (CV = average 10.79 m^3/s), 2030 irrigation water in Alto Imperial plain (CLC = average 0.96 m^3/s) and Concón-Topará irrigation water (CTP = average 11.14 m^3/s)
d) Minimum River Maintenance Flow; 4.3 m^3/s or 1.0 m^3/s

Cañete Valley: Valle de Cañete
Alto Imperial: Pampas Altas de Imperial
Concón-Topará: Pampas de Concón-Topará y Chincha Alta

<u>With Structural Measures</u>

Case W1-W12 and Other Cases: Water Demand in 2030 With Structural Measures (Dams)

a) Discharge; regulated by dams

b) D/I Water Supply Demand; combination of 2030 domestic water in Cañete River basin (CB = average 1.09 - 1.59 m^3/s and 3.37 m^3/s) and Conveyance to Lima (L10 = average 10.0 m^3/s or L5 = average 5.0 m^3/s)

c) Irrigation Water Demand; combination of 2030 Cañete valley irrigation water (CV = average 10.79 m^3/s), 2030 irrigation water in Alto Imperial plain (CLC = average 0.96 m^3/s) and Concón-Topará irrigation water (CTP = average 11.14 m^3/s)

The total annual average water demand varies from 21.17 m^3/s (667.7 MCM) to 35.8 m^3/s (1,129.9 MCM).

1.2.2 Alternative Dams

(1) Development Scale of Alternative Dams

High case and low case are planned for each of Morro de Arica dam, Auco dam, and San Jeronimo dam. Assumed full supply level and active storage volume is shown below. Single operation or multiple operation of the foregoing scales is considered as alternatives.

1) Morro de Arica dam (MDA) with FSL 2,987 m.a.s.l
(175 - 205 MCM depending on operation rule),

2) High Morro de Arica dam (H-MDA) with FSL 2,997 - 3,006 m.a.s.l (Active storage 210 - 245 MCM),

3) Paucarcocha dam (PC) with FSL 4,259 m.a.s.l (55 MCM)

4) Low Auco dam (L-AC) with FSL 2,100 m.a.s.l (167 MCM),

5) High Auco dam (H-AC) with FSL 2,113 - 2,150 m.a.s.l
(200 - 353 MCM),

6) Low San Jeronimo dam (SJ) with FSL 1,150 m.a.s.l (132 MCM),

7) High San Jeronimo dam (H-SJ) FSL 1,180 - 1,200 m.a.s.l
(200 - 360 MCM).

(2) Assumed Reservoir Operation

Outflow from the reservoirs is assumed to be the same as the water demand at Socsi station for the cases without suffix, such as Case W1 or W2.

Regulation Conditions for the cases with suffix “a” such as Case W1a or W2a, El Platanal Hydropower requirement is assumed to be a power plant factor of 60%.

1.2.3 Results of Water Balance Analysis

(1) Results of Analysis

The results of water demand and supply balance analysis are shown in Table 1.1 for the cases without structural measures, and Tables 1.1 and 1.2 for the cases with structural measures.

(2) Requirement of Reservoir Storage Capacity

1) Existing condition in 1999

At present water shortages have been experienced during drought years in particular in December1991- December1992 period mainly due to the existing irrigation water use. The amount of deficit is estimated at about 28 MCM in November-December 1992 period. (Refer to Case 1)

2) Deficit for the case, the Maximum Water Demand in 2030 Without Dams

If all the 2030 future water demand is withdrawn at or downstream of the Socsi Station of the Cañete River, the annual maximum deficit is estimated at about 455 MCM in April 1992-January 1993 period. The cumulative total deficit in July 1991-January1993 period is about 836 MCM. In short a regulation water volume of 836 MCM is required to fulfill all the water demand. The composition of the future water demand is 2030 CB, L10, CV, CLC and CTP. The total annual average water demand is 1,129.9 MCM (35.8 m^3/s). (Refer to Case 5)

<u>Scenario-1</u>

3) Assessment of dams for water conveyance to Lima

Either of Morro de Arica dam (MDA 205 MCM), High San Jeronimo dam (H-SJ 200 MCM) or High Auco dam (H-AC 200 MCM) is able to provide raw water supply to Lima 5 m^3/s. Paucarcocha dam (PC 55 MCM) is required in addition to High Morro de Arica dam (H-MDA 245 MCM) if water conveyance to Lima is increased to 10 m^3/s.

High San Jeronimo dam (H-SJ 250 MCM) or High Auco dam (H-AC 250 MCM) is also able to provide 10 m^3/s to Lima. However, combination of H-MDA (245MCM) and PC (55 MCM) is more efficient in terms of cost.

<u>Scenario-2</u>

4) Assessment of Morro de Arica dam and Concón-Topará irrigation project (El Platanal Project)

MDA (175 MCM) attains the lowest cost, but it does not fulfill the requirement of water demand.

Combination of H-MDA (245 MCM) and PC (55 MCM) fulfills the water demand, and it is also assessed to be most efficient in terms of cost among the following combination of dams:

1) Morro de Arica dam (MDA) with active storage 175 MCM only,
2) MDA (175 MCM) and Paucarcocha dam (PC; active storage 55 MCM),
3) High Morro de Arica dam (H-MDA; active storage 205 MCM) and PC (55 MCM),
4) High Morro de Arica dam (H-MDA; active storage 245 MCM) and PC (55 MCM).

Scenario-3

5) Maximum supply capacity of 3 potential dams

The maximum total 2030 water demand, 1,129.9 MCM (35.8 m^3/s) can not be supplied by even all three potential dams. The total active storage capacity of three dams is 660 MCM: i.e., Morro de Arica dam (245 MCM), High Auco dam (353 MCM), and Low San Jeronimo dam (132 MCM). (Refer to Case W1 and W2.)

The best combination of 2 dams is H-MDA (245 MCM) and H-SJ (300 MCM): i.e., total active storage of 545 MCM. This combination has a sufficient capacity for the total water demand of 1,049.3 MCM (monthly average 33.27 m^3/s) with a minor risk of failure (deficit 20 MCM for 2/12 and 1 MCM for 3/12) (Refer to Case 3.1.)

The most efficient combination in terms of cost is H-MDA (245 MCM) and PC (55 MCM).

6) Comparison of Auco dam and San Jeronimo dam

Efficiency of Auco dam and San Jeeronimo dam is almost equal if operated independently. However, San Jeronimo site is more efficient than Auco site if operated together with Morro de Arica because San Jeronimo site is able to regulate more runoff from the remaining catchment downstream of Morro de Arica.

(3) Drought Level

The largest deficit was identified in November 1992-January 1993 period in most cases during the 12-year simulation period. The second largest deficit was identified in 1987-1988 or 1990-1991 drought period. The 1992-1993 draught is evaluated as the most severe drought recorded during 66 years since 1926 in Toma Imperial- Socsi area. Drought level was approximately assessed by the frequency analysis as follows:

Drought Period	Approximate Recurrence Interval
1992-1993	1/66
1957-1958, 1990-1991	1/20 – 1/10
1987-1988	1/10 – 1/7
1976-1977, 1991-1992, 1995-1996	1/5

Note: The result is tentative and subject to further analysis, in PHASE II Study.

1.2.4 Alternative Water Resources Development Plans

(1) Alternative Scenarios

Alternative plans for water source facilities were formulated for the four scenarios established in Section 1.1. All scenarios provide the water demand inside the Cañete River basin first and conveyance of water toward users outside the basin is secondary. The demand inside the Cañete River basin includes the D/I water supply (CB), Cañete valley irrigation water (CV), irrigation water in Alto Imperial plain (CLC) and the minimum river maintenance flow (Mp or Mf). The demand outside the basin includes the Concón-Topará irrigation water (CTP or CTP5) and the water conveyance to Lima (L10 or L5).

Alternative dams are either of Paucarcocha dam (PC), Morro de Arica dam (original; MDA or High; H-MDA), Auco dam (High; H-AC or Low; L-AC) or San Jeronimo dam (High; H-SJ or Low; L-SJ) or combination of these depending on the quantity of water demand and deficit of water balance.

The results of water demand and supply balance (refer to Section 1.2) indicate that single operation of Morro de Arica dam, High Auco dam or High San Jeronimo dam, or combination of Morro de Arica dam and Paucarcocha dam is prospective for Scenario-1. Morro de Arica dam with Paucarcocha dam is prospective for Scenario-2. In short, El Platanal project composed of hydroelectric power generation and CTP irrigation is promising with some adjustment of irrigation area, active storage capacity, and reservoir operation rule. Combination of High Morro de Arica and High San Jeronimo is the possible maximum development scale that is technically justifiable. However it cannot fulfill totally all the requirement of Scenario-3 due to shortage and seasonal fluctuation of the annual runoff of the Cañete River basin.

(2) Guarantee Level

Requirement of reliability to supply water varies in different water sectors. A rule generally accepted in Peru is summarized as follows:

Sector	Guarantee Level/ Reliability (%) or Return Period
Hydroelectric power	95% or once in 20 years
D/I Water Supply	90% or once in 10 years
Irrigation	80-90% or 1 in 5 years – once in 10 years

The same guarantee level of 90% (1/10) or 80% (1/5) is applied to alternative study depending on the sectoral water requirement.

(3) Minimum River Maintenance Flow

Provision of the minimum river maintenance flow (Mp = 1.03 m^3/s or Mf = 4.3 m^3/s) is treated as one of the water demand alternatives.

(4) Alternative Cases for Scenarios

Scenario-1 refers to the D/I water supply sectoral plan (Section 1.3.2), while Scenario-2 refers to the agricultural development sectoral plan (Section 1.3.3). Scenario-3 refers to both requirement of the D/I water supply and the agricultural development. Hydroelectric power development sectoral plan (Section 1.3.4) is also considered in these scenarios.

Project component of alternative scenarios, such as cases, water demand sector, combination of dams, hydropower stations are summarized in Table 1.3.

Project system diagrams are illustrated in Figure 1.3 for Scenario-1 (Case 1.1), Figure 1.4 for Scenario-2 (Case 2.1), Figure 1.5 for Case 3.1 of Scenario-3 and Figure 1.6 for Case 3.3 of Scenario-3.

Integrated water resources development plan is descried in Chapter 2 as a tandem of the selected water resources development plan (D/I water supply, Irrigation and Hydroelectric power) and water resources management plan.

(5) Water Utilization Ratio

The water utilization ratio, which is a ratio of the mean annual water demand to the mean annual runoff, will dramatically increase from 27.3% in 1999 (existing condition) to the maximum of 75.8% in the Cañete River basin depending on the alternative cases:

Annual mean	MCM/year	Water utilization ratio %
Runoff	1,385	-
1) 1999 Water Demand	378.5	27.3
2) Case 1.1 water demand	667.7	48.2
3) Case 2.1 water demand	861.4	62.2
3) Case 3.1 water demand	1,049.3	75.8
4) Case 3.3 water demand	915.1	66.1

The water resources development ratio, which is a ratio of total active storage capacity of dams to the mean annual runoff, will also increases from null in 1999 to the maximum of 37.9 depending on alternative cases:

Annual mean	Active storage (MCM)	Development ratio %
Runoff	1,385	-
1) 1999	0	0
2) Case 1.1 MDA	205	14.8
3) Case 2.1 MDA + PC	300	21.7
3) Case 3.1 H-MDA	525	37.9
4) Case 3.3 H-MDA + H-SJ	300 (+ groundwater 94.6)	21.7 (+ 6.8)

1.3 Water Resources Sectoral Development Plan

1.3.1 Screening Criteria

The Study Team proposes the screening criteria as set out below for the master plan formulation and selection of priority projects for the feasibility study. The criteria deal with legal priority of water use (including water right), national and regional policy, cost and benefit, clearance of EIA and policy of sustainable development.

(1) Legal Priority of Water Use

The first regional priority is given to the water uses inside the Cañete River basin: districts in Yauyos Province (2-34) and Cañete Province (35-43) (refer to Figure 1.1 (1/2) Provincial Map per District of Supporting Report F). Among the areas outside the Cañete River basin the highest priority is given to the southern part of Lima Metropolitan area. Legal priority of water use sector is No. 1 domestic water supply (portable water), No. 2 animal breeding and livestock, No. 3 agriculture (irrigation), No. 4 hydroelectric power and industrial water supply including mining, No. 5 others (navigation, tourism, etc.) (Refer to General Water Law 1969). Concept of the minimum river maintenance flow is introduced for (5) sustainable development of the region (refer to Sustainable Development at the end of this Section). Regional and sector priority is assumed as follows:

Priority	Region	Water Use Sector
1	Inside the Cañete River basin	Minimum river maintenance flow
2		Domestic water supply (portable water) Ref-1
3		Animal breeding and livestock
4		Agriculture (Irrigation)
5		Hydro-electric power, industry and mining
6		Others (navigation, tourism)
7	Outside the Cañete River basin	Domestic water supply
8		Animal breeding and livestock
9		Agriculture (Irrigation)
10		Hydro-electric power, industry and mining
11		Others (navigation, tourism)

Ref-1: Article 27, Chapter 1 General Provisions, Title III As for the Water Uses, General Water Law 1969

The existing water right prevails over any water concession not approved by the authority concerned regardless the regional and sectoral priority.

(2) National and Regional Policy

National and regional development and conservation policy with respect to problems, needs and urgency shall be concretely clarified.

(3) Cost and Benefit

1) In the maser plan study initial screening of potential projects is to be done by comparison of direct construction cost (base cost).
2) Any selected project shall be economically and financially justifiable.
3) Higher IRR and net benefit has higher priority.
4) The minimum IRR and the discount rate adopted (12%) is described in Supporting Report J.

(4) Clearance of EIA

1) Natural and social environmental impacts and or constraints shall be clarified at least.
2) IEE (Initial Environmental Examination) criteria shall be applied.

(5) Policy of Sustainable Development

Policy of sustainable development of water resources shall be applied.

Provision of the minimum river maintenance flow is recommended with the following schedule:

1) The minimum river maintenance flow is assumed at 1.0 m^3/s at the river mouth of the Cañete River: i.e., it is treated as the existing condition in1999 in the Study.

2) Any new water resources development shall guarantee the essential river maintenance flow and existing riparian water uses and water right downstream of the project site, in particular water conveyance to anywhere outside the Cañete River basin after the year 2000.

   The essential river maintenance flow is required to sustain the ecology of the river basin.

   Amount of the essential river maintenance flow (Mf) shall be at least the smallest 362-day draught discharge (99% daily mean discharge, Q99) of the latest 10-year discharge record. For example it is about 4.3 m3/s at the Socsi station (5,890 km2).

   According to the river law (1997) and the technical standard (1997) in Japan, requirement of the minimum river maintenance flow is the smallest 355-day draught discharge (97% daily discharge, Q97) of the latest 10-year discharge record (or the 3rd of 30-year record). It is about 5.2 m^3/s at the Socsi station.

   The minimum river maintenance flow during the high flow season (4 months; December – March) will be also required for the tourism (boat) in Lunahuana area. It is reported at 30 m3/s by the resident concerned. It corresponds to 26% daily mean discharge or 92% monthly mean discharge at Socsi. The daily mean discharge at Socsi station is as follows:

Duration in %	Duration in Days	Discharge m^3/s	
		Daily Mean	Monthly Mean, Ref-2
10	37	137.9	6
25	92	55.5	9
50	183	17.5	1
75	274	10.5	1
90	329	8.5	3

Notes: Ref-2 = Page 34, Section II.2.3, Informe General, Estidio de Prefactibilidad de la Cuenca del Rio Cañete para Fines de Abastecimiento de Agua para Cuidad de Lima, SEDAPAL, Junio de 1995. The daily mean discharge is obtained from the daily discharge duration curve of Socsi station in 1986-1997 period.

1.3.2 Domestic and Industrial (D/I) Water Supply Sectoral Plan

In order to formulate D/I Water Supply Sectoral Plan service area has been divided as follows:

- Inside the Cañete River basin which includes districts in Yauyos Province (2-6, 12-14, 20-34), Cañete Province (35-43) and Huarochiri Province (1) (refer to Figure 1.1 (1/2)).

- Outside the Cañete River basin which includes water conveyance to the South of Lima composed by districts in Lima Province (51-60), Cañete Province (44-50) and Chincha Province (68) (refer to Figure 1.1 (1/2, 2/2)).

(1) Water Supply Projects

Based on the water conveyance system (5 m^3/s of raw water to Lima South Cone), present situation of water supply systems in the service area and topographic conditions, water supply projects are proposed region by region as summarized in the table below (see Figure 1.7).

Proposed Water Supply Regional Project

W/S System	Av. Daily Water Demand (m^3/s)	Max. Daily Water Demand (m^3/s)	Water Treatment Plant Capacity (m^3/s)
Lima South Cone	5.00	5.75	6.04
Chilca-Asia	0.48	0.55	0.58
Quilmana	0.10	0.11	0.12
Imperial-San Vicente	0.77	0.88	0.92
Pampas Concón-Topará	0.15	0.17	0.18
Upper and Middle Cañete River Basin	0.07	0.08	0.08
Total	6.57	7.54	7.92

Note: In above table Average Daily Water Demand as year 2030

- Lima South Cone Water Supply Regional Project includes the following districts: Pucusana, Santa Maria, San Bartolo, Punta Negra, Punta Hermosa, Lurin, Pachacamac, Villa Maria del Triunfo, Villa El Salvador and San Juan de Miraflores. A water treatment plant will be located at Flor de Nieve site at elevation 200 m.a.s.l. Service population in the planning horizon of 2030 is 1,747,327.
- Chilca-Asia Water Supply Regional Project includes the following districts: Chilca, Santa Cruz de Flores, San Antonio, Mala and Asia. A water treatment plant will be located at Mala. Population to be served in the planning horizon of 2030 is 117,688.
- Quilmana Water Supply Project for Quilmana district. A water treatment plant will be located at Quilmana. Service population in the planning horizon of 2030 is 30,726.
- Imperial-San Vicente Water Supply Regional Project includes the following districts: San Vicente de Cañete, Nuevo Imperial, Imperial, San Luis and Cerro Azul. A water treatment plant will be located close to the Nuevo Imperial Intake at Socsi. Service population in the planning horizon of 2030 is 186,061.
- Pampas Concón-Topará Water Supply Project includes the following districts: San Vicente de Cañete y Grocio Prado. A water treatment plant

will be located in between Palo and Quebrada Topara. Service population in the horizon of 2030 is 34,748.

- Upper and Middle Cañete River Basin Water Supply Project includes the small individual water supply projects. Among them the more important is existing one at Lunahuana. Service population in the planning horizon of 2030 is 36,175.

(2) Expansion Plan

1) Water supply expansion plan excluding Lima South Cone

These are small systems at present which have groundwater as a main water source. The basic proposal is that such water supply systems be independent on the Cañete River water conveyance to Lima South Cone. Regional authorities have their own improvement and rehabilitation programs which principally plans to expand water supply systems step by step to meet with the growth of the demand. In other words, once water demand exceeds available water source, then expansion is made.

Tentative expansion plan is shown below:

Expansion Plan (tentative)

Project	Operation Year	Water Source	W. T. Plant Capacity (m^3/s) Stage I	W. T. Plant Capacity (m^3/s) Stage II
Chilca-Asia	2021 2026	Cañete / Groundwater	0.25	0.50
Quilmana	2021 2026	Cañete / Groundwater	0.06	0.10
Imperial-S. Vicente	2021 2026	Cañete / Groundwater	0.50	0.80
Pampas Concón-Topará	2021 2026	Cañete / Groundwater	0.10	0.15
Upper & Middle Cañete Basin	2021 2026	Cañete / Groundwater	0.04	0.08

(3) Water Supply to Lima South Cone (Cañete Scheme vs. Mantaro-Carispaccha Scheme)

<u>SEDAPAL Master Plan</u>

1) Background

As the main result of SEDAPAL M/P, four (4) alternatives (1, 1a, 2 and 3) were considered and evaluated in order to meet water demand of Lima & Callao metropolitan area up to year 2030, in which Alternative 1a (Cañete) and 2 (Mantaro-Carispaccha) are assumed to convey 5 m^3/s.

Alternatives 1a and 2 have common project components to be implemented up to 2030, if Mantaro-Carispaccha and Cañete projects are excluded. Figures 1.8 and 1.9 show above two alternatives.

2) Balance between demand and supply up to year 2030

Relationships between water demand, water source and plant treatment capacity are shown in Tables 6.1 and 6.2 in Supporting Report F for low water period (Winter) as foreseen by SEDAPAL M/P.

Water availability during the low water period are summarized below for both alternative 1a and 2.

<u>Existing water source</u>

	Alternative 1a (Cañete)	Alternative 2 (Mantaro-Carispaccha)
Rimac River:	13.01 m^3/s	13.01 m^3/s
Yuracmayo reservoir	1.78	1.78
Lurín River:	0.08	0.08
Wells:	7.86	7.86(*)
Total:	22.73 m^3/s	22.73 m^3/s

<u>Future water source</u>

Year Schedule	Water Source	Discharge (m^3/s)	
		Alternative 1a	**Alternative 2**
2000	Marca III	3.0 m^3/s	3.0 m^3/s
2002	Chillon River Development (Under tendering for BOT)(**)	0.71 m^3/s	0.71 m^3/s
2003	Lurin New Wells	0.3 m^3/s	0.3 m^3/s
2003 – 2004	Marca II	6.5 m^3/s	6.5 m^3/s
2011 / 2014	Huascacocha	2.5 m^3/s	2.5 m^3/s
2022 / 2026	Mantaro (Carispaccha)	-----	2.94/5.00m^3/s
2022 / 2026	Cañete	2.5/5.0 m^3/s	----

Water sources up to year 2021 are same in both alternatives, new water of 5 m^3/s will be required from the Alternative 1a or 2.

3) Water production up to year 2021

Table 6.3 in Supporting Report F presents the capacities of water sources for both alternatives (Alternative 2 and 1a) categorized into river basin and status of implementation.

Table 6.4 in Supporting Report F presents the capacities of water treatments plants to be completed by year 2005.

Table 6.5 in Supporting Report F presents water demand prediction up to year 2030 prepared by use of the data in the SEDAPAL M/P.

By comparing above tables, it is said that water demand will be satisfied until year 2015 by either alternative water source development plan, but

(*) Maximum annual exploitable production.
(**) Chillón River: 0.5 – 1.9m^3/s
Jacaybamba Reservoir: 1.2 – 0.1 m^3/s
Wells: 0.3 – 0 m^3/s

La Atarjea (***) water treatment plant should be in operation with full design capacity up to 20 m^3/s.

Figure 1.10 shows water demand and supply balance for the period 1998 – 2030 taking into consideration ongoing projects.

4) Preliminary assessment of water sources development alternatives.

The economic evaluation at net present value which includes total investment cost as well as operation and maintenance costs shows that Alternative 2 is more recommendable than alternative 1a. Cost of surface water development, raw water conveyance, water treatment plant, conveyance of drinking water, reservoirs, main and secondary distribution network pipes and domiciliary connections, are included within the total investment cost. The marginal cost also named "incremental cost" which is the average cost of one cubic meter of drinking water was calculated as US\$0.52/m^3 for Alternative 1a and US\$ 0.50/m^3 for Alternative 2.

Taking further into consideration technical, environmental and social aspects, the Master Plan concludes that Alternative 2 is the one which has minimum implementation cost and less negative environmental impact and consequently recommended for implementation. (see Table 1.4).

<u>Current status of implementation</u>

5) Tentative list of alternative water source development plan after year 2015

SEDAPAL is speeding up the project implementation. For example, MARCA III project to convey 3.1 m^3/s to the Rimac River was commissioned on October 1999, and the construction of Huachipa Water Treatment Plant Stage I (Q=5 m^3/s) as well as Ramal Norte Conveyance (Q=5 m^3/s, D = 1.6 m) and part of Ramal Sur Conveyance (Q=5 m^3/s, D = 1.8 m), (see Figure 1.11), have been scheduled to start in year 2001 and to be commissioned in year 2005. This project has been committed for loan by OECF. Also Chillón River Development project is at present under BOT procedure. Refering to such accelerated situation a new demand supply balance is worked out as in Table 1.5 and Figure 1.12, which aims to define alternatives to meet and cope with increasing water demand.

In conclusion it can be stated that Huascacocha Project (Q=2.5 m^3/s) should be under operation in year 2016, either Mantaro or Cañete Project (Q=2.5 m^3/s) in year 2021 and year 2026, besides there is another

(***) La Atarjea is the SEDAPAL water treatment plant with current water production of 15.72 m^3/s

alternative that either Mantaro or Cañete for a discharge of 5 m^3/s in year 2021 should be in operation. Table below shows the summary.

Alternative	Operation Year	Surface Water Source		Water Production Capacity	
		Source	Q (m^3/s)	Water Treatment Plant	Q (m^3/s)
2[a]	2016	Huascacocha	2.50	Chillón Stage II	2.50
	2021	Mantaro-Carispaccha	5.00	Huachipa Stage II	5.00
2a.1	2016	Huascacocha	2.50	Chillon Stage II	2.50
	2021	Mantaro-Carispaccha	2.50	Huachipa Stage II	7.50(*)
	2026	Mantaro-Carispaccha	2.50	Huachipa Stage III	10.00
1a.1	2016	Huascacocha	2.50	Chillón Stage II	2.50
	2021	Cañete	5.00	Flor de Nieve	5.00
1a.2	2016	Huascacocha	2.50	Chillón Stage II	2.50
	2021	Cañete	2.50	Flor de Nieve Stage I	2.50
	2026	Cañete	2.50	Flor de Nieve Stage II	5.00

Comments by JICA Study team to the SEDAPAL M/P

6) Development of surface water source

Regarding Mantaro–Carispaccha water transfer project, SEDAPAL M/P did not assessed following fundamental issues:

- The reliability of the annual mean discharge (5 m^3/s) to be diverted from Mantaro upper catchment area to Marcapomacocha reservoir.
- How Marca III water transfer project already commissioned affects the above annual mean discharge to be diverted from Mantaro - Carispaccha. Current water diversion from Corsucancha River is 0.65 m^3/s and from Casacancha River is 1.35 m^3/s and both of them belong to Marca III scheme as well as to Mantaro- Carispaccha water transfer project.
- How Mantaro-Carispaccha water transfer will affect the potential for generating electricity on Mantaro Hydropower Station (under operation). Gain /Loss balance among increase electricity generation on Rimac River, decrease electricity generation on Mantaro River and energy required for pumping up from Carispaccha reservoir to Marcapomacocha reservoir has to be carried out.
- Losses between upper part of Rimac River and La Atarjea Water Treatment Plant Intake has been considered by SEDAPAL M/P to be 5%, however measurements of discharge conducted by SEDAPAL

(*) Stage I for 5m^3/s is scheduled to be commissioned in 2005 having as surface water source Marca III and Marca II Projects.

itself lead to assess that losses are in the range of 25%, if this fact is confirmed then shortage of raw water will take place in the future.

- SEDAPAL M/P did not considered relocation of Marcapomacocha village with a population of 1,756 in 1981 and 1,301 in 1993 which is required for construction of Marcapomacocha new dam. This relocation constitute a big negative environmental issue
- Rimac River is very contaminated due to heavy metals, intensive agriculture development and sewerage outflow, then in some extend fresh water from Rimac River basin is required as agent diluent. This fresh water to be used as diluent instead to use it as source of drinking water has to be replaced for another surface source and Cañete River is an alternative for this purpose.

7) Development of groundwater source

- Lurin new wells (0.30 m^3/s) to be developed in 2002 for Lima South Cone are not reliable from view point of water quality besides nearby in Punta Hermosa salt water has contaminated the aquifer.
- There are evidences that Lima aquifer due to overdraft salt water has moved inland and contaminated it.
- Then as a general policy is better to think in develop surface water rather than groundwater. Under this circumstances Cañete River is an alternative for Lima South Cone.

8) Water demand and water production

- Both water demand and water production have been well assessed however uncertainty remains regarding reduction in consumption due to introduction of water meters. Experience in other countries shows that reduction in consumption following the implementation of meters is usually only temporary.

<u>Recommendation</u>

As discussed above, estimates of available water in the SEDAPAL M/P, in particular along the Rimac River and comparison results between the Cañete and Mantaro-Carispaccha schemes may have some uncertainty. If amount of water is less than that expected in the M/P by 5 m^3/s, input of new water (by Mantaro-Carispaccha or Cañete) would be required in around 2010, rather early time ahead to the timing planned in the M/P (2022). Further, the Cañete scheme may have cost advantage compared with the Mantaro-Carispaccha scheme, depending on dam cost allocation among multipurpose sectors as presented in Section 5.2. It is therefore recommended to carry out feasibility study of the Cañete water conveyance plan in PHASE II.

1.3.3 Agricultural Development Sectoral Plan

(1) Agricultural Development Plan

The study on agricultural development plan was conducted by INADE. In the process of crop selection and formulation of cropping patterns, the physical conditions of the Study area, the general crop selection criteria and the current policies are carefully considered under the following concepts and conditions (Source: Hidrologia Valle de Cañete, INADE, June 1990).

a) Adaptability of the crop to soil and agro-climatic conditions of the area and its ability to perform optimally under irrigation.
b) Expected level of technology and the experience of the farmers.
c) Practically in terms of the available labor force.
d) Market potential and price prospect for the agricultural products.
e) Optimization of the use of the supplied water resource.
f) Generation of the maximum benefits to the farmers, to the region and country as a whole.

The proposed cropping pattern, developed after due consideration of the matters stated above, is summarized below and presented in Tables 4.3 (1) to (3) in Supporting Report D.

Cropping pattern in the Valle de Cañete

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	10,726	-	10,726
Starchy maize and potato	2,745	1,373	4,118
Yellow maize (feed) and starchy maize	1,965	1,965	3,930
Yellow maize (feed)	1,965	1,965	1,965
Cotton (in the submerged area)	1,811	-	1,811
Horticulture	868	868	868
Citrus	819	819	819
Orchard (apple, grape, etc.)	1,710	1,710	1,710
Pasture (alfalfa, etc.)	667	667	667
Starchy maize	776	-	776
Total	24,052	9,367	27,390

Cropping pattern in the Pampas de Concón-Topará y Chincha Alta

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	5,400	-	5,400
Starchy maize and potato	3,510	3,510	7,020
Yellow maize (feed) and potato	2,700	2,700	5,400
Horticulture and potato	2,700	2,700	5,400
Citrus	540	540	540
Horticulture	2,700	2,700	2,700
Orchard (apple, grape, etc.)	2,700	2,700	2,700
Pasture (alfalfa, etc.)	6,750	6,750	6,750
Total	27,000	21,600	35,910

Cropping pattern in the Pampas Altas de Imperial

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	300	-	300
Starchy maize and sweet potato	280	280	560
Horticulture and sweet potato	320	320	640
Orchard (citrus, apple, etc.)	210	210	210
Forest	1,365	1,365	1,365
Total	2,475	2,175	3,075

(2) Irrigation Development Plan

1) Valle de Cañete (see location in Figure 1.13)

As discussed in Supporting Report D, a considerable loss of water is observed due to the deteriorated intake structures and canals. To cope with this situation, the OECF (now JBIC) of Japan and the World Bank financed for the rehabilitation and improvement of the existing agricultural lands in Peru in 1986 and a budget has been allocated for the four sub-projects of (i) Nuevo Imperial, (ii) Viejo Imperial, (iii) Palo Herbay, (iv) Maria Angola y San Miguel, which consist of construction/improvement of intake structures, main and lateral canals, water distribution structures as well as installation of water measuring devices.

In order to control fluctuating river discharge to meet the seasonal agricultural water demand and to maximize irrigation efficiency (furrow irrigation should be practiced only daytime), it is indispensable to regulate water by impounding it in reservoirs and/or in farm ponds. In the Valle de Cañete, there are several natural lagoons. At least, it is possible to store water with a volume of 42.6 MCM by creating reservoirs by means of damming up water in the three lagoons of Paucarcocha, Piscococha and Pariachata.

Development of drainage system is essential in the Valle de Cañete, because it is observed that consecutive loss of land is progressing due to inundation and/or salinization, which have been caused by over-irrigation with saline water and little rainfalls. The depth of drains for desalinization should be more than 2 m with an interval of less than 100 m. The total length of the drains to be constructed is estimated at 78.9 km. It is a common practice to use pumps to drain such water thus collected.

2) Pampas de Concón-Topará y Chincha Alta (see location in Figure 1.13)

It is possible to develop the lower basins at the left bank of the Cañete River and at the right bank of the Quebrada Topará as an irrigated agricultural land using the river water of the Cañete River. The intake structure may be located at about 10 km upstream of Luahuana. For the maximum conveyance efficiency, the main canal with a length of 58.38 km will consist of reinforced concrete channel and tunnel, aqueduct, box culvert, etc. The secondary and tertiary distribution networks may require another approx. 360 km of either concrete lined channels or pressure vessels (pipelines).

Mechanical water saving irrigation is proposed to be practiced from the main and the secondary canals. In this regard, electric pumping stations will be installed at the canals so as to boost water to the pipelines, which will be connected to irrigation equipment such as sprinkler and drip. Furthermore, in order to raise application efficiency, land grading will be performed where the topography is undulating.

In view of the existing poor soil condition and little vegetation in the area, it is proposed to improve the soil and to plant trees for protection against the wind under the project. Farm roads will be constructed for the transportation of farming inputs and outputs. For the proper management of the irrigation system, some offices will be build in the area. Any transportation and office equipment necessary for the operation and maintenance of the facilities will be purchased under the project.

However, it should be noted that the preparation of the drainage system will be postponed to the next stage.

3) Pampas Altas de Imperial

According to the alternative study on the D/I water conveyance route to the Lima metropolitan area between the mountain side and the sea side, the former alternative has been selected (see Supporting Report D). In this case, it is possible to irrigate 2,475 ha of lands by means of gravity from the said D/I water conveyance canals at the point at 48 km from the intake (Zuñiga), where outlet facilities are to be installed. A concrete regulating pond with a capacity of approx. 200 m^3 will be constructed to receive the water released from the outlet of the canals. The total length of the main and lateral canals lined with concrete will be approx. 56 km, and the length of irrigation ditches will be 150 km. In order to cope with the seasonal agricultural water demand and to maximize efficiency of furrow irrigation, which is practiced only daytime, it is proposed to construct a regulating reservoir with a capacity of 8.3 MCM by means of damming up water in Mollococha lagoon. It is noted, however, no development of drainage system is proposed at this stage.

1.3.4 Hydroelectric Power Sectoral Plan

(1) Background

Several studies were carried out on Cañete river basin aimed at regulation and development of water resources including hydroelectric power development. Among those important ones are the following:

- In year 1955, La Panadile Peruana S.A., ordered by Compañía Peruana de Irrigación, made a study on evaluation of several alternatives for seasonal regulation and/or water transfer from Mantaro river basin in order that the agricultural demands of Cañete Valley and requirements for extension of agricultural frontier in Concón-Topará pampas were met.
- In year 1956, Electricité de France as part of the National Electrification Plan in Cañete river basin identified and recommended the development and equipping of El Platanal Hydropower Station, including schemes of daily and seasonal regulation.
- In year 1966, Motor Columbus made the study “Hydropower Development in Cañete River Valley” ordered by Empresas Eléctricas Asociadas. Integrated development of hydropower resources in the basin were put forward in such study, based on two hydropower schemes (Yauyos and El Platanal Hydropower Stations) and regulation works in lakes located at the upper part of basin and water transfer works in lakes located in Mantaro River basin.
- In year 1978, Lahmeyer Salzgitter Consortium, as part of Evaluation of National Hydropower Potential studied hydropower potential of Cañete River basin and evaluated several alternatives of hydropower development made up groups of stations in cascade.
- In years 1985-1986, the association of Motor Columbus, ElectroWatt, Cesel, MotLima and Ipesa, ordered by Electroperú S.A. carried out the feasibility study of El Platanal Hydropower Station, taking into account seasonal regulation of lakes located in upper part of Cañete River basin.
- In year 1995, CyA Consultores SRL, ordered by SEDAPAL made the “Feasibility Study of Cañete River basin for Water Supply to Lima city” where diversion of water in excess to Lima city after being met requirements of agricultural and local urban uses was proposed, considering facilities plan of El Platanal Hydropower Station.
- Finally Cementos Lima within the framework of Electrical Concession law has been developing in last years the integrated project in Cañete River

basin “El Platanal Hydropower Station and Irrigation of Uncultivated Lands Concón-Topará” which includes two seasonal regulation dams, two hydropower stations and impounding works and diversion of waters to Concón-Topará pampas.

(2) Hydropower Potential in the Basin

Cañete River has rather high potential of hydropower, indicating specific hydropower capacity at a value of 3,42 MW/km, which is one of the highest among those in the Pacific watershed in Peru, as shown in Table 1.6.

Stretches of specific hydropower potential capacity higher than 10 MW/km are located between the elevation 2,650 and 825 masl, as shown in Table 1.7

Small scale hydropower development with use of water head at rapid is possible in many places along the mid-stream.

Large scale development is depicted on Figure 1.14.

1) El Platanal hydropower scheme is being promoted by Cementos Lima and deemed to be the best development, comprising two storage dams (Paucarcocha and Morro de Arica) with 50 MW power capacity attached to the Morro de Arica dam and 220 MW run-off-river type power station in the downstream reach (intake dam at Capillucas and power station at El Platanal), utilizing a 600 m high head yielded by river bent and a steep slope of river stretch.

2) If storage dam is constructed at Auco and/or San Jeronimo for the purpose to regulate runoff for D/I water and irrigation uses, power station would be able to be attached to the dam, with capacity of about 50 MW. Another possible power development is assumed at Paruco located between Morro de Arica and Auco dam, which would yield power of about 50 MW.

(3) Evaluation of El Platanal Hydropower Project

The most promising El Platanal hydropower project was evaluated within the framework of the SIN (National Interconnected System).

The Project is being promoted by Cementos Lima with main features as listed below:

- Total installed power : 270 MW (Morro de Arica 50 MW plus El Platanal 220 MW)
- Total peak power : 270 MW
- Energy in the System (Hydrology - Average Year) : 1,502 GWh

- Energy in system
  (Hydrology - Dry Year) : 821 GWh
- Construction years : 4
- Start-up year
  (with the minimum lead time): 2004

Evaluation was made with adoption of a model of economical dispatching program (PDE). Assumptions and procedure are as explained below:

- Year 2001 is assumed to be the initial year for technical-economical analysis
- Two alternatives for expansion plan of the SIN are prepared; they are "WITH Project", and "WITHOUT Project", either of which makes a supply-demand balance of the system with similar reserve margins (see Table 8 in Supporting Report E).
- Demand data, existing hydropower and thermal station data, investment data and date of starting-up of new power stations of each alternative of expansion plan are entered.
- Flows of operation expenditures are determined for the following cases:
  - Expansion plan WITHOUT project in case hydrocondition of average year (probability of 85%)
  - Expansion plan WITH project in case hydrocondition of average year
  - Expansion Plan WITHOUT project in case hydrocondition of dry year (probability of 15%)
  - Expansion Plan WITH project in case hydrocondition of dry year
- Present Net Value as of 2001 of investment costs and costs of operation and maintenance for different discount rates are calculated. Assuming the cost of the WITHOUT project as benefit and the cost of WITH project as cost, economic indicators are calculated as shown on Table 11 in Supporting Report E. Economic internal rate of return (EIRR) is estimated at 16% and net benefit is valued at 73 million US dollars, therefore the project is deemed economically feasible.

1.4 Implementation Schedule of Water Resources Development Projects

Alternative seven cases are selected for water resources development scenarios of the Cañete River based on the results of water demand supply balance analysis in the foregoing Section 1.2.4. See description of alternative cases in Table 1.3 and its system diagram in Figures 1.3 – 1.6. 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 Supporting

Report J. 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). An implementation schedule of the option is shown in Figure 1.15.

(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 about 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. Feasibility study of the project is to be carried out in 2000. Five years between 2006 and 2010 are assumed for implementation (design and construction) of the other works for starting operation in 2011. As discussed in Section 4.3.2, SEDAPAL M/P for D/I water supply to Lima region assumes operation commencement to be in 2022. This commencement time, however, may be required to be put ahead, depending on the actual condition of water source to Lima, to the year of 2011 in case of 5 m^3/s deficit. An assessment of the Lima water source is proposed in the coming feasibility study as explained in Section 9.3, which would contribute to better scheduling of the implementation.

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 1.5). Current demand is supplied by groundwater with wells. Supply to the additional demand is assumed to be surface water, since groundwater potential has 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. Commencement time of the additional water supply is assumed in 2021/2026, however, expansion of supply system may be carried out step by step to meet with actual demand growth since the amount is relatively small, as discussed in Section 1.3.2.

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 1.6). Agricultural development (construction of primary irrigation system) is being promoted by the private firm, Cementos Lima. It is herein assumed that the start of operation to be in 2005 as same as the start time of the primary irrigation system, however, water demand will depend on the progress of the farmland development.

(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 1.2.6). Rehabilitation and improvement of the irrigation facilities are going on with a co-finance by OECF (JBIC) and World Bank (see Section 1.3.2). 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 of Concón-Topará, by providing 11.1 m^3/s irrigation water from Cañete River (see Figure 1.6). This is to enjoy an integrated effect of the hydropower development, which is to construct relatively large storage dams for the natural runoff regulation, thus yielding new firm water. Implementation is planned to go with the hydropower development, to be ready for irrigation in 2004. It is deemed to be the earliest case with the minimum lead time for license, finance, design and construction. Therefore the start of operation is herein assumed to be in 2005.

(3) Hydropower

1) Morro de Arica

Two storage dams, Paucarcocha and Morro de Arica, are to be implemented for 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 1.2.6). 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 2004. It is deemed to be the earliest case with the minimum lead time for license, finance, design and construction. Therefore the start of operation is herein assumed to be in 2005.

2) El Platanal

In the downstream of the above dams, located is El Platanal power plant which is composed of an intake dam at Capillucas, a headrace tunnel and 220 a MW power station. Implementation of the power plant is integrated with the above Morro de Arica scheme for the start of operation in 2005.

- It is noted that implementation of the following projects will be supplemented, if the development Scenario-3, Case 3.1 is adopted:
- Alto de Imperial for agriculture; feasibility study in 2002, followed by implementation in 2003/2004, for the start of operation in 2005.
- San Jeronimo dam for multi-purpose; feasibility study in 2004/2005, followed by implementation in 2006/2010, for the start of operation in 2011.

Chapter 2 Water Resources Management

2.1 Integrated Management of Water Resources

2.1.1 Concept of Integrated Management

The holistic management of freshwater as a finite and vulnerable resources, and the integration of sectoral water plans and programs within the framework of national economic and social policy, is an importance action to achieve the objective of the sustainable development of water resources defined in Section 2.3 of the Inception Report (April 1999).

Integrated water resources management, including the integration of land -and water - related aspects, should be carried out at the level of the catchment basin or sub-basin. Four principal objectives should be pursued, as follows:

1) To promote a dynamic, interactive, interactive multisectoral approach to water resources management,
2) To plan for the sustainable and rational utilization, protection, conservation and management of water resources,
3) To design, implement and evaluate projects and programs that are both economically efficient and socially appropriate within clearly defined strategies,
4) To identify and strengthen or develop, as required, appropriate institutional, legal and financial mechanisms to ensure that water policy and its implementation are a catalyst for sustainable social progress and economic growth.

2.1.2 Scope of Study

The study deals with the following management items as a part of integrated management of water resources:

1) Watershed management with respect to protection against natural disasters, in particular, flood, debris flow, and sediment control,
2) Flood control in the flood prone areas,
3) Water use management with respect to superintendency of multisectoral water use including legal and institutional arrangement,
4) Environmental conservation, in particular, maintenance of healthy quantity and quality of water for the riparians and ecosystem,
5) Monitoring system.

2.2 Watershed Management and Flood Control

2.2.1 Watershed Management

(1) Conditions of Watershed and Natural Disaster

The Cañete River basin is covered by little vegetation from downstream to upstream except the delta and alluvial plain areas in the downstream where subsurface and groundwater are prevailing. Small strips of vegetation coverage are scattered inside the river regime only. It owes to little rainfall in the middle and lower reaches, and low temperature in the upper reaches higher than 3,000 masl.

The prevailing geological formations are the volcanic-sedimentary and plutonic rocks and the carbonated rocks in the upstream. Slope instability is a noticeable feature, in particular, in the dry sub-basin located below the altitude of about 2,500 masl. Heavy rainfalls generate flood runoff immediately over the steep mountain slopes, and the runoff flows down along steep riverbeds without regulation by natural vegetation. It induces landslides and failures with large production of alluvial materials and sediments. Debris flow and alluvial fans created by debris flow are called as “huaycos” in Quechuan.

(2) Damages

In the Cañete River basin, damages due to the natural disasters, such as flood, debris flow and landslide are assessed to be fairly low comparing to the other river basins according to the record by INDECI. Injury of people and collapse of houses and roads were typical damages. Death report was a little.

(3) Structural And Non-Structural Measures

Debris flow and sediment control, so called Sabo, is studied as one of the structural measures for the watershed management of the Cañete River basin. Provision of Sabo dams or sand regulation pockets is one of the structural measures, but it will not be economically feasible due to sparse population in the vulnerable areas in the middle and upper reaches. Reforestation or afforestation as a non-structural measures will be extremely difficult due to scarce rainfalls during dry season and prevailing topographic and geologic conditions in the basin.

Provision of a forecasting and warning system for flood and debris flow will be one of the practical non-structural measures.

2.2.2 Flood Control

Only flood control is subject to excess water management in the lower reaches of the Cañete River basin. Urban storm excess water does not exist because of little rainfall in the lower reach, and flood is induced by the rainfall higher than 1,000 masl.

Flood damages were reported in the area downstream of Chavin gauging station, in particular, in the coastal area. The largest flood discharge was recorded in 1971 at the Socsi station. The flood prone areas in the Cañete River basin is identified mainly delta and old river channel areas inside the river regime. The river regime is generally lower by several meters than the riverbanks where population prevails. Coverage of these areas is very small due to high riverbed gradient (about 1/50) and narrow V-shaped valleys.

Provision of a flood forecasting and warning system will be one of the practical non-structural measures in the area because of minor flood damages and less flood frequencies.

2.3 Water Use Management

2.3.1 Water Use Issues

(1) Transboundary and Multisectoral Water Use

Rapid growth of socioeconomic development in Lima metropolitan area has been pressing fresh water resources in its neighbor areas excessively over a sound level. In the Cañete River basin the same condition is going to be prevailing. The irrigation water and the domestic and industrial water inside Cañete Valley have been the main water use in the basin. However, existing water use is expected to compete with the water demand outside the basin such as conveyance to Lima and Concón-Topará irrigation project in the near future. In short, the integrated management of transboundary water resources and their multisectoral use are of great importance to riparian regions, provinces, districts and organizations.

(2) Irrigation Water Use

Agricultural sector consumes about 90% of the existing water use in the Cañete River basin at present (1999). Gross water use efficiency of the existing Cañete Valley irrigation system is reported at about 30 - 45% combined with conveyance and irrigation efficiency. Saving of irrigation water and improvement of the existing irrigation system will be a key component of the water use management in the Cañete River basin.

Water management of agricultural sector will deal with mainly operation and maintenance and institutional arrangement of irrigation systems for rational and efficient water use and allocation.

2.3.2 Necessary Arrangement for Cañete Valley

As discussed in Chapter 8, Ministry of Agriculture (MAG) has the primal responsibility for water sector planning and regulatory tasks. In the MAG, the General Directorate for Water and Soils (Direccion General de Agua y Suelos, DGAS) is the principle agency responsible for water sector. Technical Administration for Irrigation District (ATDR) under DGAS is responsible for planning and regulatory tasks at local level.

At present, there are 63 ATDRs implemented in the country. The Boards of Users (Juntas de Usuarios, JU) are made up of water users solely for agricultural purposes, whereas small-scale agencies are formed by Irrigators' Commissions. There is usually one JU per valley, and since a ATDR may cover more than one valley, it may exist more than one JU in a ATDR (see Figure 2.1).

In Valle de Cañete, there are seven Irrigators' Commissions under the respective Irrigation Sub-sectors, organized according to the same number of the following main canals:

- Nuevo Imperial Canal
- Viejo Imperial Canal
- Huanca Canal
- Palo Herbay Canal
- Maria Angola Canal
- San Miguel Canal
- Pachacamilla Canal

According to the recent information given by the National Institute for Natural Resources (Instituto Nacional de Recursos Naturales, INRENA) of MAG, the DGAS and the ATDR have installed 105 measuring flumes and gauges in the Nuevo Imperial irrigation system this year. In addition, the projects are being executed for the implementation of 200 water measuring devices in the Huanca, Palo Herbay, Maria Angola and San Miguel irrigation systems. Moreover, the Irrigation Sub-Sector Project (Proyecto Subsectoral de Irrigación, SPI) has planned to carry out irrigation system improvement works.

After establishing the distribution systems as well as the operation and management of such systems, monitoring should be executed on a permanent basis for both of the existing and new irrigation projects (such as Pampas de Concón-Topará). It includes evaluation of method of supply and scheduling of irrigation water as well as water use efficiencies studies by direct measurements of the respective components. Water use studies in the farmer's field are also required. Particular attention should be given to irrigation methods and practices for traditional and new cropping patterns. Scheme management including institutional aspects, personnel, communication facilities, and improvement and maintenance schedules should be periodically reviewed.

It is important to establish the demand system with advance scheduling through the above procedures. In other words, requests for water are to be made 2 or 3 days in advance and the distribution of water is to be programmed accordingly. The well-trained staff should be available to operate the system that requires full control of water level and discharge at the intake and at each part of the distribution system.

2.3.3 Hydrologic Cycle and Water Quality in Cañete Valley

(1) Linkage between Surface Water and Groundwater

The groundwater in the Cañete Valley is recharged by two components. One is the supply of subsurface water and groundwater from the upper reach of the Cañete. The other is the return flow recharge from the existing irrigation system. Water logging was reported north of San Vicente de Cañete. Amount of the total rechargeable groundwater in the Cañete Valley was reported at about 4 m^3/s (annual average).

(2) Hydrologic Cycle and Water Quality Monitoring

The groundwater in the Cañete Valley might be contaminated by fertilizer and pesticide used for farming and heavy metals from the mine industries in the upstream.

Management of the hydrologic cycle of the valley together with water quality monitoring is significant necessity.

2.4 Monitoring System

2.4.1 Task and Target of Monitoring System

(1) Task of Monitoring System

Task of monitoring systems is to provide necessary information and data for achieving the objective of integrated management of water resources. The necessary information and data is to be classified into three:

1) data for project planning and implementation, including forecasting models, multisectoral water use and improvement projects, and guidelines and standards,

2) data for administration and superintendence, including legal systems, institutional framework and bulletin to the citizen, and

3) data for operation and monitoring, including operation and maintenance of water and river facilities such as dams, intakes, and pumping stations.

(2) Target of Monitoring System

Target of desirable monitoring system is set tentatively as follows:

1) to establish appropriate regional density of monitoring stations,
2) to establish dynamic and multi-dimensional monitoring among government and private organizations and citizens,
3) to establish unified monitoring and recording standard and procedures among the monitoring stations established by different organizations,
4) to establish simultaneous monitoring of water quality and quantity,
5) to establish hydrologic cycle monitoring with linkage of surface water and groundwater, and
6) to establish integrated superintendence of operation and maintenance systems and monitoring systems.

2.4.2 Component of Monitoring System

A desirable monitoring system shall integrate rainfall stations, river reservoir flow measurement stations, water quality monitoring stations, groundwater measurement stations, data recording, transfer and bank systems.

The component of a desirable integrated monitoring system shall cover the following function:

1) hydrologic cycle monitoring and simultaneous monitoring of water quality and quantity,
2) monitoring of ecosystem library,
3) forecasting and warning of flood and debris flow,
4) bulletining to the citizens.

2.4.3 Environmental Parameters

The monitoring system for environmental parameters in the Cañete River Basin will involve the measurement and recording of environmental, social and economic variables associated with IWRD. This system should provide information on the characteristic and functioning of variables in time and space, and in particular on the occurrence and magnitude of environmental impacts, in terms of ecosystem, water quality and public awareness. The proposed will be component of the entire project monitoring system and will improve the overall project management. It will also be used as an early warning system to identify harmful trends in the Cañete river basin before it is too late to take remedial measures. It helps in identifying unanticipated impacts. Monitoring of environmental parameters will also provide an acceptable database, which will be used in mediation between interested parties. As a result, monitoring of the origins, pathways and the final effect on the environment may identify where the responsibility lies. Monitoring of environmental parameters will be one of the most effective guarantees by SEDAPAL of its commitment to environmental quality. It will be comprise of:

1) Continuous Water Quality Monitoring
2) Terrestrial Ecology Monitoring
3) Fishery and Aquatic Biodiversity Monitoring
4) Resettlement and Compensation Monitoring
5) Public Outreach and Participation Mechanism

(1) Water Quality Monitoring

Continuous water quality monitoring will be required to establish base line database for heavy metals, nitrates, phosphates and pesticides. Measurements will also be needed for basic parameters, BOD, COD and bacteriological contamination. (details in Sector Report)

(2) Terrestrial Ecology Monitoring

Monitoring will be carried out of the basic inventory of flora and fauna. The monitoring system will also be collecting information on soils, forest cover, grazing, timber cutting and agriculture in the Cañete River basin. Information will also be collected for habitat degradation and hunting in the upper basin.

(3) Fishery and Aquatic Biodiversity Monitoring

The number of species are said to be less in the Cañete River because of toxic mining discharges, introduction of trout, and ‘Huayco’. The monitoring will be carried out to study the validity of this assessment. A monitoring program is recommended that will collect samples for fish and plankton every two months at four places.

(4) Resettlement and Compensation Monitoring

The community acceptance of large dam projects is now being judged by the fairness of the resettlement and compensation procedures. Similarly, in Auco/San Jeronimo dam’s case it will not only be the amount that the affected people will receive but also whether this handled by SEDAPAL in a speedy and acceptable manner to the people linked to the land around the reservoir and the dam site. Perhaps NGO groups active in the region would be able to act impartially with respect to mediation between SEDAPAL and locals.

(5) Public Outreach and Participation Mechanism

Carefully designed public outreach and community awareness program will be beneficial to advise and reassure the local community. Through credible NGO and locals, grassroots level participation will be encouraged and facilitated.

TABLES

Table 1.1 Water Balance Without and With Structural Measures
(Simulation period of 12 years: 1986-1997)

Balance Analysis Case	Annual Demand (MCM)	Deficit Year (MCM) 1/12 Deficit	Deficit Year (MCM) 2/12 Deficit	Deficit Year (MCM) 3/12 Deficit	Paucarcocha (MCM)	Morro de Arica (MCM)	Auco (MCM)	San Jeronimo (MCM)	Combination of Water Demand CB	CV	CLC	CTP	L	M
Without Structural Measures														
Case1	378.50	28.00	15.90	11.00	No	No	No	No	Y	Y	N	N	N	N
Case2	403.20	32.70	18.50	10.90	No	No	No	No	Y	Y	N	N	N	N
Case3	813.50	245.20	225.80	180.80	No	No	No	No	Y	Y	Y	Y	N	N
Case4	971.70	337.70	329.90	266.10	No	No	No	No	Y	Y	Y	Y	5	N
Case5	1129.70	448.40	438.70	382.80	No	No	No	No	Y	Y	Y	Y	10	N
With Structural Measures														
W16amf	867.54	172.08	10.21	9.51	No	High	No	Low	Y	Y	Y	N	10	4.3
W02	1129.75	298.11	77.16	62.65	No	Low	High	Low	Y	Y	Y	Y	10	N
W04	971.71	107.75	20.71	14.23	No	Low	High	Low	Y	Y	Y	Y	5	N
W02a	894.24	301.68	98.39	9.31	No	Low	High	No	Y	Y	Y	10	5	N
W02amp	925.76	324.03	93.78	20.04	No	Low	High	No	Y	Y	Y	10	5	1.0
W03amp	925.76	68.40	0.29	0.16	No	Low	Low	High	Y	Y	Y	10	5	1.0
W15amf	872.31	0.52	0.26	0.18	No	Low	Low	High	Y	Y	Y	5	5	4.3
W15amf-m1	872.36	6.97	0.00	0.00	No	Low	Low	High	Y	Y	Y	5	5	4.3
W15amf-m	1030.48	182.76	35.23	0.00	No	Low	Low	High	Y	Y	Y	10	5	4.3
W01	1129.75	298.11	87.64	70.94	No	Low	Low	Low	Y	Y	Y	Y	10	N
W03	971.71	139.66	20.71	15.53	No	Low	Low	Low	Y	Y	Y	Y	5	N
W05	626.67	0.00	0.00	0.00	No	Low	Low	Low	Y	Y	Y	5	N	N
W06	784.70	6.09	0.00	0.00	No	Low	Low	Low	Y	Y	Y	10	N	N
W07	622.65	0.00	0.00	0.00	No	Low	Low	Low	Y	Y	Y	N	5	N
W08	780.68	3.34	0.00	0.00	No	Low	Low	Low	Y	Y	Y	N	10	N
W01a	894.24	116.74	0.29	0.10	No	Low	Low	Low	Y	Y	Y	10	5	N
W09	720.99	172.42	137.45	89.89	No	Low	No	No	Y	Y	N	10	N	N
W09a	736.02	195.00	100.91	76.72	No	Low	No	No	Y	Y	Y	10	N	N
W09amp	767.54	215.73	109.69	86.78	No	Low	No	No	Y	Y	Y	10	N	1.0
W09amf	714.10	180.58	95.15	71.28	No	Low	No	No	Y	Y	Y	5	N	4.3
W11	780.68	0.00	0.00	0.00	No	No	High	Low	Y	Y	Y	N	10	N
W10	780.68	0.00	0.00	0.00	No	No	High	No	Y	Y	Y	N	10	N
W14amf	867.54	106.01	0.10	0.05	No	No	Low	High	Y	Y	Y	N	10	4.3
W13amf	709.51	0.03	0.00	0.00	No	No	No	High	Y	Y	Y	N	5	4.3
W12	780.68	92.07	74.81	53.37	No	No	No	Low	Y	Y	Y	N	10	N
W13amp	604.92	0.31	0.23	0.21	No	No	No	Low	Y	Y	Y	N	5	1.0
W16amf1	867.54	172.08	50.05	30.48	No	Low	No	Low	Y	Y	Y	N	10	4.3
W17amf	857.10	140.28	90.46	5.47	No	Low	No	Low	Y	Y	N	10	N	4.3
W17amp	752.51	68.51	54.46	0.00	No	Low	No	Low	Y	Y	N	10	N	1.0
W18amp	752.51	134.94	119.78	36.16	No	Low	No	Low	Y	Y	N	10	N	1.0

Table 1.2 Water Balance With Structural Measures

(Simulation period of 33 years, monthly data : 1965 - 1997)

Balance Analysis Case	Scenario/ Case	Annual Demand	Deficit Year (MCM)			Paucarcocha	Morro de Arica	Auco	San Jeronimo	Combination of Water Demand					
		(MCM)	1/12 Deficit	2/12 Deficit	3/12 Deficit	(MCM)	(MCM)	(MCM)	(MCM)	CB	CV	CLC	CTP	L	M
WMP1mp		757.37	50.59	8.92	5.97	55	205	No	No	Y	Y	N	Y	N	1.0
WMmf	Case 1.1	667.70	0.00	0.00	0.00	No	205	No	No	Y	Y	N	N	5	4.3
WM5mf	Case 2.2	685.73	0.00	0.00	0.00	No	205	No	No	Y	Y	N	5	N	4.3
WMP1mf1		861.44	142.42	24.10	2.33	55	205	No	No	Y	Y	N	Y	N	4.3
WMP2mp1		757.37	2.10	1.66	1.47	55	245	No	No	Y	Y	N	Y	N	1.0
WMP2mf1	Case 2.1	861.44	126.07	1.89	1.77	55	245	No	No	Y	Y	N	Y	N	4.3
WMP3mf2	Case 3.2	843.42	108.04	0.00	0.00	55	245	No	No	Y	Y	N	5	5	4.3
WMP3mp		757.37	0.00	0.00	0.00	55	205	No	130	Y	Y	N	Y	N	1.0
WMP3mp1		766.67	0.00	0.00	0.00	55	205	No	130	Y	Y	Y	10	N	1.0
WMP3mp2		802.72	7.61	1.61	0.00	55	205	No	130	Y	Y	Y	Y	N	1.0
WMP3mf1		870.74	40.96	6.27	0.00	55	205	No	130	Y	Y	Y	10	N	4.3
WMP3mf3		906.79	92.65	10.45	9.75	55	205	No	130	Y	Y	Y	Y	N	4.3
WMP3mf4		1028.42	268.42	59.18	51.42	55	205	No	130	Y	Y	Y	10	5	4.3
WMP4mf1		1028.42	258.35	50.96	38.92	55	245	No	130	Y	Y	Y	10	5	4.3
WMP4mf2		1028.42	178.40	19.66	8.14	55	245	No	200	Y	Y	Y	10	5	4.3
WMP4mf3	Case 3.1	1049.30	130.00	20.00	2.30	No	245	No	280	Y	Y	Y	10	5	4.3
WMJ1mp		757.37	0.00	0.00	0.00	No	205	No	130	Y	Y	N	Y	N	1.0
WMJ1mp1		766.67	5.09	0.00	0.00	No	205	No	130	Y	Y	Y	10	N	1.0
WMJ1mp2		802.72	30.32	1.61	0.00	No	205	No	130	Y	Y	Y	Y	N	1.0
WMJ1mf1		870.74	69.35	18.32	6.27	No	205	No	130	Y	Y	Y	10	N	4.3
WMJ1mf2		906.79	122.20	24.23	10.45	No	205	No	130	Y	Y	Y	Y	N	4.3
W10A1	Case 1.2(AC)	855.55	170.58	0.00	0.00	No	No	250	No	Y	Y	Y	N	10	4.3
W10A2		866.10	132.42	1.31	0.88	No	No	300	No	Y	Y	Y	N	10	4.3
W10A3		866.10	79.41	1.31	0.88	No	No	353	No	Y	Y	Y	N	10	4.3
W10S1	Case 1.2(SJ)	855.55	142.26	0.00	0.00	No	No	No	250	Y	Y	Y	N	10	4.3
W10S2		866.10	104.11	0.00	0.00	No	No	No	300	Y	Y	Y	N	10	4.3
W10S3		866.10	44.11	0.00	0.00	No	No	No	360	Y	Y	Y	N	10	4.3
W10M		866.10	188.36	5.74	1.50	No	245	No	No	Y	Y	Y	N	10	4.3
W10PM	Case 1.2(MD-P)	855.55	129.14	0.00	0.00	55	245	No	No	Y	Y	Y	N	10	4.3

Notes

CB: D/I water in Canete basin, L: Lima D/I water supply, CV: Canete Valley Irrigation, CLC: Alto Imperial Irrigation, CTP: Concon-Topara Irrigation, M: Maintenance flow

No: without dam, N: no demand, Y: full demand, 5: a half demand

Table 1.3 Water Resources Development Scenarios and Alternative Cases

	Scenario-1		Scenario-2		Scenario-3		
	Case 1.1 *	Case 1.2	Case 2.1 *	Case 2.2	Case 3.1 *	Case 3.2	Case 3.3 *
Water Demand:							
1)D/I Water Supply	CB+L5	CB+L10	CB	CB	CB+L5	CB+L5	CB+L5
2)Irrigation Demand	CV	CV+CLC	CV+CTP	CV+CTP5	CV+CLC+CTP	CV+CTP5	CV+CTP
3)Maintenance Flow	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mp1.0
4)Total Demand (MCM)	667.7	855.55	861.4	685.73	1049.28	843.41	915.05
Dam: Active Storage							
1)Morro de Arica (MCM)	205	245	245	205	245	245	245
2)Paucarcocha (MCM)	Not Applicable	55	55	Not Applicable	Not Applicable	55	55
3)Capillucas (MCM)	2.8	2.8	2.8	2.8	2.8	2.8	2.8
4)San Jeronimo (MCM)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	280	Not Applicable	Not Applicable
Power Station:							
1)Morro de Arica (MW)	46	50	50	46	50	50	50
2)El. Platanal (MW)	200	220	220	200	220	220	220
3)San Jeronimo (MW)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
New Ground Water							3m3/s(94.6MCM)
Water Conveyance	L5=5m3/s	L10=10m3/s	Not Applicable	Not Applicable	L5=5m3/s	L5=5m3/s	L5=5m3/s
Irrigation Facilities	Not Applicable	Not Applicable	CTP Full Scale	CTP Half Scale	CTP Full Scale	CTP Half Scale	CTP Full Scale

Notes

*: The selected scale for respective scensrios.

CB: D/I Water in Canete River Basin(34.22MCM), L5: Lima D/I Water Supply 5m3/s(157.68MCM), L10: Lima D/I Water Supply 10 m3/s(315.36MCM),

CV: Canete Valley Irrigation(340.20MCM), CLC: Alto Imperial Irrigation(30.17MCM), CTP: Concon-Topara Irrigation (Full Scale 351.41MCM),

CTP5: Concon-Topara Irrigation (Half Scale 175.71MCM)

Mf4.3: Maintenance Flow 4.3m3/s(135.60MCM), Mp1.0: Maintenance Flow 1.0m3/s(31.54MCM)

Table 1.4 Assessment Matrix

Criteria	Alternative 1a	Alternative 2
Tecnical		
Viability	B	B
Technology	B	B
Maintenance	C	B
Operation	B	C
Guarantee	C	A
Construction	B	B
Control	B	B
Flexibility	C	A
Environmental		
Effects	C	B
Vulnerability	C	B
Social		
Social	C	B
Economic-Financial		
Investment	C	A
Net Present Value	C	A
Overall Assessment	**C**	**A**

A = Favorable, B = Indifferent, C = Unfavorable

Table 1.5 Demand and Supply Balance After Year 2015

(m3/s)

Operation Year / **Item**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Avg. Daily Demand	33.05	33.55	34.05	34.54	35.04	35.54	36.04	36.54	37.05	37.55	38.05	38.58	39.10	39.63	40.15	40.68
Total Sources up to Year 2015 (*)and after	33.24	35.74	35.74	35.74	35.74	35.74	38.24	38.24	38.24	38.24	38.24	40.74	40.74	40.74	40.74	40.74
New Surface Sources																
Huascacocha		2.50														
Mantaro-Carispacha Stage I or Cañete Stage I							2.50									
Mantaro-Carispacha Stage II or Cañete Stage II												2.50				
Superavit (Deficit)	0.19	2.19	1.69	1.20	0.70	0.20	2.20	1.70	1.19	0.69	0.19	2.16	1.64	1.11	0.59	0.06
New Treatment Plant																
Chillón		2.50														
Huachipa Stage II or Flor de Nieve Stage I							2.50									
Huachipa Stage II or Flor de Nieve Stage II												2.50				

(*) Rimac River Basin : 13.01 m^3/s
Yuracmayo Reservoir : 1.78 m^3/s
Marca II + Marca III : 10.87 m^3/s
Chillón Development : 0.71 m^3/s (0.61 + 0.10)
Lurín : 0.38 m^3/s
Wells : 6.49 m^3/s
Total : 33.24 m^3/s

Table 1.6

Hydropower Potential Capacity of Rivers

Part of Pacific Watershed in Peru

N°	River	Watershed Area (KM ^{2})	Theorical Potencial Capacity (MW)	Specific Potencial Capacity (MW/KM)
1	ZARUMILLA	817.00	17	0.13
2	TUMBES	2729.00	278	1.18
3	CHIRA	11564.00	722	0.70
4	PIURA	10476.00	209	0.29
5	CASCAJAL	4147.00	21	0.07
6	OLMOS	965.00	22	0.24
7	MOTUPE	1951.00	61	0.26
8	LA LECHE	1578.00	107	0.71
9	CHANCAY - LAMBAYEQUE	4906.00	531	1.34
10	ZAÑA	2080.00	125	0.74
11	CHAMAN	1248.00	19	0.19
12	JETEQUEPEQUE	4257.00	695	1.70
13	CHICAMA	4454.00	443	0.98
14	MOCHE	2161.00	278	0.91
15	VIRU	1967.00	151	0.67
16	CHAO	1443.00	82	0.51
17	SANTA	12479.00	4953	4.34
18	LACRAMARCA	685.00	9	0.13
19	NEPENA	1885.00	87	0.33
20	CASMA	3064.00	207	0.68
21	CULEBRAS	671.00	16	0.15
22	HUARMEY	2354.00	169	0.88
23	FORTALEZA	2342.00	114	0.41
24	PATIVILCA	4908.00	1675	3.26
25	SUPE	1078.00	78	0.68
26	HUAURA	4483.00	1062	2.95
27	CHANCAY - HUARAL	3382.00	576	2.37
28	CHILLON	2321.00	332	1.57
29	RIMAC	3134.00	887	2.98
30	LURIN	1600.00	176	1.06
31	CHILCA	798.00	29	0.30
32	MALA	2522.00	527	2.23
33	OMAS	1741.00	82	0.81
34	CAÑETE	5981.00	1927	3.42
35	TOPARA	489.00	24	0.40
36	SAN JUAN	5333.00	774	2.50
37	PISCO	4054.00	872	2.50
38	ICA	7366.00	458	1.35
39	GRANDE	10522.00	424	0.38
40	ACARI	4082.00	660	1.95
41	YAUCA	4589.00	298	0.83
42	CHALA	1284.00	42	0.26
43	CHAPARRA	1387.00	67	0.48
44	ATICO	1425.00	32	0.21
45	CARAVEL I	2009.00	75	0.38
46	OCONA	15908.00	3248	2.27
47	MAJES - CAMANA	17141.00	2910	2.80
48	QUILCA O CHILI	13254.00	1030	1.17
49	TAMBO	12697.00	1508	1.64
50	OSMORE	3595.00	164	0.51
51	LOCUMBA	5316.00	97	0.25
52	SAMA	4809.00	83	0.30
53	CAPLINA	1629.00	54	0.43
	Sub-Total Pacific Watershed: Theorical Potencial Capacity = 29256.5 MW			

SOURCE: "Evaluación del Potencial Hidroeléctrico Nacional"
(Assesment of National Hidropower Potencial Capacity)
Consorcio LAHMEYER - SALZGITTER, 1979

NOTE: Specific Theorical Potencial Capacity is obtaired by dividing
Theorical Potencial by total length of Main River and this tributaries.

Table 1.7 Hydropower Potential Cañete River

Stretch	Length (KM.)	Altitude (masl)	Discharge (m3/s)	Affluent (m3/s)	Length Difference (km)	Altitude Difference (m)	Slope %	Mean Discharge (m3/s)	Theoretical Potential Capacity (MW)	Specific Potential Capacity (MW/KM)
1	222.0	4429.0	0.4	0.0						
					12.0	179.0	1.49	1.50	2.63	0.22
2	210.0	4250.0	2.6	0.0						
					10.0	100.0	1.00	3.85	3.77	0.38
3	200.0	4150.0	5.1	0.0						
					10.0	180.0	1.80	6.00	10.58	1.06
4	190.0	3970.0	6.9	0.0						
					10.0	140.0	1.40	7.65	10.50	1.05
5	180.0	3830.0	8.4	0.0						
					10.0	210.0	2.10	9.35	19.24	1.92
6	170.0	3620.0	10.3	0.0						
					11.0	390.0	3.55	10.95	41.85	3.80
7	159.0	3230.0	11.6	1.7						
					4.0	90.0	2.25	13.30	11.73	2.93
8	155.0	3140.0	13.3	6.3						
					6.0	205.0	3.42	19.85	39.88	6.65
9	149.0	2935.0	20.1	2.7						
					9.0	206.0	2.29	23.40	47.24	5.25
10	140.0	2729.0	24.0	0.0						
					5.0	79.0	1.58	24.15	18.70	3.74
11	135.0	2650.0	24.3	5.7						
					5.0	225.0	4.50	30.15	66.48	13.30
12	130.0	2425.0	30.3	0.0						
					10.0	235.0	2.35	31.45	72.43	7.24
13	120.0	2190.0	32.6	0.0						
					10.0	240.0	2.40	33.10	77.85	7.79
14	110.0	1950.0	33.6	1.7						
					8.0	250.0	3.13	35.40	86.73	10.84
15	102.0	1700.0	35.5	3.6						
					6.0	80.0	1.33	39.25	30.77	5.13
16	96.0	1620.0	39.4	0.0						
					10.0	200.0	2.00	39.75	77.91	7.79
17	86.0	1420.0	40.1	0.0						
					10.0	70.0	0.70	40.25	27.61	2.76
18	76.0	1350.0	40.4	2.6						
					1.0	60.0	6.00	43.00	25.28	25.28
19	75.0	1290.0	43.0	7.4						
					6.0	110.0	1.83	50.40	54.33	9.06
20	69.0	1180.0	50.4	5.2						
					9.0	355.0	3.94	55.40	192.74	21.42
21	60.0	825.0	55.2	0.0						
					20.0	350.0	1.75	54.90	188.31	9.42
22	40.0	475.0	54.6	0.0						
					12.0	135.0	1.13	54.70	72.37	6.03
23	28.0	340.0	54.8	0.0						
					3.0	40.0	1.33	54.80	21.48	7.16
24	25.0	300.0	54.8	0.0						
					25.0	300.0	1.20	54.85	161.26	6.45
25	0.0	0.0	54.9	0.0						

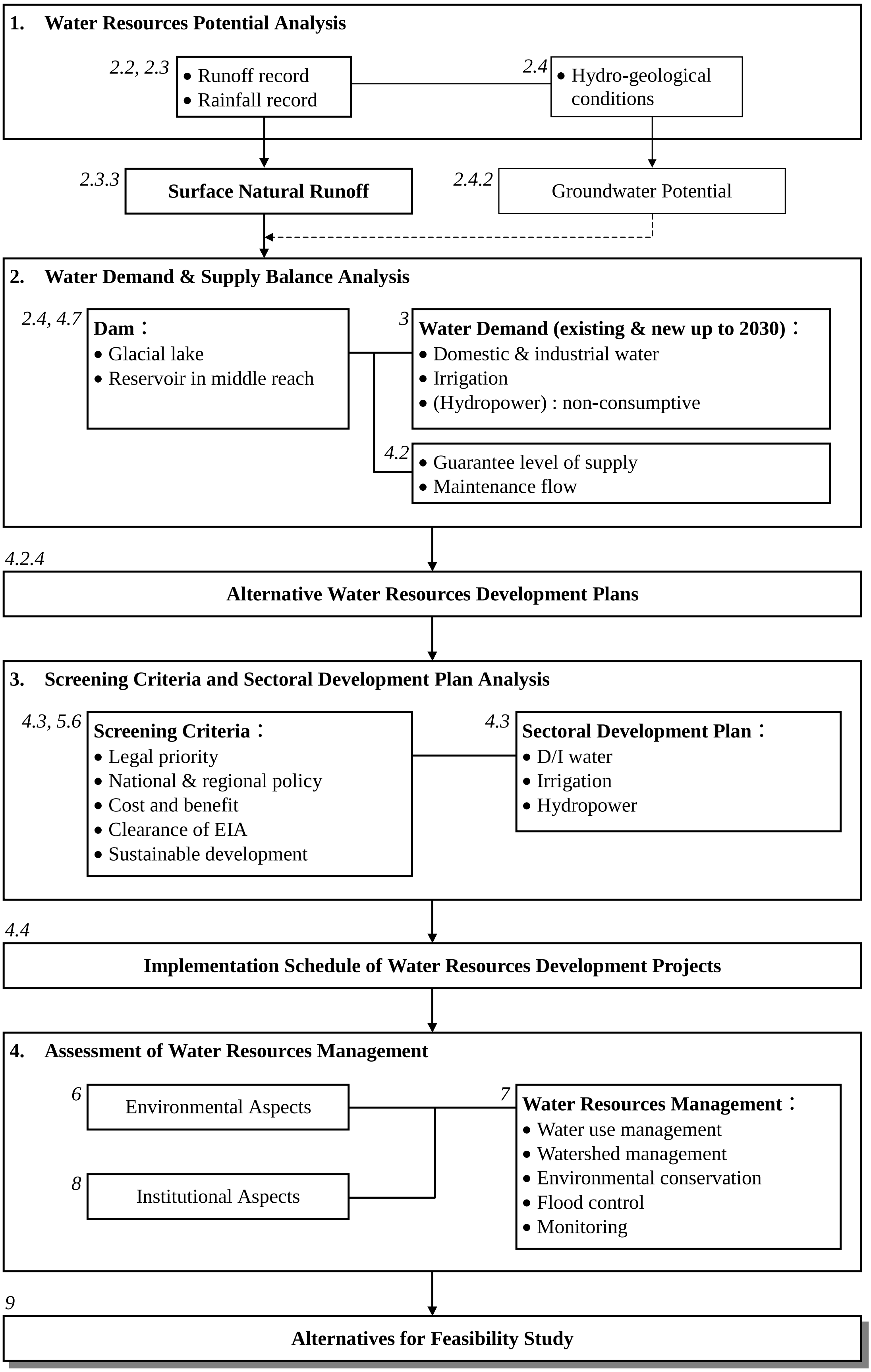
Source : "Evaluación del potencial hidroeléctrico Nacional" (Assessment of National Hydropower Potential Capacity). Consorcio Lahmeyer - Salzgitter, 1979

Note : The theoretical potential capacity of each stretch is obtained by multiplying the mean discharge by the altitude difference and by the gravity acceleration (9.8 m3/s). This value is obtained by dividing by 1,000 so as to be converted into Megawatts

Specific potential capacity of each stretch is obtained by dividing theoretical potential capacity by length difference.

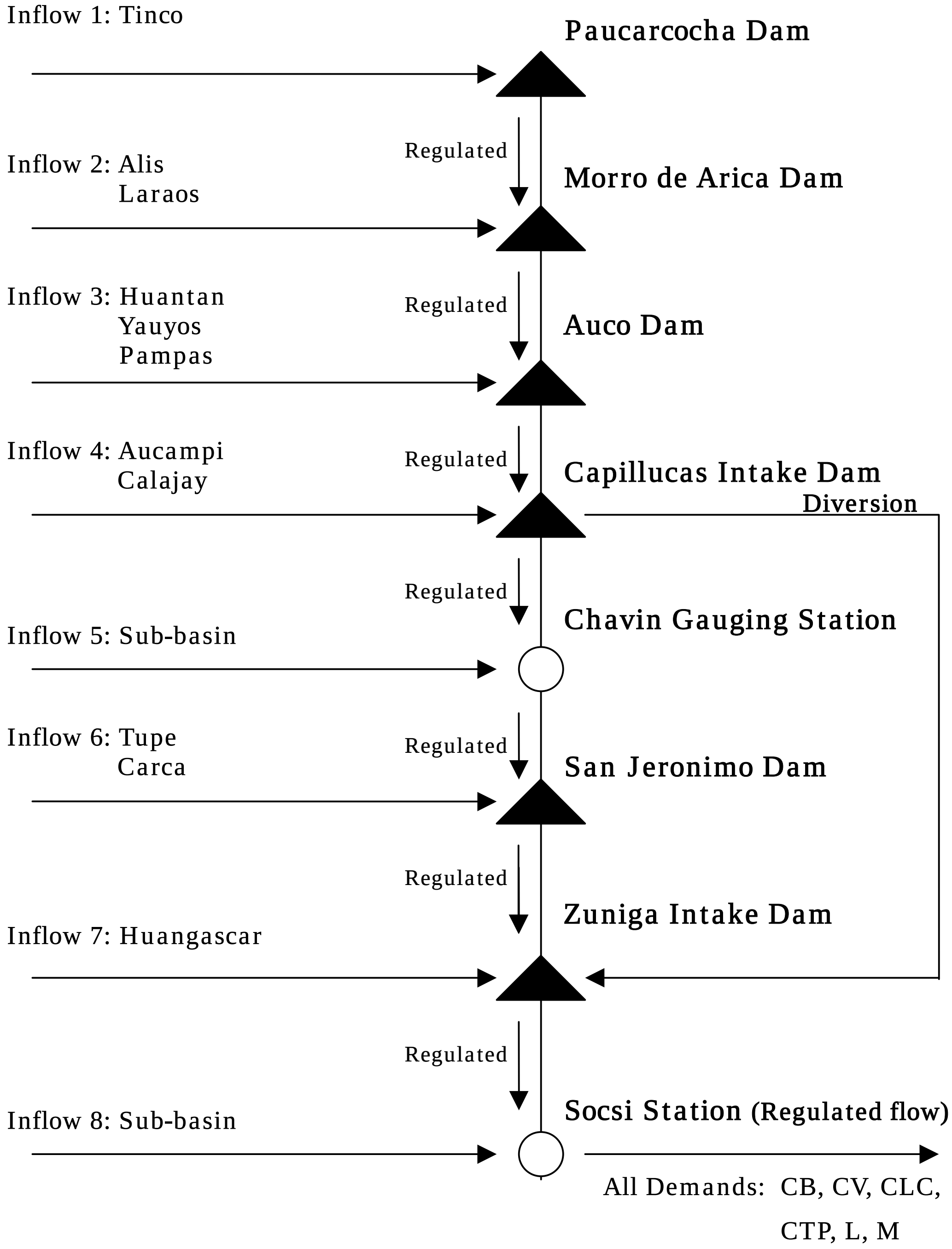
The lengths in kilometers have been measured from outlet from Cañete river into sea.

FIGURES



Note: Italic numbers indicate CHAPTER or Section No.

STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU	**Figure 1.1** **Plan Formulation of PHASE I (M/P)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



CB:	2030 domestic water in Cañete river basin
CV:	2030 Cañete valley irrigation water
CLC:	2030 irrigation water in Alto Imperial plain in Cañete
CTP:	Planned Concon Topara irrigation water
L:	Conveyance to Lima
M:	Maintenance flow

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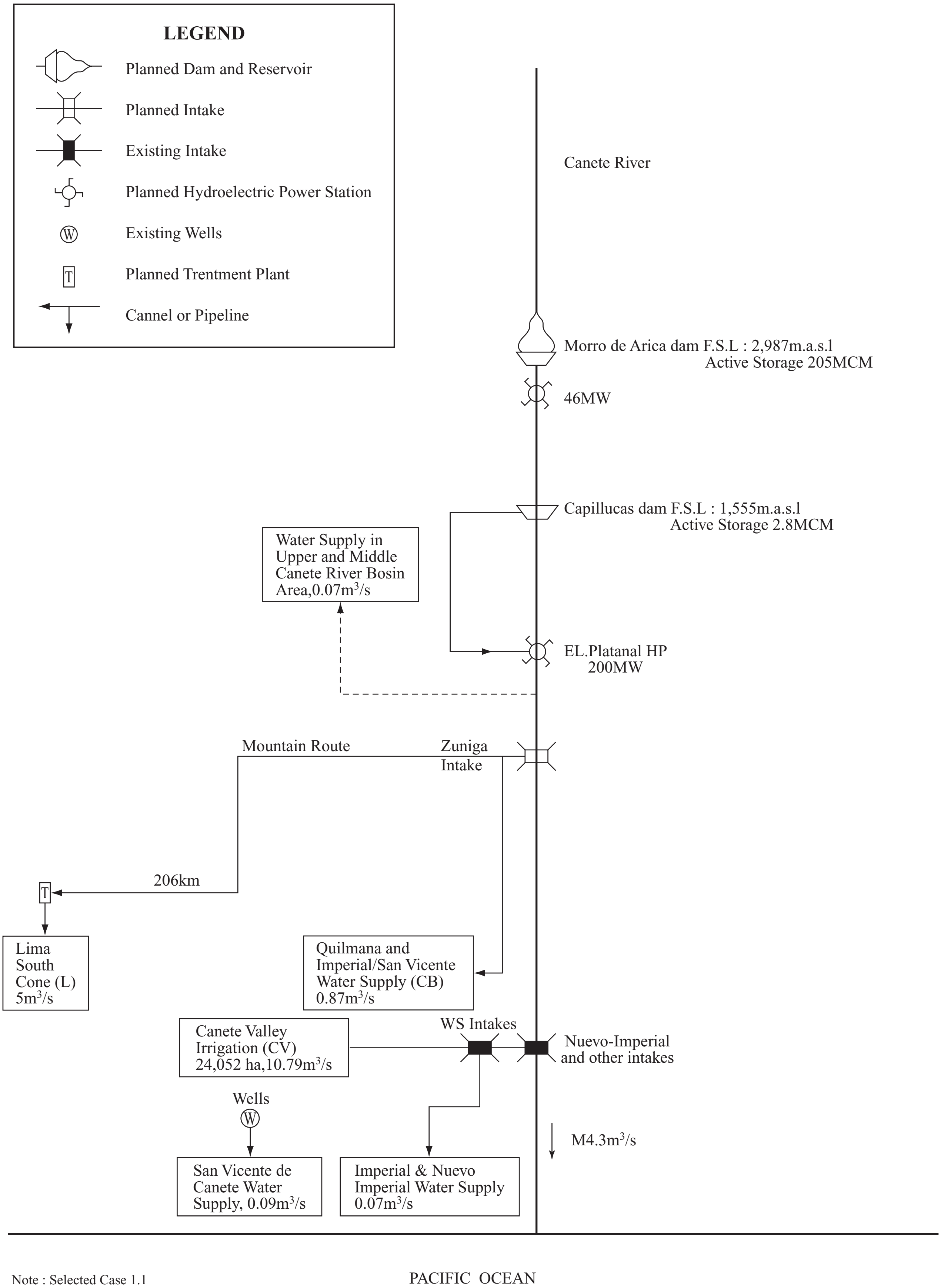
Figure 1.2

HEC-5 Model



Note : Selected Case 1.1

STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU	**Figure 1.3**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Project System Diagram for Scenario-1**

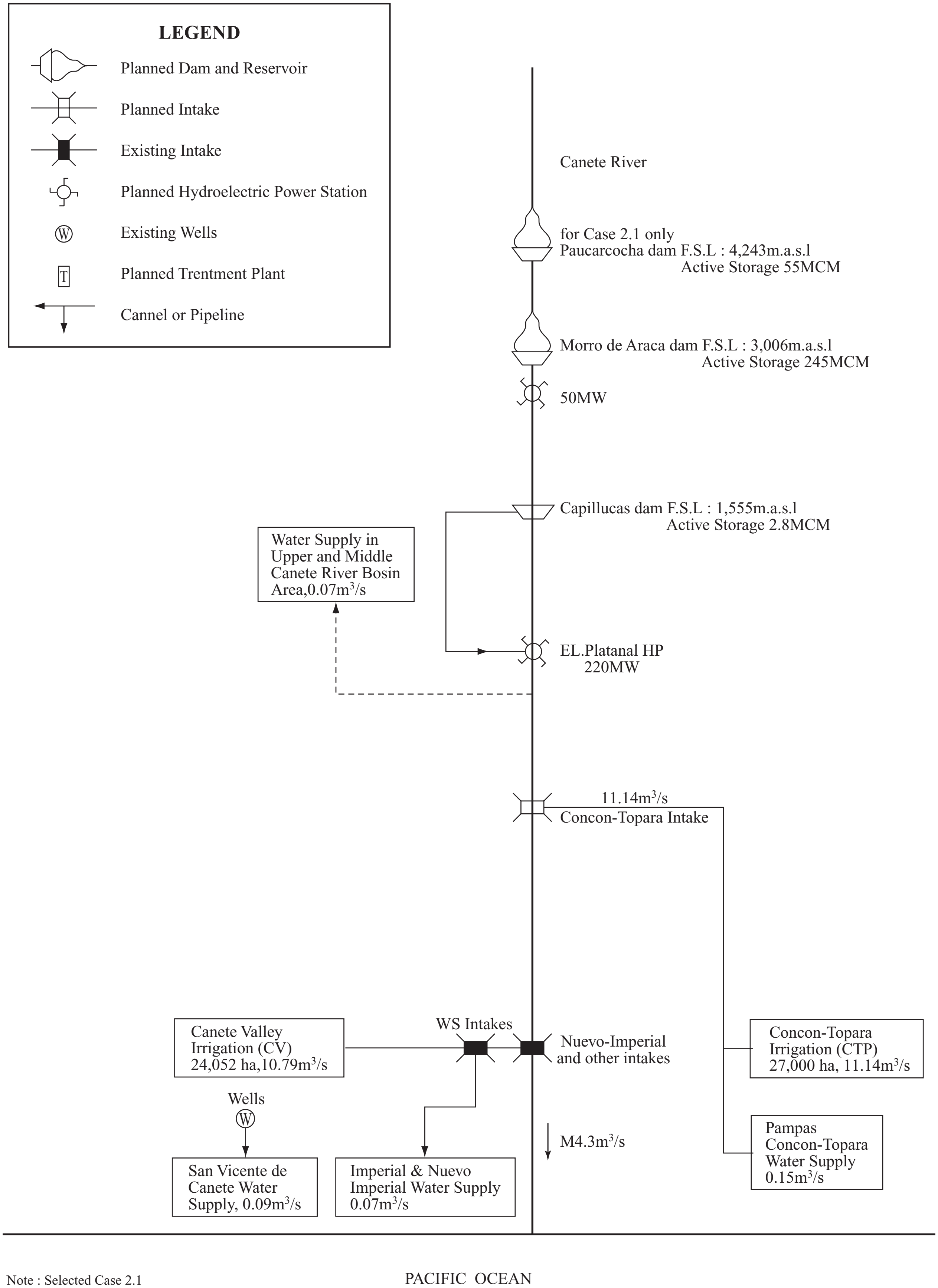


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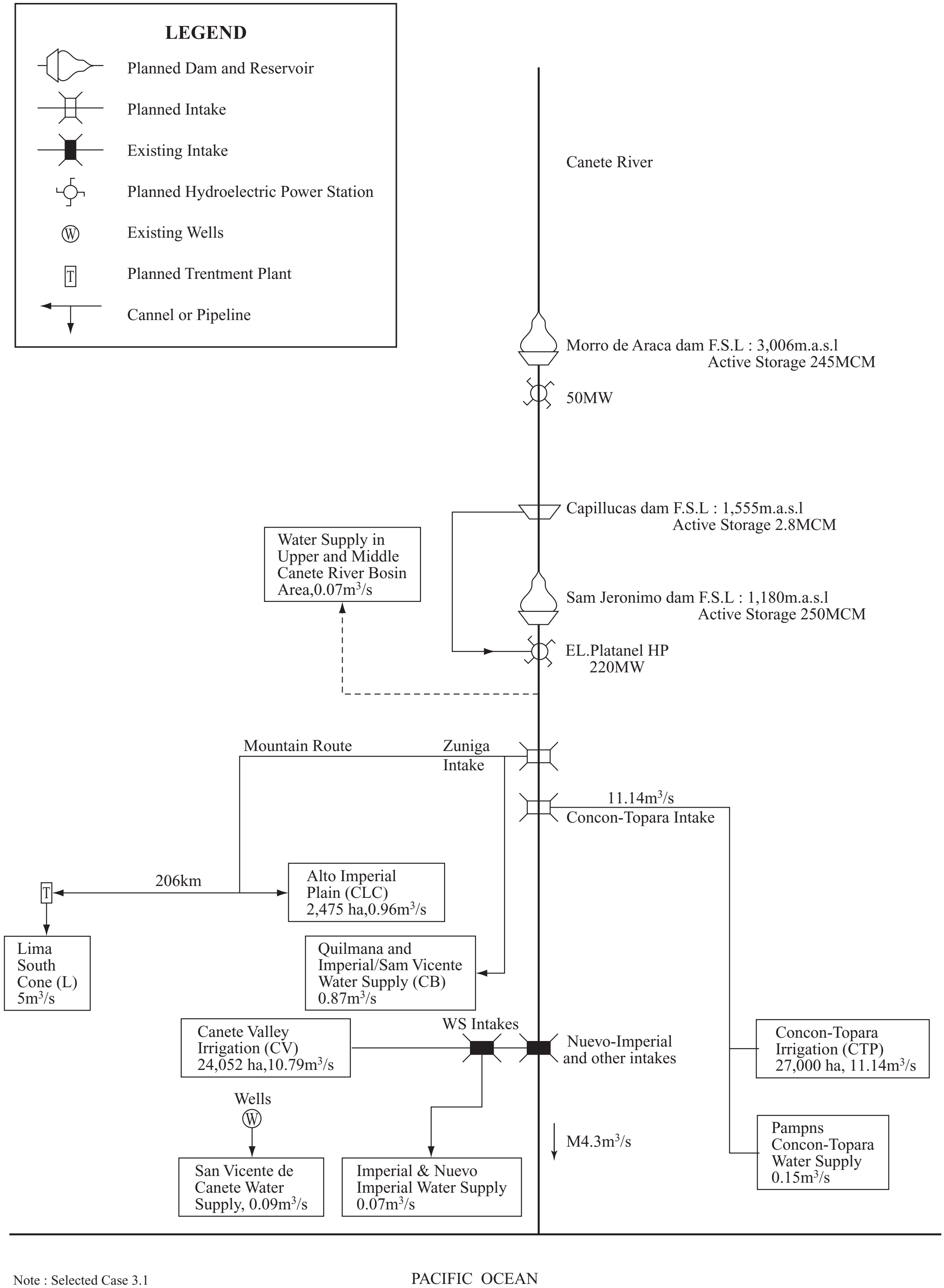
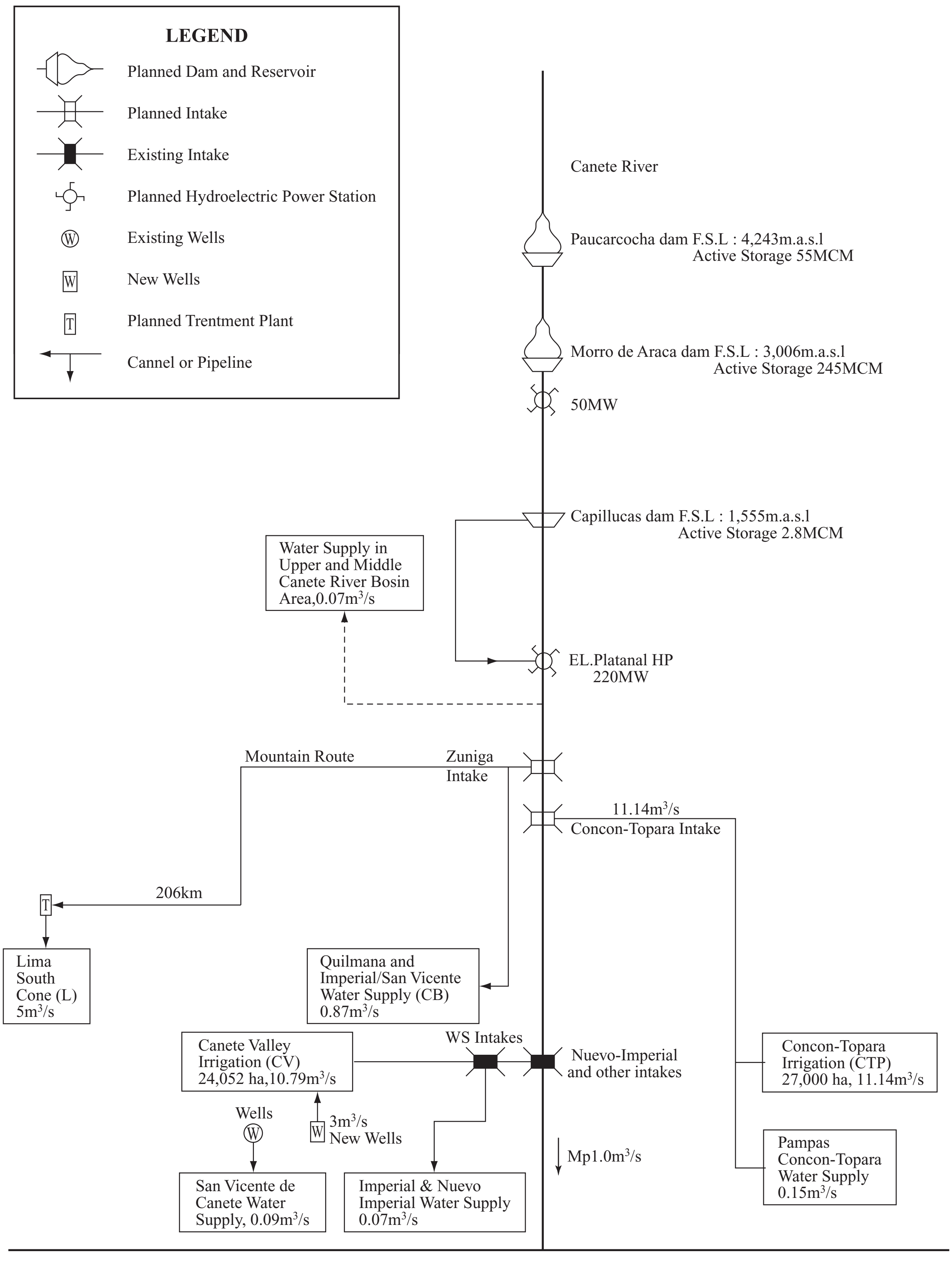
Figure 1.4

Project System Diagram for Scenario-2



Note : Selected Case 3.1

STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU	**Figure 1.5**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Project System Diagram for Scenario-3, Case 3.1**



Note : Selected Case 3.3

STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 1.6** **Project System Diagram for Scenario-3, Case 3.3**

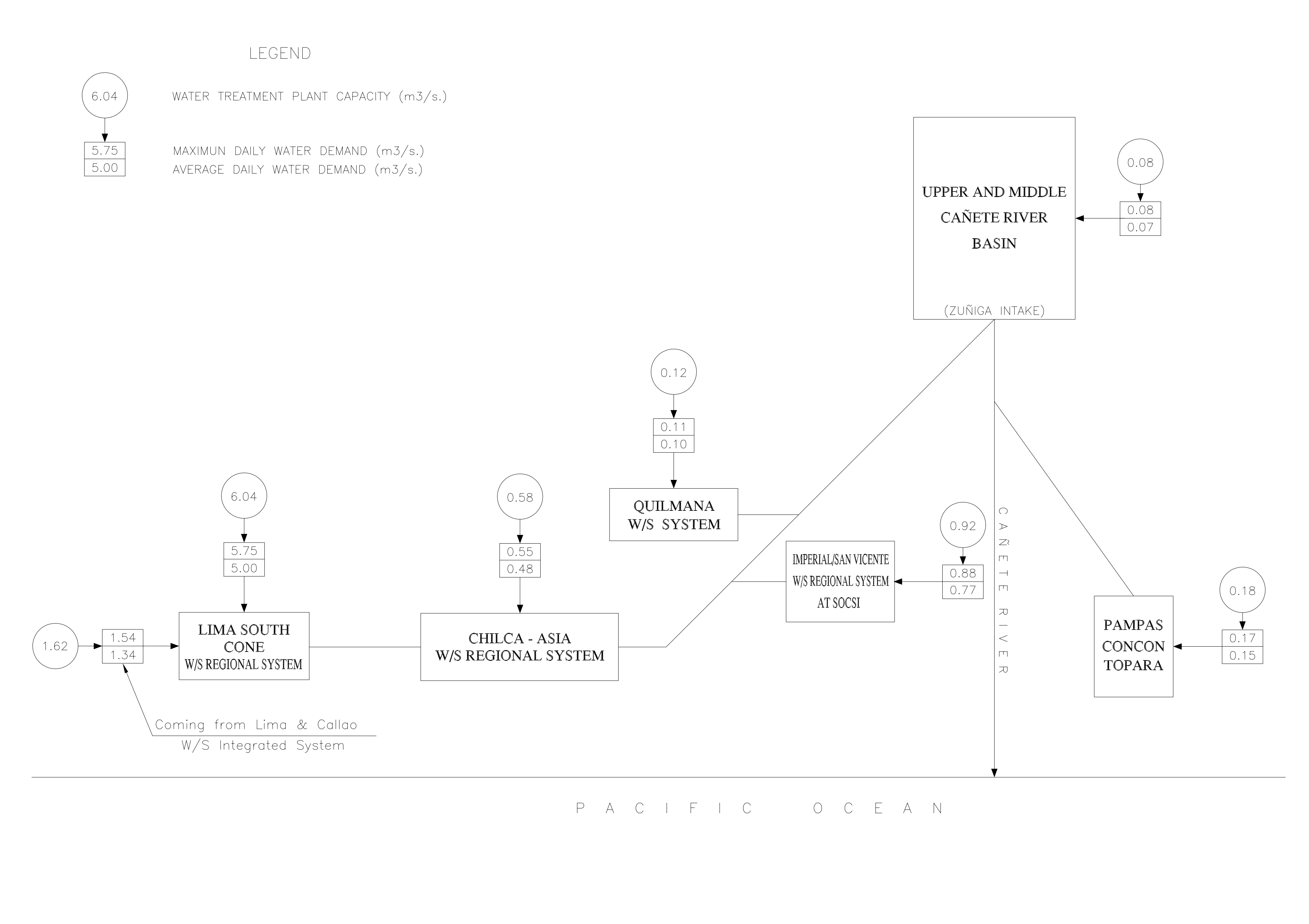


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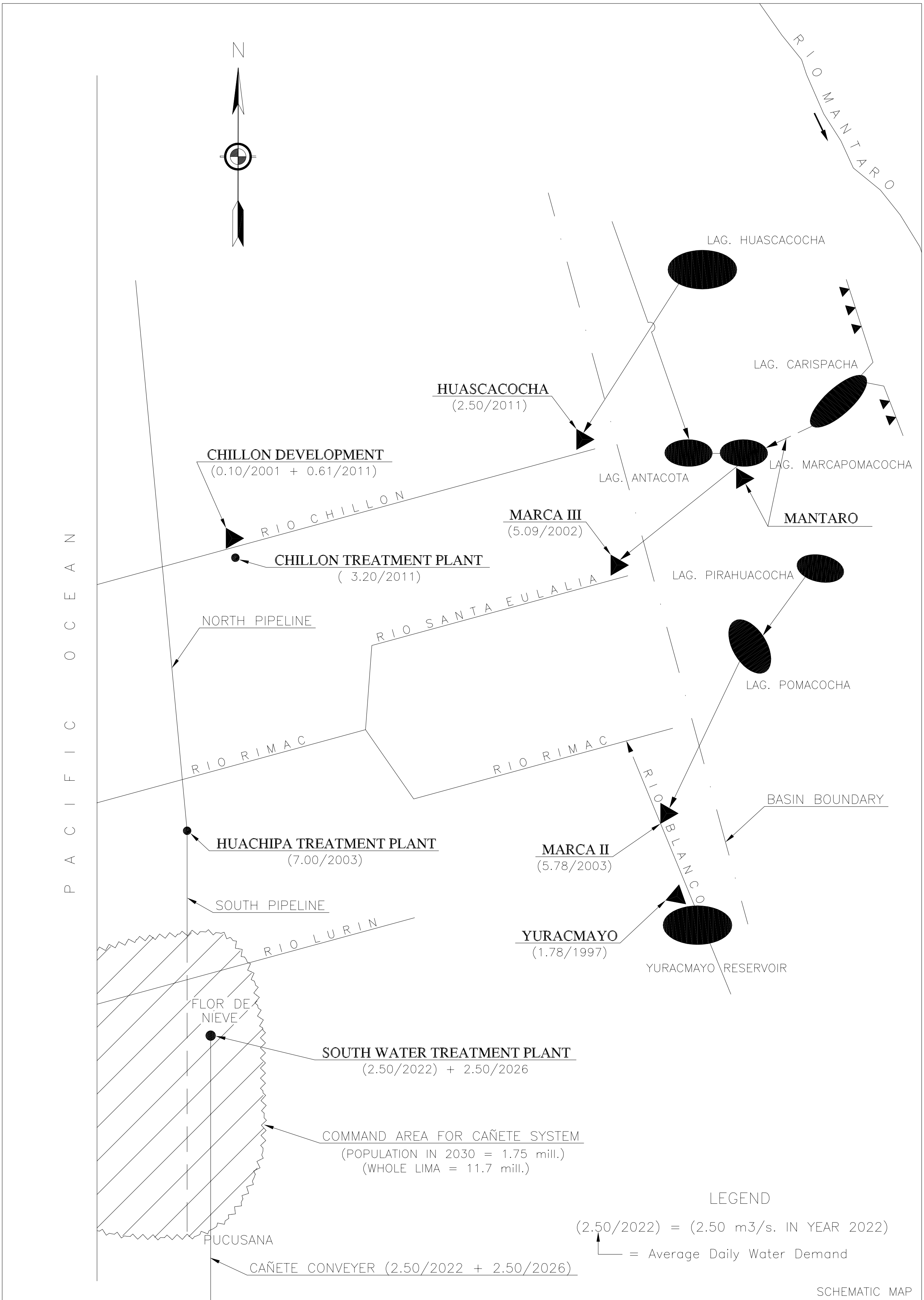
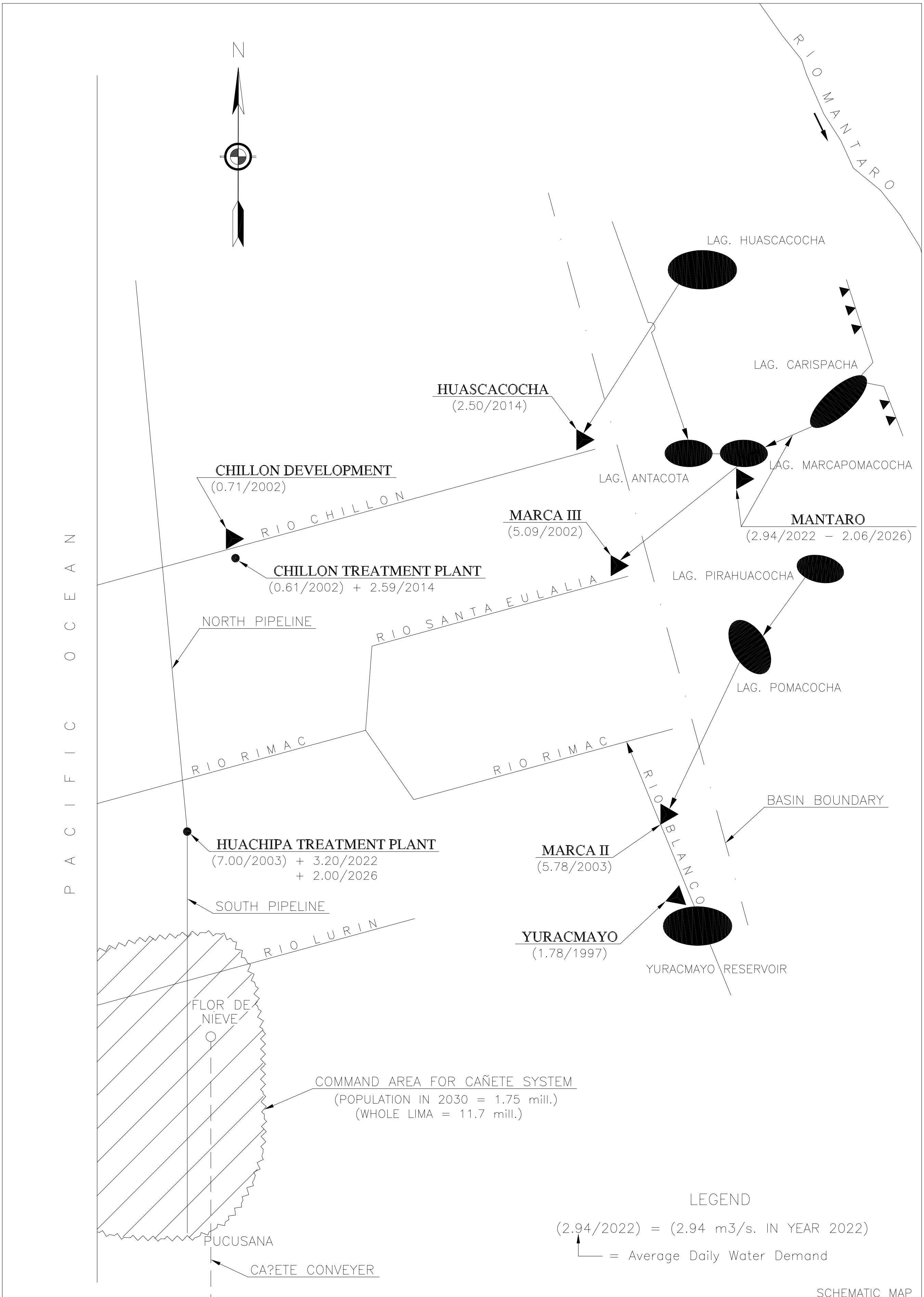
Fig. 1.7

PROPOSED WATER SUPPLY SYSTEM



STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU	Fig. 1.8 SELECTED CASE (ALT.1a) FOR NEW WATER SUPPLY SYSTEM AND KEY TREATMENT PLANT (SEDAPAL MASTER PLAN)
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT IN THE CA?ETE RIVER BASIN IN THE REPUBLIC OF PERU	Fig. 1.9 SELECTED CASE (ALT.2) FOR NEW WATER SUPPLY SYSTEM AND KEY TREATMENT PLANT (SEDAPAL MASTER PLAN)
JAPAN INTERNATIONAL COOPERATION AGENCY	

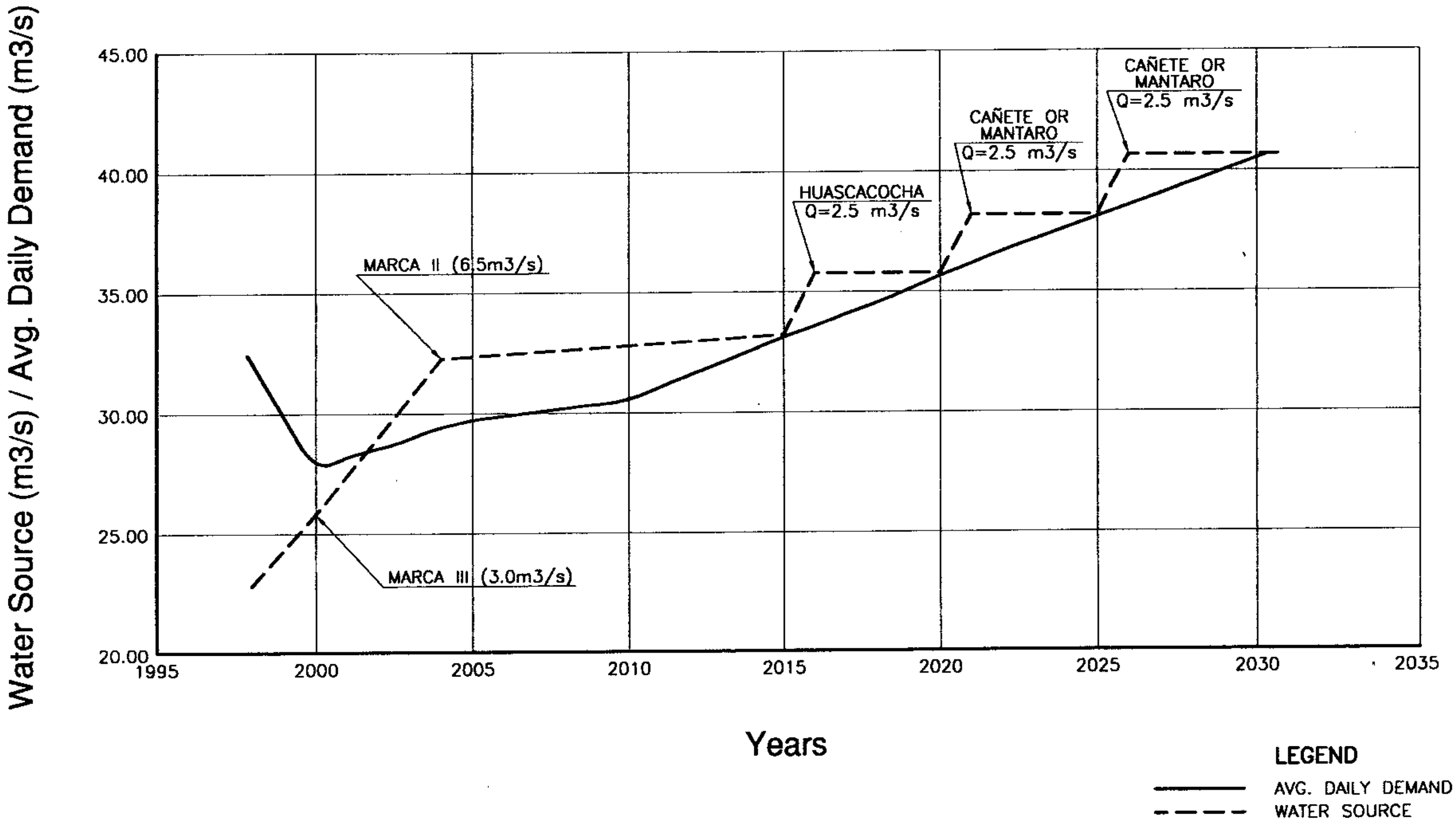


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Figure 1.10
Water Demand - Supply Balance for Metropolitan Lima Water Supply System, Period 1998 - 2030

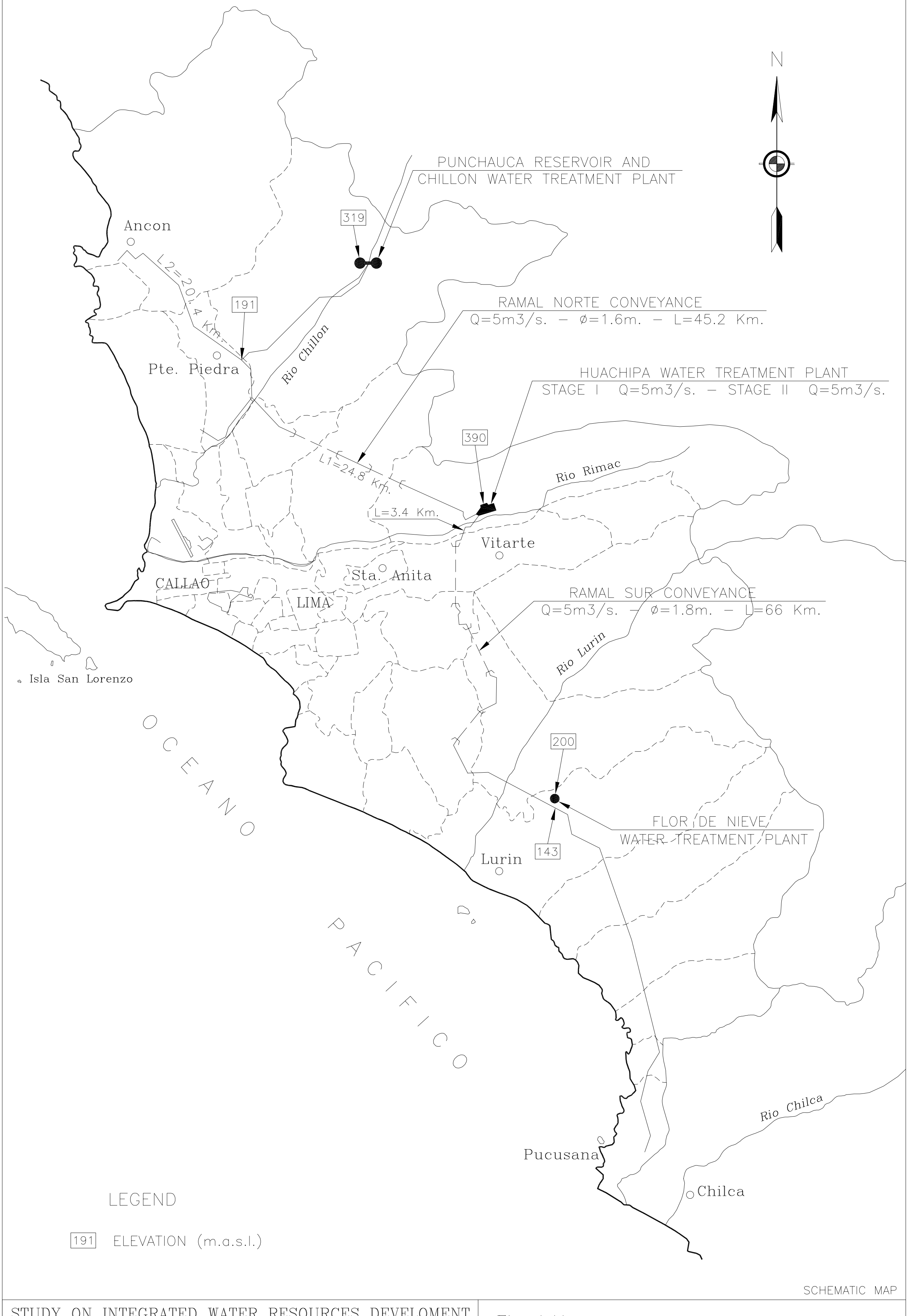

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Fig. 1.11

SEDAPAL COMMITTED PROJECT FOR
CONSTRUCTION AT SHORT TERM

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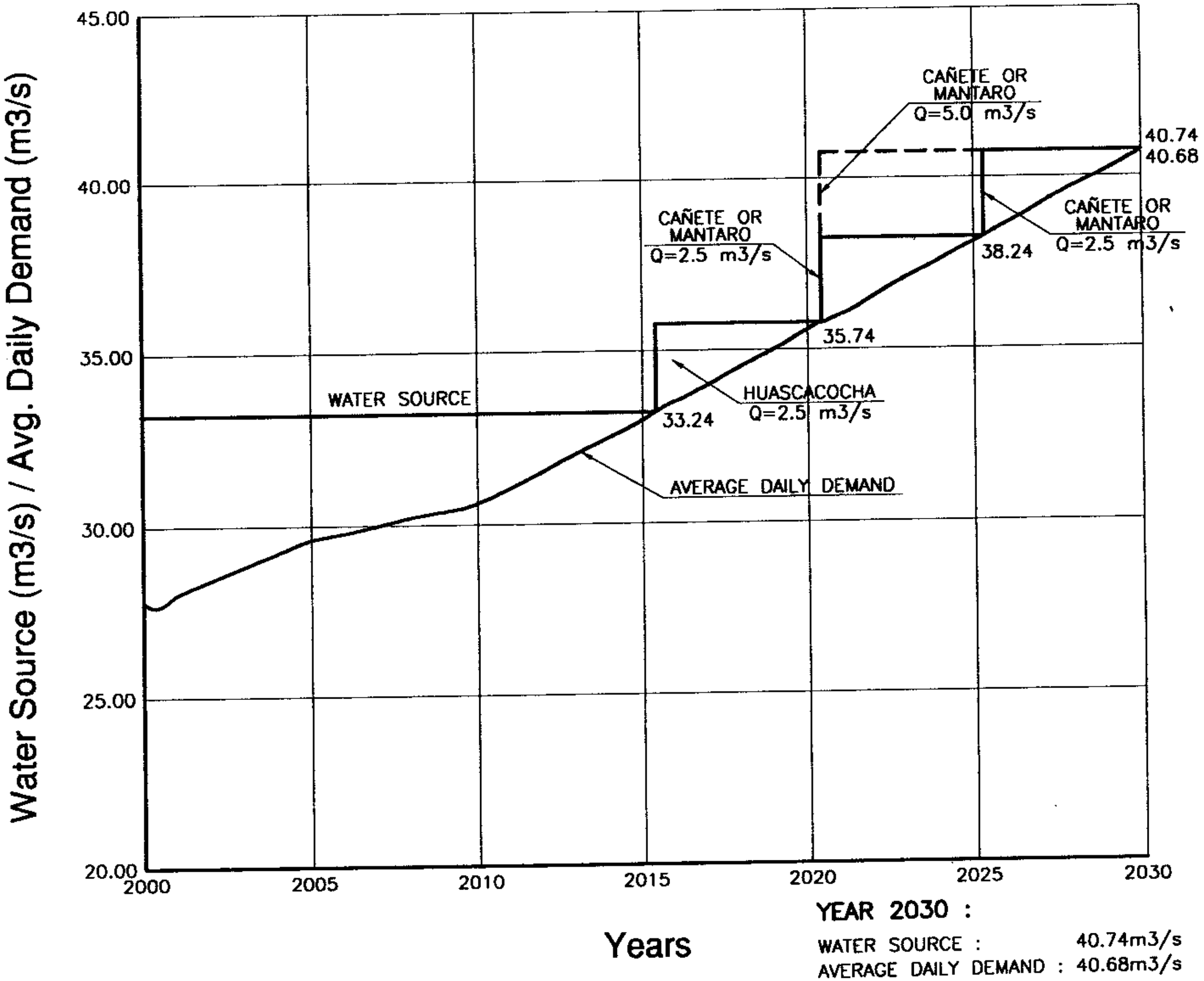
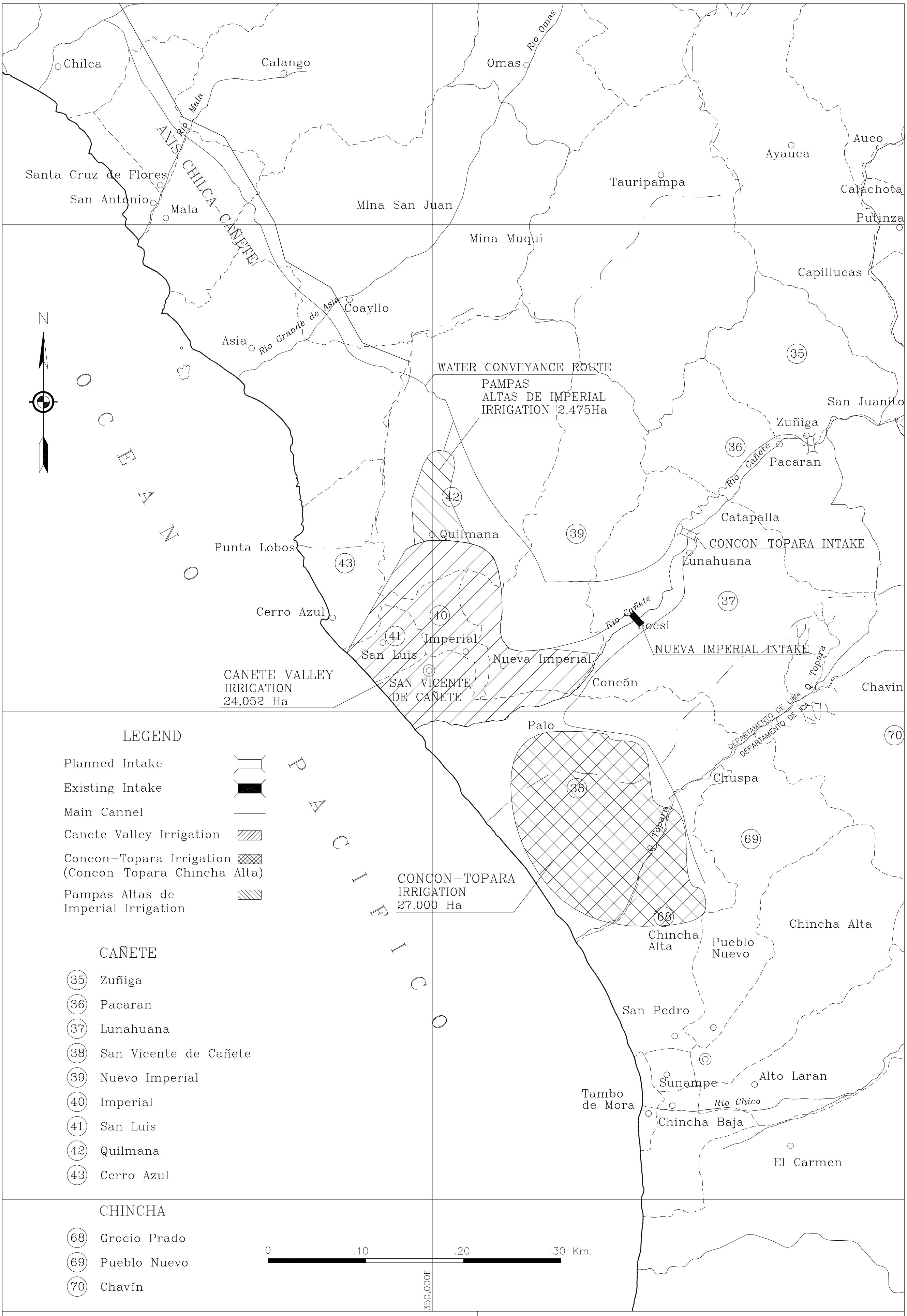


Figure 1.12
Demand - Supply Balance and Proposed Expansion System for Metropolitan LimaWater Supply System



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

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Figure 1.13

Map on Irrigation Areas