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REPUBLIC OF PERU

SERVICIO DE AGUA POTABLE Y ALCANTARILLAD DE LIMA

(SEDAPAL)

THE FEASIBILITY STUDY ON THE IMPROVEMENT OF SEWERAGE SYSTEM IN SOUTHERN PART OF LIMA

FINAL REPORT

VOLUME II
MAIN REPORT

MARCH, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of Peru, the Japanese Government decided to conduct a Feasibility Study on the Improvement of the Sewerage System in the Southern Part of Lima and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Peru a survey team headed by Mr. Hiroshi Irie, Nippon Jogesuido Sekkei Co., Ltd., from April to June, 1989, and from October to November, 1989.

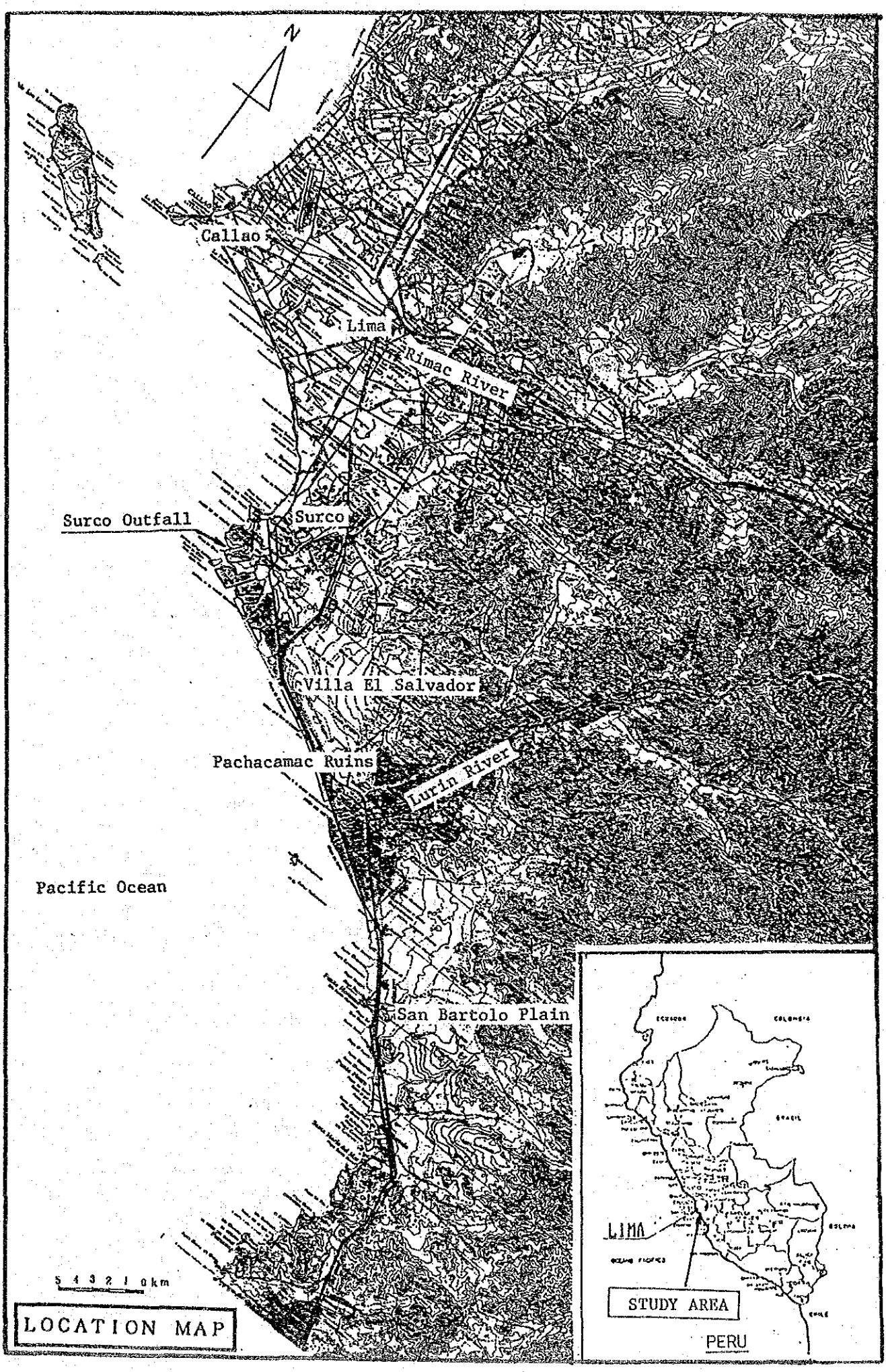
The team held discussions with concerned officials of the Government of Peru, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Peru for their close cooperation extended to the team.

March, 1990

Kensuke Yanagiya
President
Japan International Cooperation Agency


N
Callao
Lima
Rimac River
Surco Outfall
Surco
Villa El Salvador
Pachacamac Ruins
Lurin River
Pacific Ocean
San Bartolo Plain
5 4 3 2 1 0 km
LOCATION MAP
LIMA
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PERU

FEASIBILITY STUDY
ON
IMPROVEMENT OF SEWERAGE SYSTEM
IN
SOUTHERN PART OF LIMA

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ABBREVIATIONS AND ACRONYMS

UNIT

CFU:	colony formed unit
cu.m/s:	cubic meter per second
ha:	hectare
I/.:	Peruvian intis
kg/cm^2:	kilogram per square centimeter
kW:	kilowatt
kWH:	kilowatt-hour
l/capita/day:	liter per capita per day
lpcd:	liter per capita per day
m:	meter
m^2:	square meter
m^3:	cubic meter
m^3/m^2/day:	cubic meter per square meter per day
m^3/min:	cubic meter per minute
m^3/s:	cubic meter per second
m^3/sec:	cubic meter per second
m^3/year:	cubic meter per year
µg/kg:	microgram per kilogram
mg/kg:	miligram per kilogram
µg/l:	microgram per liter
mg/l:	miligram per liter
mm:	milimeter
MPN/100ml:	most probable number per 100 mililiter
m/s:	meter per second
µS/cm:	micro-siemens per centimeter
MW:	megawatt
%:	percentage
ppb:	parts per bilion
ppm:	parts per milion
sec.:	second
ton/m^2:	ton (metric) per square meter
ton/m^3:	ton (metric) per cubic meter
US$:	United States dollar
Yen:	Japanese yen

ORGANIZATION

CEPIS:	Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (Pan American Center for Sanitary Engineering and Enviromnmental Sciences)
DITESA:	Direccion Tecnica de Salud Ambienta, Ministerio de Salud (Environmental Health Technical Ofiice, Ministry of Health)
GOJ:	Government of Japan
GOP:	Government of Peru
IMARPE:	Instituto del Mar del Peru (Peruvian Institute of the Sea)
INE:	Instituto Nacional de Estadistica (National Institute of Statistics)
JICA:	Japan International Cooperation Agency
SEDAPAL:	Servicio de Agua Potable y Alcantarillado de Lima (Lima Water Supply and Sewerage Service)
SEDTACNA:	Servicio de Agua Potable y Alcantarillado de Tacna (Tacna Water Supply and Sewerage Service)
SENAPA:	Servicio Nacional de Abastecimiento de Agua Potable y Alcantarillado (National Water Supply and Sewerage Service)
UNI:	Universidad Nacional de Ingeneiria (National University of Engineering)

OTHERS

AL:	Aerated Lagoon System
ASP:	Activated Sludge Processing System
BOD:	Biological Oxigen Demand
BOD_5:	Biological Oxigen Demand in 5 days
COD:	Chemical Oxigen Demand
D/S.H:	Direct Water Supply High Consumption
D/S.L:	Direct Water Supply Low Consumption
EAP:	Exrended Aeration Processing System
EIRR:	Economic Internal Rate of Return
FIRR:	Financial Internal Rate of Return

GDP:	Gross Domestic Product
G.F.:	Grabity Flow
GL:	Ground Level
GNP:	Gross National Product
HWL:	High Water Level
I.D:	Indirect Water Supply
IRR:	Internal Rate of Return
I.S.:	Inverted Siphon
LWL:	Low Water Level
MUC:	Mercado Unico de Cambios (Sole Market Exchange Rate)
OD:	Oxidation Ditch System
SS:	Suspended Solid
STP or S.T.P.:	Sewage Treatment Plant
TF:	Trickling Filter System
WSP:	Waste Stabilization Pond System

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Metropolitan Lima, the capital of the Republic of Peru, has a population of around 6 million people, roughly one-third of the country's total population. According to studies conducted in year 1985, the domestic sewage and industrial wastewater generated daily by the city amounts to approximately 16 m^3/sec.

The first sewers that were constructed in Lima in 1859 were brick-lined conduits. At present, some 6,000 kilometers of sewer lines have been laid covering an area of about 30,000 hectares. The sewage collection system is of the separate sewer type designed to carry only sanitary sewage since the annual rainfall amount is very minimal. The sewerage system of the city consists of several watersheds: four (4) large sewer systems discharging to the Pacific Ocean; three (3) including the Chosica sewerage system to the Rimac river (Rio Rimac); and one (1) to an irrigation area (San Juan).

Treatment of sewage is carried out at two treatment plants located in San Juan and Chosica, which have capacities of 21,600 m^3/day and 12,000 m^3/day, respectively. The latter plant, completed in October 1988, was provided under a Japanese Government Grant-in-Aid Program. Since the combined capacity of the two plants is only about 0.4 m^3/sec, most of the remaining sewage is discharged without any treatment down the cliffs fronting the Pacific Ocean coast, through four (4) main drainage pipes in Surco, Costanero, Callao and Comas. Two (2) main sewers, namely the Colector No.6 and the Colector No.19 discharge directly to the Rimac river.

This untreated sewage is visibly contaminating Lima's coast and beaches and has become a social problem. From the point of view of environmental conservation, some form of measures must be taken, but to carry out treatment of 16 m^3/sec of sewage is an enormous task requiring an equally enormous investment entailing many years of work, as what has been done in industrially advanced countries.

Rainfall on area along the Pacific Ocean coast of Peru is excessively

low, thus in the area the soil is arid, there is no vegetation, and the whole land surface is beige in color.

After being treated at the San Juan Stabilization Pond discharged sewage is reused for irrigation in agriculture and forestry. Recently, an experiment in aquiculture using treated water has been carried out by an international research institute.

In some areas with no water for irrigation, raw sewage is often used to cultivate crops, although this is prohibited by the concerned authority. Lawn and trees in the parks in the urbanized area of Lima, are sometimes irrigated by damming up the surrounding sewers such that the streets and pavements are flooded. The aesthetic contribution of the parks to the environment is one positive aspect in the reuse of sewage for irrigation.

This was the background situation of the Government of Peru, when it conducted initial inquiries on this Project in August 1986, with the Japanese Government.

In September 1988, it presented an official request with a Terms of Reference giving priority to the plan for the improvement of the environment through improvement of the sewerage system, with the southern part of Lima as objective.

The Japanese Government, responding to the request from the Peruvian Government, decided to carry out a feasibility study of the proposed project and dispatched to the subject area a preliminary survey team through the Japan International Cooperation Agency (hereinafter referred to as JICA) between the end of November and the beginning of December 1988. Investigation on the problem of the existing sewerage system was made in coordination with the Servicio de Agua Potable y Alcantarillado de Lima (hereinafter referred to as SEDAPAL), which is the counterpart agency for the study. The Scope of Work for this study was agreed between the JICA preliminary survey team and the SEDAPAL in Lima on December 7, 1988.

1.2 Objectives of the Study

Based on the Peruvian Government's request, the objectives of this study are:

- To carry out a feasibility study relating to the improvement of the existing sewer system in the southern part of Lima and, subsequently, to carry out the feasibility study relating to the plan for constructing a Treatment Plant, and

- To transfer the technology to Peru through activities of the study team.

1.3 Scope of the Study

1.3.1 Study Area

The area to be studied covers from an intake point to be constructed at the middle point of the Colector Surco and/or other trunk sewers, to the Quebrada Pucara northern boundary of the San Bartolo plain.

1.3.2 Target Year

The target year for the Project in this study is year 2000.

1.3.3 Outline of the Study

Based on the Agreement and the Minutes of Meeting prepared on December 7, 1988 by the preliminary survey team of JICA, the study which consisted of field work in Peru and the home office work in Japan, covers the following items in pursuit of the objectives mentioned above.

- Data collection and review
- Field survey
  - Sewage quantity and quality

  - Topographic survey and soil investigation
- Preparation of alternatives
- Identification of the optimum plan
  - Facilities planning
  - Implementation planning
  - Organization, operation and management planning
- Evaluation of the proposed system

CHAPTER 2

DESCRIPTION OF THE STUDY AREA

CHAPTER 2 DESCRIPTION OF THE STUDY AREA

2.1 Brief History of Metropolitan Lima

Metropolitan Lima is composed of the Province of Lima and the Constitutional Province of Callao. The history of the principal part of Lima province actually began in 1535, when Francisco Pizarro of Spain, after conquering the Inca Empire capital of Cusco, decided on a new capital for the Colony of Peru. The first site chosen was Jauja, in the mountains but due to unfavorable climatic conditions, he finally settled on the Rimac valley on the coast. On January 18, 1535, in the present Plaza de Armas, he laid the first cornerstone of the Cathedral and began construction. There were only 71 people at that time.

Later on, the city of Lima which was considered by Spain as the central administration base for its colony, flourished as the prime city in South America.

After July 28, 1821 when the independence of Peru was proclaimed, Lima prospered as the capital of the Republic of Peru. At about that time (1820) it had 64,000 inhabitants. Population increased rapidly during the Second World War with the annexation of the neighboring Constitutional Province of Callao to Metropolitan Lima. Together, the city grew fast, and in recent years, especially in the southern part of the city, the zone has extensively developed outwards.

At present, 1989, the population of Metropolitan Lima is estimated to exceed six million, of which nearly half are people who have migrated from the hinterlands of the country. Most of these migrants live in new areas called "Pueblos Jóvenes" (young towns - shanty towns) and consider an improvement in their living environment to be of utmost importance.

FIGURE 2-1 shows the historical changes in the population of the province of Lima including the subject area of the study, which covers around a half of Metropolitan Lima.

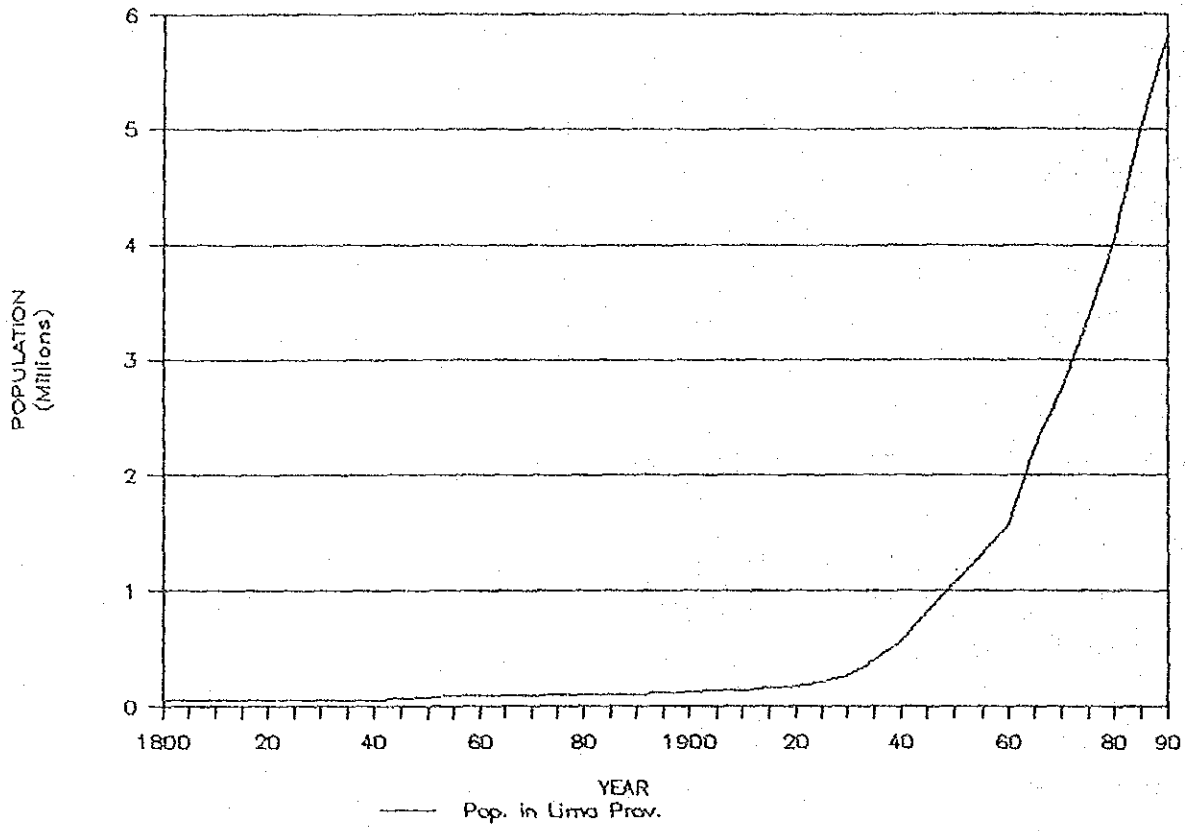


FIGURE 2-1 TRANSITION OF POPULATION
(LIMA '87)

2.2 Natural Condition

2.2.1 Location

Peru is located in the South American Continent, between the southern latitudes of 0 degrees 48' and 18 degrees 21' and the western longitudes of 8 degrees 21' and 68 degrees 48'. It covers 1,280,000 km^2 and is 3.4 times the size of Japan. It is bordered on the north by Ecuador and Colombia, on the east by Brazil and Colombia, and on the south by Chile.

The subject area of the study is located in southern part of Metropolitan Lima, the capital of Peru, and includes 16 districts of the 41 districts which make up the province of Lima. (It does not include the 6 districts of the constitutional province of Callao.)

The province of Lima covers 2,800 km^2 and has around 6 million inhabitants. This Project includes 122 km^2 of the province and 1,800,000 of its inhabitants. Since 1960, the inhabitants have migrated from the rural zones towards the capital, forming extensive marginal zones called "Pueblos Jóvenes" (young town). The study especially includes these zones because they are in immediate need of water supply and sewerage service.

2.2.2 Topography and Geology

(1) Topography

Peru is located on the western side of the South American continent and in the central zone of the Great Cordillera which runs through the continent. This great cordillera, also known geographically as the Peruvian Andes, is made up of peaks at 5,000 m above sea level and its highest peak, Huascaran, reaches 6,768 m above the sea level.

The cordillera of the Andes which runs through Peru from north to south, parallel to the coast, divides Peru into three regions: coast, mountains and forest.

The coast is a narrow strip about 2,000 km long. Its widest zone is

about 200 km wide and at its narrowest, the mountains come down to the sea itself, forming cliffs that rise abruptly from the sea. The coast is mostly desert, except where rivers cross the coast to the sea.

The mountains are made up of plateaus which form the Andean cordillera and whose highest peaks are over 5,000 m above sea level.

The forest is on the eastern side of the Andean cordillera. It is the zone which feeds the Amazon River. It is a very dense jungle, with abundant rainfall and accounts for 50% of all of Peru.

Lima is situated on the coast of a fan shaped valley formed by the rivers, Rimac, Chillon and Lurin. It is an at attitude of 40 to 200 m above sea level. The zone of the current project is in the southern part of the city of Lima and falls between the Rimac and Lurin Rivers. Except for the river valleys, which is low terrain, all is desert and there are cliffs along the shore. The lands in the river valleys have a grade of less than 5% and the desert zones have grades of over 5% sloping towards the sea. FIGURE 2-2 shows the topographic configuration of the zone.

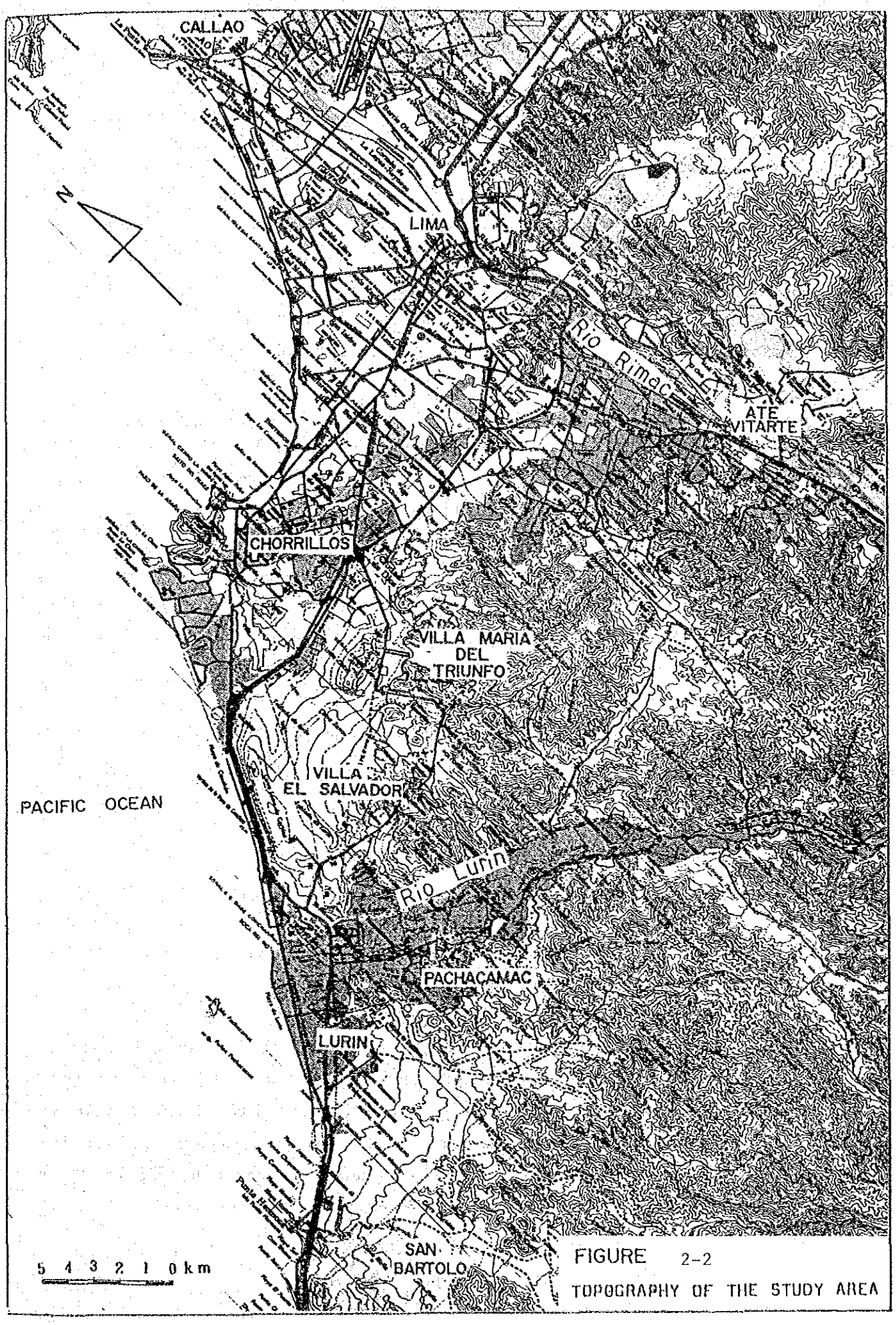


FIGURE 2-2

TOPOGRAPHY OF THE STUDY AREA

(2) Geological Configuration

Geologically, Peru can be divided into 4 formations or strata: the strata of the Mesozoic-Triasic era (250 million years ago) which is located in the Andean cordillera and in the area of Punto Hornillos; the strata of the Mesozoic-Cretaceous (64 million years ago) which is located on the western edge of the Andean Cordillera; the strata of the Tertiary era (1,7000,000 years ago) which is located in the area of Otuzco, Canta, Coracora, Arequipa and the Amazon forest region; and lastly the strata of the Quaternary era (less than 1,700,000 years ago) which is located on the coastal zone between Lima and Nazca.

In the area of north of Lima, there exists a geological constitution that has as its base the Tertiary strata, whose upper level is covered with sands from the Quaternary era. These sands can be divided into three classes:

a) Sands deposited by the river
b) Sands from fluvial terraces
c) Sands from dunes formed by aeolian deposits

These three types of sand formations can be described simply as follows:

a) These sands are accumulated by the Rimac and Lurin rivers and other small seasonal rivers. Their grain size varies, their compacting is good and they have low permeability. The valley width, resulting from the rivers, is varied and the topographical changes in the valleys are not very pronounced. The top level of soil is of varied thickness.

b) These sands are found on the sides of the river valleys and formed over a long period of time by the coastline combined with the formation of mountains, the rising of the sea level and floods. The grain size varies, their compacting is relatively good and permeability is normal. The top soil layer is relatively thin and the surface has a slight grade.

c) This strata was formed by aeolian deposits. A thicker layer has been deposited where the land was flooded than in sloped areas. The grain size is uniform, its compacting is not good and it is highly permeable. The thickness is not uniform, its surface has the characteristic shapes blown by the wind and its grade is not uniform either.

FIGURE 2-3 shows the geological map of study area.

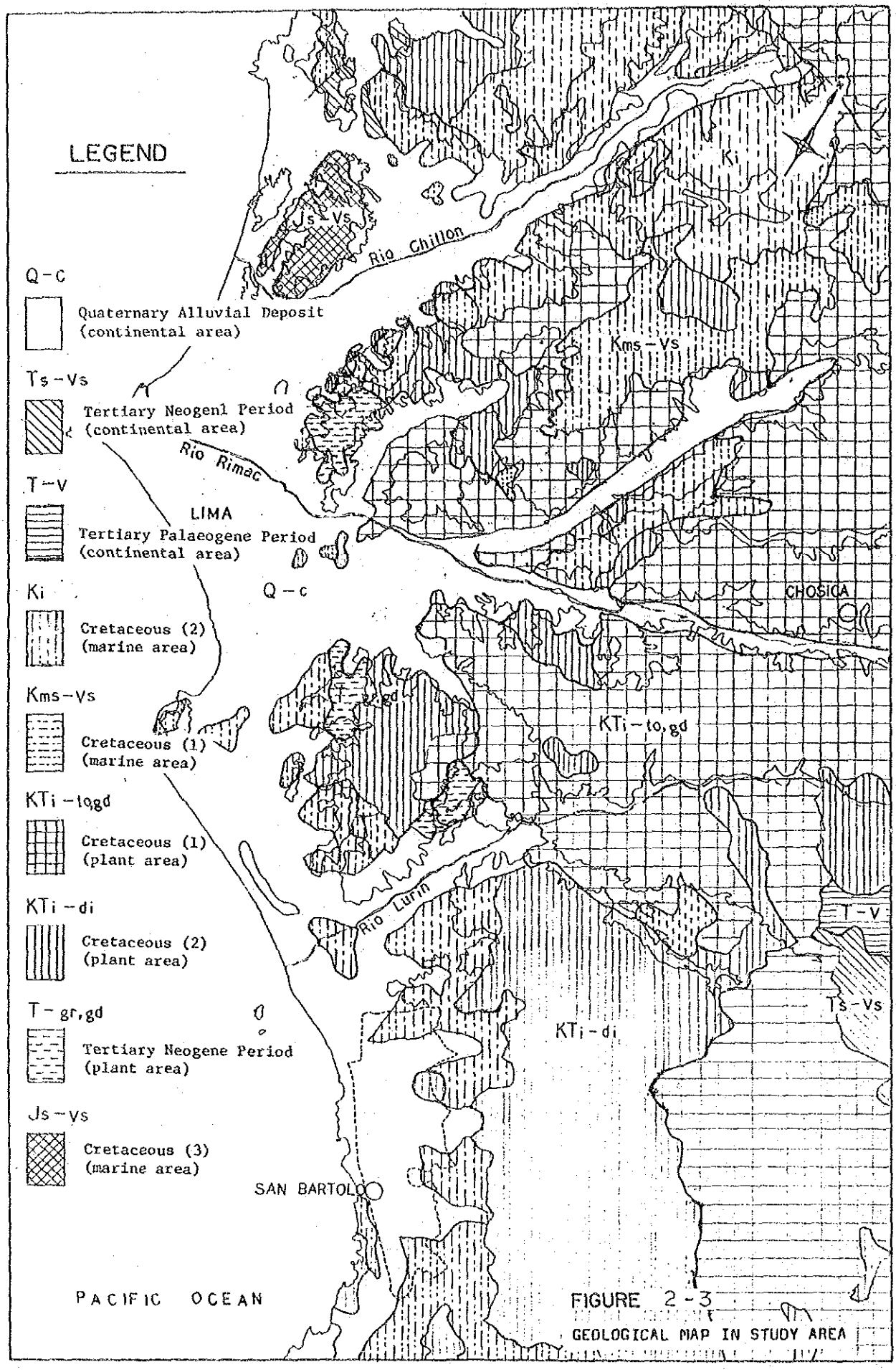


FIGURE 2-3
GEOLOGICAL MAP IN STUDY AREA

2.2.3 Rivers and Sea

(1) Rivers

Within Metropolitan Lima there are three rivers: the Rio Chillon (Chillon river) which runs in the central and northern part, the Rio Rimac (Rimac river) which is Metropolitan Lima's most important source of water supply and cuts through the heart of city, and the Rio Lurin (Lurin river), which lies in the area covered by the present study.

The three rivers rise in the snow-capped peaks of the Andes mountain range, and run down in a south-westerly direction to empty into the Pacific ocean.

In the summer they are swollen by the rains and the thaws in the mountains and the waters are used daily by the villagers living on their banks; the downstream of river is a very important source of water supply in Metropolitan Lima. Moreover, these waters are distributed through irrigation channels, so-called "acequia", for irrigating agriculture, and for parks and green areas in the urban area.

In the winter, the Andes range freezes up and this, together with the scanty rainfall reduces the discharge of the rivers radically, and adversely affects the utilization of same for irrigation of parks, for potable water use for the city, to such an extent that water has to be provided in sufficient quantities for daily life. FIGURE 2-4 shows the location of the rivers.

a) Chillon River

This river runs through the northern side of central Metropolitan Lima and provides a relatively small quantity of water during the year.

In the Metropolitan Lima, it is mainly used for agriculture, the quantity of water provided for agriculture in 1987, during its maximum flow, amounting to 4.9 m^3/sec.

In the year 2000, due to the reduction of the agricultural area, it is expected that this quantity of water may be used to supply water for domestic use.

It is estimated that the amount of water consumption for domestic use will increase by 0.6 m^3/sec.

b) Rimac River

This is the largest river in Metropolitan Lima, and runs through the center of it, but the discharge varies greatly from summer to winter. In its upstream areas, there are mining zones and paper-producing factories, and areas of constant landslides and avalanches; the quality of the river water changes notably, beginning with the turbidity.

It is the main source of water supply and very important to the Metropolitan Lima. The present volume of drinking water is 16.5 m^3/sec, for parks and agriculture 4 m^3/sec, and a minimum amount emptying from the river into the sea of 7.8 m^3/sec in summer season.

c) Lurin River

This river runs through the southern part of Lima, with a discharge that varies greatly according to the season, its winter volume being equal to 0 m^3/sec.

At present it is used practically totally for agriculture, the potable water being river-bed water of the river, as in wells, etc. (approximately 2.0 m^3/sec.).

There are projects being carried out at present to convert the water use from agricultural to potable water.

TABLEs 2-1 to 2-3 show the annual variations of the water volume of the Chillon, Rimac and Lurin rivers.

FIGURE 2-4 LOCATION OF RIVERS

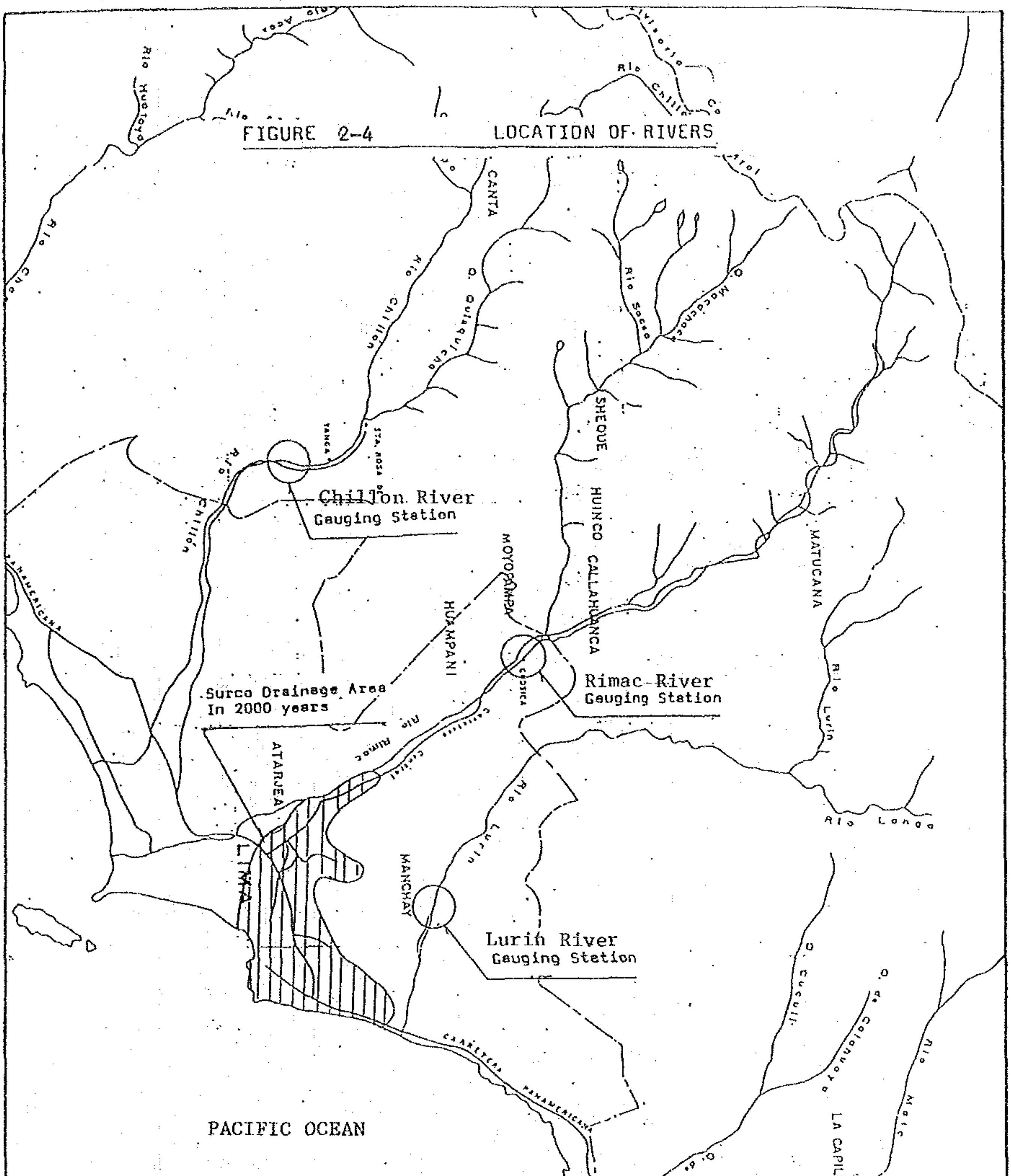


TABLE 2-1 CHARACTERISTICS OF MONTHLY AND ANNUALLY DISCHARGE OF CHILLON RIVER

Gauging Station: Huarabi Bridge-Magdalena Bridge

Location: Longitude: 76°50'

Latitude: 11°41'

Height: 950 metres above sea level

Extension of the watershed down to the Gauging Station:

Total Area: 1241 Km²

Wet Area: 1010 Km²

Recorded Period: 1920-1965

DESCRIPTION	UNITS	MONTHS											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Daily median minimum	m3/seg.	0.42	0,60	0.80	0.64	1.98	2,00	2,30	0.30	0.56	0.39	0.44	0.47
Monthly median minimum	m3/seg.	0.69	0.81	0.96	1.71	5.91	12.34	3.81	1.47	0.85	0.51	0.54	0.65
Monthly module	m3/seg.	1.92	2,46	4.95	12,96	24.18	30.84	16.13	6.31	3.07	2,52	1.83	1.70
Monthly median maximum	m3/seg.	6.13	8.83	20.68	62,84	57.25	59.18	70.57	69.60	8.43	6.72	5.29	6.34
Daily median maximum	m3/seg.	15.00	12.50	54.60	150.17	91.85	180.13	153.70	112.00	18.00	7,54	5.92	6.50

Annual module: 8.97 m3/seg.

Annual Median Maximum: 29.30 m3/seg.

Annual Median Minimum: 4.30 m3/seg.

Hourly Maximum: 180.13 m3/seg.

Hourly Minimum: 0.30 m3/seg

Annual Median Volume : 282'940,000 m3.

Annual Maximum Volume : 924'000,000 m3.

Annual Minimum Volume : 135'600,000 m3.

Annual Median Yield

Total Basin : 228,000 m3/Km2

Wet Basin : 280,000 m3/Km2

TABLE 2-2 CHARACTERISTICS OF MONTHLY AND ANNUALLY DISCHARGE OF RIMAC RIVER

Gauging Station: Chosica (1)
Location: Longitude: 76° 41'
Latitude: 11° 56'
Height: 850 metres above sea level

Extension of the watershed down to the Gauging Station:
Total Area: 2,311 Km2.
Wet Area: 1,998 Km2.

Recorded Period: 1921-1972

DESCRIPTION	UNITS	MONTHS											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Daily median minimum (2)	m3/seg.	5.63	5.64	10.90	13.05	13.05	18.90	14.19	7.35	6.66	6.00	5.75	5.85
Monthly median minimum	m3/seg.	9.69	9.07	9.92	9.44	26.90	39.80	16.93	12.41	6.96	6.75	7.35	7.20
Monthly module	m3/seg.	13.55	15.27	22.86	40.14	64.05	79.14	41.51	21.26	13.68	11.70	11.45	12.49
Monthly median maximum	m3/seg.	22.79	29.52	40.38	85.12	136.11	145.17	75.82	46.24	22.43	16.05	14.86	15.00
Daily median maximum (2)	m3/seg.	51.00	45.00	98.80	184.60	480.00	500.00	203.00	67.80	35.40	22.10	21.70	22.80

Annual module: 28.76 m3/seg.
Annual Median Maximum: 37.14 m3/seg.
Annual Median Minimum: 20.44 m3/seg.
Hourly Maximum: 500.00 m3/seg.
Hourly Minimum: 5.63 m3/seg.

Annual Median Volume : 907'010,000 m3.
Annual Maximum Volume : 1,174'460,000 m3.
Annual Minimum Volume : 644'600,000 m3.

Annual Median Yield:
Total Basin: 392,000 m3/Km2
Wet Basin : 454,000 m3/Km2.

(1) Does not include Marcapomacocha derivation

(2) The 1965-1868 period not considered

TABLE 2-3 CHARACTERISTICS OF MONTHLY AND ANNUALLY DISCHARGE OF LURIN RIVER

Gauging Station: Puente Manchay
Location: Longitude: 76° 50'
Latitude: 12° 09'
Height: 206 metres above sea level

Extension of the watershed down to the Gauging Station:
Total Area: 1,425 Km2.
Wet Area: 788 Km2.

Recorded Period: 1938 - 1968 (1)

DESCRIPTION	UNITS	MONTHS											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Daily median minimum(2)	m3/seg.	0.00	0.00	0.00	0.00	0.00	1 60	0.00	0.00	0.00	0.00	0.00	0.00
Monthly median minimum	m3/seg.	0.00	0.00	0.00	0.00	7.25	9.11	0.95	0.00	0.00	0.00	0.00	0.00
Monthly module	m3/seg.	0.01	0.41	1.44	5.56	15.64	19.13	8.36	2.44	0.78	0.16	0.03	0.00
Monthly median maximum	m3/seg.	0.19	3.29	11.59	20.87	35.17	46.97	30.48	13:86	5.89	1.08	0.18	0.07
Daily median maximum(2)	m3/seg.	0.75	8.20	20.00	100.00	88.00	68.00	55.00	15.20	11.30	2.52	0.30	0.12

Annual module: 4.43 m3/seg.
Annual Median Maximum: 8 03 m3/seg.
Annual Median Minimum: 1.99 m3/seg.
Hourly Maximum: 100.00 m3/seg.
Hourly Minimum: 00.00 m3/seg.

Annual Median Volume: 139'700,000 m3
Annual Maximum Volume: 253'230,000 m3.
Annual Minimum Volume: 62'930,000 m3.

Annual Median Yield:
Total Basin: 98,000 m3/Km2.
Wet Basin: 177,000 m3/Km2.

(1) Figures for the May 1961-September 1985 period have been estimated.

(2) Maximums and minimums are given for the period from October 1938 to March 1961.

(2) Sea

The cold Humboldt Current runs northward through the offshore of Metropolitan Lima, coming from the Antarctic Ocean, and the Chilean coast. This sea current, named after its discoverer, Alexander Humboldt, changes course westwards below the southern part of Ecuador, becoming the South Equatorial Current.

The South Equatorial Current changes course again to the south near New Guinea, passing the western coast of Australia and returning to the Antarctic Ocean to become, once again, the Humboldt Current.

The Humboldt Current running from Chile, up Peru to Piura, is especially called the Peruvian Current, and has an average velocity of 28 km/day, an average temperature of 19°C, warming to 21°C in the summer and dropping to 17°C in the winter. Moreover, the salinity is approximately 35 g/l.

Peruvian government insists that it has sovereignty over the seas within 200 miles from its coastline, including the fish, shellfish, and other marine life within this extension of ocean. The ocean near Peruvian coast is one of the most abundant fishing zones in the world, Peru being the world leader in fish-meal production. In this fishing zone, the warm Equatorial Contra Current coming from the Gulf of Guayaquil in Ecuador, clashes with the cold Peruvian Humboldt Current, giving rise to a great volume of plankton. The continental shelf, less than 200 m. deep, is very wide and the sun's rays penetrate deeply, and this, together with the flow of cold sea waters in the ocean depths between Peru and Chile, is considered to be the cause of the great quantity of marine life and chlorophylls.

Sometimes, due to the strong flow of the warm current running south, towards the Department of Ica, south of Lima, there are heavy rainfalls over the Peruvian coast, giving rise to a condition known as the "Corriente del Niño" (the Babe's Current) which greatly influences the catch of fishing at that time.

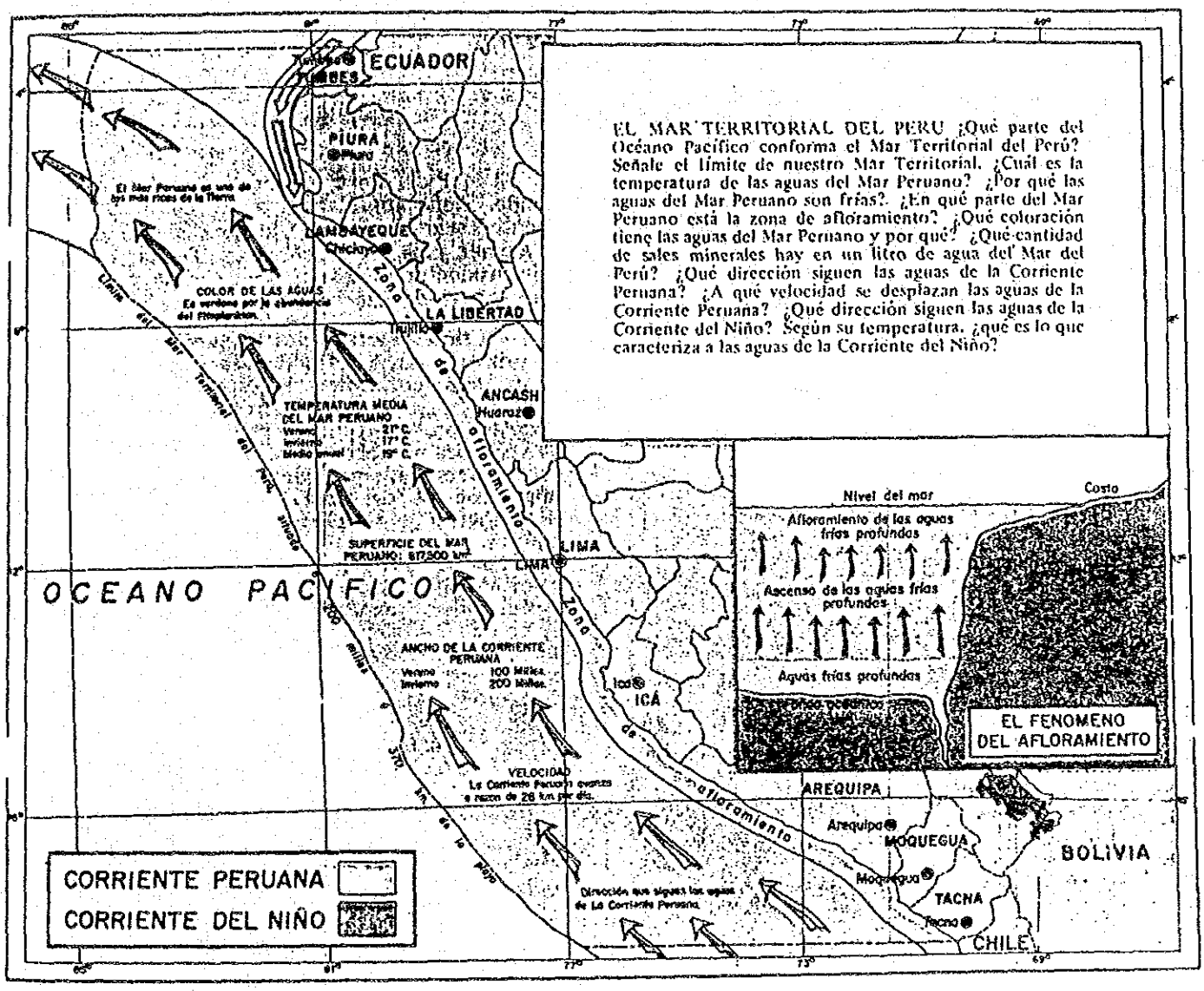
The warm current of the Equatorial Contra-Current comes down mainly to the northern zone of Peru and, since it raises the temperature and the

humidity of the air over the coastal provinces it brings plentiful rains which give rise to vegetative prairies. Peru, on the central and southern coast, although a tropical area, is temperate as a result of the Humboldt current, and the high humidity in the air forms clouds. These clouds prevent the sun's rays from penetrating, resulting in mists, which do not become rainfall, and as a result, the coast is desert.

The marine area of Peru can be said to have a strong and varied influence on the fishing and on the coastal agro-industry.

The condition of sea current in the offshore of Peru is shown in FIGURE 2-5.

FIGURE 2-5 CURRENT IN THE OFF SHORE OF PERU



2.2.4 Natural Disasters

The study area geographically belongs to the sub-tropical desert type climate area. The earth has a predominantly dry climate but humidity of air is high due to the influence of the ocean's cold Humboldt Current. In the winter, a season in which there is no snow melt in the Andean cordillera and no precipitation in the forest, the discharge of the coastal rivers decreases greatly. But provision of water during this season is assured by groundwater through wells. There are no hurricanes, nor seasonal windstorms, and it may be concluded that there is practically no damage caused by stormwater.

The only natural disasters that could occur would be earthquake. In the zone of the Andes, the land has a greater propensity for disaster due to earthquakes, but these areas are far from Lima.

With modern techniques of architecture, enormous high buildings are currently being built. At the same time, there is increasing construction of brick houses which are more fragile in earthquake. But since they are generally low buildings, earthquake damage is slight.

TABLE 2-4 shows the latest earthquakes which have occurred in Peru. TABLE 2-5 shows the earthquakes which have occurred in the area of Metropolitan Lima.

There are no landslide nor debris flow problems in the study area since there are no steep slopes nor precipitation except for the San Bartolo Plain where many trace of debris flow can be found.

TABLE 2-4 Latest Earthquakes in Peru

Fecha	Hora (TMG) H M S	Posición Lat.S	Long.O	Prof. km.	Mag.	Región afectada
13-01-1960	15:40:24	16.0	73.0	63	7.5	Arequipa
15-01-1960	09:30:19	15.0	75.0	150	7.0	Nazca
09-03-1960	23:54:26	16.0	72.0	——	6.0	Arequipa
20-11-1960	22:01:56	6.7	80.8	——	6.75	costa de Lambayeque
28-01-1961	03:24:50	13.7	75.8	——	5.0	Mala-Cañete
03-07-1961	14:49:31	8.6	79.2	25	——	Trujillo
04-03-1962	00:41:39	10.6	75.8	20	——	Junín
18-04-1962	19:14:39	9.9	78.9	39	6.75	Casma
30-08-1963	15:30:00	7.1	81.0	33	6.5	Trujillo
17-09-1963	05:54:34	10.6	78.2	61	6.75	Ancash
24-09-1963	16:30:16	10.6	78.0	80	7.0	Ancash
26-01-1964	09:09:34	16.3	71.7	116	6.3	Arequipa
08-05-1965	22:23:00	13.7	71.6	20	4.3	Ureos
30-07-1965	05:45:16	18.0	70.6	73	5.5	Arequipa
17-10-1966	21:41:57	10.7	78.6	38	7.5	Norte de Lima
19-06-1968	08:13:36	5.6	77.2	28	7.0	Moyobamba
28-09-1968	13:53:35	13.1	72.4	66	6.3	Mala - Pisco
05-02-1969	04:10:13	8.1	80.1	——	6.5	——
24-07-1969	02:59:21	11.8	75.1	1	5.6	Pariahuanca
01-10-1969	05:05:43	11.6	75.2	43	6.2	Pariahuanca
14-02-1970	11:18:00	9.9	75.6	35	5.9	Panao
31-05-1970	20:23:29	9.2	78.8	43	7.7	Chimbote-Huaraz
10-12-1970	04:34:39	4.0	80.7	25	7.1	Querocotillo
05-05-1971	17:28:11	8.3	77.8	34	4.9	Quiches
10-06-1971	06:47:35	10.8	76.2	89	5.7	Pasco
11-06-1971	01:33:00	4.2	80.7	43	5.4	Tumbes
24-09-1971	04:32:55	16.4	73.7	37	5.6	Arequipa
15-10-1971	10:33:47	14.2	73.5	54	5.7	Apurimac
22-03-1972	07:34:00	6.8	76.8	64	6.5	Juanjuí
18-08-1972	14:50:51	13.9	74.6	14	5.4	Ayacucho
05-01-1974	08:33:51	12.3	76.4	98	6.6	Huarochirí
03-10-1974	14:21:29	12.3	77.8	13	7.5	Lima y Sur

SOURCE : HISTORIA DE LOS SISMOS MAS NOTABLES OCURRIDOS EN EL PERU, MINISTERIO DE ENERGIA Y MINAS.

TABLE 2-5 Main Earthquakes in Metropolitan Lima

Fecha		Hora local	Epicentro Aproximado Lat. S.	Long W	L u g a r	Magnitud
22 Enero	1582	11:30	16.3	73.3	Costa Dpto. de Arequipa	7.9
9 Julio	1586	19:30	12.2	77.7	Costa Dpto. de Lima	8.1
24 Noviembre	1604	13:30	18.0	71.5	Costa de Moquegua y Tacna	8.4
14 Febrero	1619	11:30	8.0	79.2	Costa de Trujillo	7.8
31 Marzo	1650	14:00	13.8	72.0	Cuzco	7.2
13 Noviembre	1655	14:38	12.0	77.4	Frente Isla San Lorenzo	7.4
12 Mayo	1664	04:15	14.0	76.0	Ica	7.8
20 Octubre	1687	05:30	13.0	77.5	Costa Sur Dpto. Lima	8.2
28 Octubre	1746	22:30	11.6	77.5	Costa Norte Dpto. de Lima	8.4
13 Mayo	1784	07:36	16.5	72.0	Costa de Arequipa	8.0
7 Diciembre	1806	18:00	12.0	78.0	Frente Pto. de Callao	—.—
10 Julio	1821	13:00	16.0	73.0	Costa de Arequipa	7.9
13 Agosto	1868	16:45	18.5	71.2	Costa de Tacna	8.6
9 Mayo	1877	20:28	19.5	71.0	Costa S. de Arica	——

NOTA: Las coordenadas del epicentro son aproximadas y son apreciaciones del autor. La magnitud instrumental, un concepto que se utiliza hoy en día para determinar el tamaño o grandor de un terremoto lo establece en base de las relaciones empíricas que ha encontrado entre la magnitud, intensidad y extensión areal de los sismos ocurridos en el Perú durante los últimos treinticinco años.

SOURCE : HISTORIA DE LOS SISMOS MAS NOTABLES OCURRIDOS EN EL PERU, MINISTERIO DE ENERGIA Y MINAS.

2.2.5 Meteorology

(1) General

Lima is located in the sub-tropical zone and be considered belonging to the desert type climate. Humidity is high due to the influence of the ocean's cold Humboldt current and Lima is covered with fog for almost three quarters of the year.

There are no considerable precipitations at any time of the year. The temperature difference between summer and winter is very small and the temperature difference between day and night is minimal (4 to 6 degrees Centigrade).

There are no hurricanes nor seasonal wind at any time during the year. The atmospheric pressure as well as the winds are stable.

(2) Temperature

Lima's average temperature year-round is 18 degrees Centigrade, relatively lower than that of Brazil in spite of being in the same latitude. This is due to the influence of the Humboldt current. The temperature does not vary throughout the year. The average temperature during the months from January to March is approximately 22 degrees Centigrade and the highest average temperature is in the month of March: 28.9 degrees Centigrade. The average temperature during the months from July to August is 15 degrees Centigrade and the lowest average is for the month of July: 12.7 degrees Centigrade.

TABLE 2-6 TEMPERATURE IN LIMA

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.
Monthly Average	22.1	23.0	22.4	21.8	19.1	17.5
Avg. Monthly Max.	28.8	28.9	28.9	27.2	25.0	22.9
Avg. Monthly Min.	17.5	18.5	18.3	16.7	14.9	14.2

Months	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Monthly Average	16.5	16.0	16.4	17.0	18.5	20.4	19.2
Avg. Monthly Max.	21.5	21.1	21.0	22.6	22.6	26.1	24.7
Avg. Monthly Min.	13.4	12.9	13.1	14.0	14.9	18.1	15.5

Source: Las Palmas Meteorological Observation Center, 1969-78

(3) Relative Humidity

In Lima, there are frequent heavy fogs. Many days of the year have relative high humidity. The annual average relative humidity is over 80%. The average maximum relative humidity is over 80%. The average maximum relative humidity for the month is over 95% for the whole year and the average minimum is over 60%, which shows that the humidity is very high all the year round.

TABLE 2-7 RELATIVE HUMIDITY IN LIMA

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.
Month.Av.Rel.Hum.	82.0	78.8	84.0	86.0	87.2	87.6
Avg. Monthly Max.	89.4	91.0	91.6	90.6	91.6	91.0
Avg. Monthly Min.	87.6	66.6	87.6	70.0	74.0	77.6

Months	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Month.Av.Rel.Hum.	87.8	88.6	88.0	86.2	84.2	82.0	85.2
Avg. Monthly Max.	90.4	91.8	91.6	90.4	87.0	86.8	90.4
Avg. Monthly Min.	76.4	78.0	76.8	72.8	69.4	67.4	75.4

Source: Las Palmas Meteorological Observation Center, 1969-78

(4) Precipitation

The annual average accumulation of precipitation in Metropolitan Lima is 30 mm. The month of August has the highest precipitation (7 mm) and the months of February to April have the lowest. It can be considered the precipitation in this area is practically zero.

TABLE 2-8 PRECIPITATION IN LIMA

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.
Avg.Month.Prec.	3.2	0.6	0.7	0.4	1.0	3.2

Months	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Avg.Month.Prec.	3.5	6.9	6.1	1.9	1.6	1.6	30.7

Source: Pachacamac Meteorological Observation Center, 1971-80

(5) Winds

Winds are predominantly from the south and secondarily from the southeast. Fifty percent of the data obtained throughout the year have shown no wind at 7:00 a.m. At 1:00 p.m, 20 - 25% of the winds have been from the south to south east at 2.3 - 4.5 m/sec. At 7:00 p.m., 50 - 70% of the winds have been from the south at 4.5 m/sec. and the rest have been light or non-existent. (Based on Data from Las Palmas Meteorological Observation Center, 1969-78)

(6) Others

The average annual accumulation of evaporation in the environment of Metropolitan Lima is on the order of 1,470 mm. The highest average is in the month of February and registers at 170 mm. The lowest average registers at 70 mm. in the month of July.

The minimum atmospheric pressure was registered during the months from July to September at about 12 mmHg. The maximum was registered between January to March at about 16 mmHg. The atmospheric pressure during the other months varies moderately.

The month of April registered the most hours of sun for the whole years 58 - 60 % (approximately 14 hours) and the month of August, the least: 14 - 16 % (approximately 3.5 hours). (Based on Data from Las Palmas Meteorological Observation Center, 1969-78)

2.3 Economy

2.3.1 Economic Structure

(1) Economic Growth

GDP (Gross Domestic Product) of Peru, which showed increase of 9.5% and 7.8% in 1986 and 1987, respectively, ended up in 1988 with a decrease of 8.4% as shown in TABLE 2-9. This resulted from the multiple exchange rates system under which import settlement rates for daily necessities were higher than those for other goods, as slashed prices of food and other goods, due to governmental subsidies. Raised minimum wages also caused increase of domestic consumption. It is through the expansion of domestic demand that the economic growth in 1986 and 1987 could be achieved.

The economic growth, however, led to reduced foreign currency reserves, which in 1988 turned minus despite the consecutive growths in the previous two years. Increased money supply necessarily resulted in inflation, and the price increase rate for 1986, 1987 and 1988 turned out to be 62.9%, 114.5% and 1,722.3% respectively.

Tightening financing policies, Peruvian Government has raised wages of public service personnel and controlled money supply in an attempt to strengthen the Inti against the U.S. dollar, or to induce Inti's appreciation, in order to avoid inflation. Today, difference with the free rates, however, is as high as 30 to 40%, and future devaluation rates will be set by taking inflation into account.

TABLE 2-9 shows recent gross domestic products of Peru, along with the growth rates of different industrial sectors.

TABLE 2-9 INCREASE OF GROSS DOMESTIC PRODUCT

Increment over year (%)

	1985	1986	1987	1988*
Agriculture	2.9	4.3	6.5	4.9
Fishing	17.1	32.1	-11.9	17.2
Mining	4.3	-4.5	-2.9	-18.7
Electricity	6.2	17.6	9.0	-0.4
Manufacturing	4.9	16.8	13.8	-14.3
Construction	-10.5	21.4	15.5	-5.4
Services	2.2	14.2	9.6	-9.9
Others	1.4	7.3	5.6	-5.4
G.D.P.	2.4	9.5	7.8	-8.4

*: Estimated

Source:INE(Instituto Nacional de Estadistica)

The good result of the fishery sector was owing to the favorable oceanic currents which contributed to the increased catch of major products such as fish meal anchovy and sardine.

The manufacturing, construction and commercial sectors, which made vigorous growths in 1986 and 1987 due to increased domestic consumption, were then on the decline because of reduced consumption under the accelerated inflation since late 1988.

(2) Industrial Structure

Peru is basically a nation which main products are primary products of agriculture and mining. TABLE 2-10 shows the breakdown of the GDP by industries.

TABLE 2-10 GROSS DOMESTIC PRODUCT (PRICE IN 1979)

Unit: I/.1000

	1985		1986		1987	
Agriculture-Forestry	414,334	11.7%	430,088	10.9%	456,323	10.9%
Fishing	29,102	0.8%	37,387	1.0%	31,779	0.8%
Mining	453,225	12.8%	432,491	11.0%	422,632	10.1%
Manufacturing	757,439	21.3%	921,245	23.4%	1,028,362	24.5%
Electricity -Water Supply	40,501	1.1%	45,354	1.2%	49,254	1.2%
Construction	163,958	4.6%	203,492	5.2%	235,644	5.6%
Services	617,520	17.4%	703,148	17.9%	755,795	18.0%
Transportation and Communication	237,808	6.7%	258,160	6.6%	277,264	6.6%
Banking and Insurance	329,117	9.3%	347,678	8.8%	377,273	9.0%
Public Administration	95,308	2.7%	97,931	2.5%	100,477	2.4%
Others	456,679	12.9%	487,837	12.4%	503,605	12.0%
(Banking Charges etc.)	(111,155)	-3.1%	(116,924)	-3.0%	(121,910)	-2.9%
Import Tax	67,639	1.9%	81,348	2.1%	84,449	2.0%
G.D.P. Total	3,551,475	100.0%	3,929,235	100.0%	4,200,947	100.0%

Source:INE(Instituto Nacional De Estadistica)

As seen from the table, the agriculture and forestry, fishery and mining industries accounted for 10.9%, 0.8% and 10.1%, respectively, of GDP in 1987. No major changes have been seen in the industrial structure of Peru, except in the manufacturing sector which showed 3% increase to 24.5% from 21.3% in 1985.

(3) Tourism

Ever before the reign of Spain, Peru has been blessed with natural tourist resources, and the present Peru Government has spared no effort to foster the tourist industry as an important means of acquiring foreign currency.

The number of tourists visiting Peru reached the all time high of 372,790 in 1980 and had ever since showed a gentle decline for several years. After that it again began to increase gradually until 1987 in which some 330,000 tourists visited Peru.

The tourists who visited Peru in 1987 were from Africa and Oceania (26.0%), Europe (14.2%), Asia (13.8%), and other parts of the world. The number of tourists from Latin America and North America (22.3%) increased by 9.1% and 8.3% respectively from those in the previous year. The total number of tourists who visited the Metropolitan area including Callao was 1,886,184, which consisted of 250,251 foreigners and 1,635,933 Peruvians. The average lengths of stay of some foreigners and Peruvians are 2.64 days/capita and 1.54 days/capita, respectively, with an average 1.69 days/capita.

In 1986, the Metropolitan area had 343 hotels, which is about 1.8 times more than the 194 in 1977. The number of persons to be accommodated increased from 13,644 in 1979 to 19,921 in 1986. Foreign currency revenues of Peru from tourism business amounted to 302 million dollars in 1986 and 393 million dollars in 1987, which are higher than revenues from fishery- related goods that are major exports of Peru. The amount of money spent by each tourist in 1987 averaged 1,191 dollars.

Major tourist spots in Lima include beach resorts extending north and such along the Pacific coast. Major beach resorts are as follows (from north to south):

Name of Coast	
1. Cantolado	7. Herradura
2. Arenilla	8. Villa
3. Marbella	9. Conchan
4. Miraflores	10. San Pedro
5. Barranco	11. Lurin
6. Agua Dulce	

FIGURE 2-6 give a map of the coast area around Lima. Although Chira is not a beach resort now, its resort plan (Chira Plan) is now being drawn

up jointly by the district of Chorrillos and the Metropolitan Government of Lima. This plan is intended for tourist development in the Lima area through the construction of a breakwater at the southern end of the coast and hotels, restaurants, parks, roads and houses along the coast.

However, Chira has an outfall of raw sewage (Surco Interceptor outfall) that has polluted seawater, posing a major environmental problem.

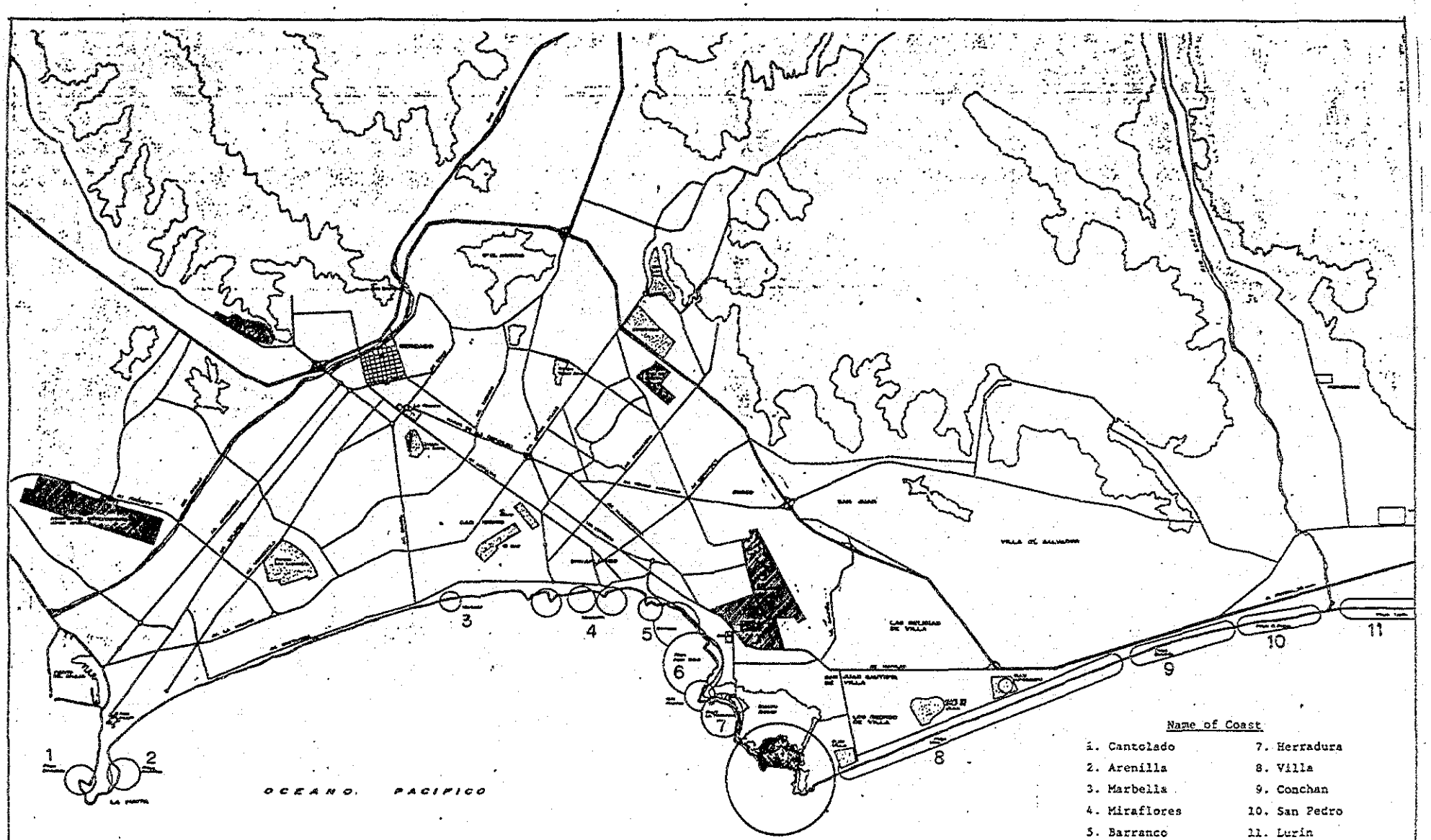


FIGURE 2-6 MAP OF THE COAST AREA ARDUND LIMA

2.3.2 Trade Balance

The trade surplus of Peru in 1985 was 1,172 million dollars but has been in the red since 1986. TABLE 2-11 shows major exports and imports in 1987 and 1988, along with their balances.

TABLE 2-11 TRADE BALANCE

Unit: US$1,000

		1987	1988	Increment
EXPORTS	Fish meal	229	364	59.0%
	Raw cotton	19	30	57.9%
	Sugar	15	16	6.7%
	Coffee	143	121	-15.4%
	Copper	516	608	17.8%
	Iron ore	58	59	1.7%
	Gold	1	3	200.0%
	Silver	93	60	-35.5%
	Lead	251	202	-19.5%
	Zinc	234	260	11.1%
	Petroleum	274	166	-39.4%
	Others	772	805	4.3%
	TOTAL	2605	2694	3.4%
IMPORTS	Consumer goods	405	276	-31.9%
	Raw material & Intermediate goods	1450	1584	9.2%
	Capital goods	923	687	-25.6%
	Others	290	203	-30.0%
	TOTAL	3068	2750	-10.4%
BALANCE		-463	-56	-87.9%

Source: INE(Instituto Nacional de Estadistica)

The trade balance in 1988 showed a deficit of 56 million dollars, 407 million dollar improvement from a deficit of 463 million in 1987. This mainly resulted from 318 million dollar decrease in import due to lack of foreign money reserves.

2.3.3 Inflation

As mentioned earlier, inflation has been greatly affecting people's living in Peru. The rate of increase of the general price index between January 1986 to April 1989 was as high as 26,730 or 2,046% a year. As men-

tioned in subsection 2.3.1, inflation intensified since mid 1987 and has accelerated during the last six or seven months. Inflation for the month of September 1988 hit the new high of 114.1% (which is almost equal to the annual inflation rate of 114.5% of 1987), and the monthly inflation rates of 1989 have so far hit more than 40% (47.3% for January, 42.5% for February, 42.0% for March and 48.6% for April). The Government has taken such measures as controlling money supply and raising minimum wages to cope with inflation. The actual wage index, however, lowered from 100 in 1979 down to 59.5 for public service personnel and 47.8 for private sector workers in 1988.

Consumption items that showed an extremely high rate of price increase include furniture, house rents, medical service and transportation. Partly for political reasons, the rate of increase of public utilities charges including water supply and sewerage between January 1985 and March 1989 was held down at 2,070%, which is less than a half of the consumer's price index which increased by about 6,000% during same period. TABLE 2-12 shows price indices and official exchange rates (MUC) against the U.S. dollar.

TABLE 2-12 INFLATION RATE

Year/ Month	Inflation (1979=100)	A (1986/1=1)	Exchange (MUC)	B (1986/1=1)	A/B	Monthly Increment(%)
1986/1	7,577.8	1.00	13.91	1.00	1.00	5.2
2	7,897.6	1.04	13.91	1.00	1.04	4.2
3	8,312.7	1.10	13.91	1.00	1.10	5.3
4	8,650.2	1.14	13.91	1.00	1.14	4.1
5	8,939.6	1.18	13.91	1.00	1.18	3.3
6	9,257.6	1.22	13.91	1.00	1.22	3.6
7	9,682.7	1.28	13.91	1.00	1.28	4.6
8	10,066.7	1.33	13.91	1.00	1.33	4.0
9	10,426.0	1.38	13.91	1.00	1.38	3.6
10	10,839.0	1.43	13.91	1.00	1.43	4.0
11	11,224.7	1.48	13.91	1.00	1.48	3.6
12	11,739.1	1.55	13.91	1.00	1.55	4.6
1987/1	12,510.4	1.65	14.85	1.07	1.55	-0.2
2	13,209.6	1.74	14.85	1.07	1.63	5.6
3	13,914.4	1.84	14.85	1.07	1.72	5.3
4	14,831.5	1.96	14.85	1.07	1.83	6.6
5	15,707.7	2.07	14.85	1.07	1.94	5.9
6	16,443.7	2.17	15.85	1.14	1.90	-1.9
7	17,645.9	2.33	15.85	1.14	2.04	7.3
8	18,945.5	2.50	15.85	1.14	2.19	7.4
9	20,171.6	2.66	15.85	1.14	2.34	6.5
10	21,456.4	2.83	15.85	1.14	2.48	6.4
11	22,986.6	3.03	15.85	1.14	2.66	7.1
12	25,181.9	3.32	33.00	2.37	1.40	-47.4
1988/1	28,398.4	3.75	33.00	2.37	1.58	12.8
2	31,757.9	4.19	33.00	2.37	1.77	11.8
3	38,935.1	5.14	33.00	2.37	2.17	22.6
4	45,910.7	6.06	33.00	2.37	2.55	17.9
5	49,819.1	6.57	33.00	2.37	2.77	8.5
6	54,209.6	7.15	33.00	2.37	3.02	8.8
7	70,962.6	9.36	33.00	2.37	3.95	30.9
8	86,365.8	11.40	33.00	2.37	4.80	21.7
9	184,926.3	24.40	250.00	17.97	1.36	-71.7
10	260,008.7	34.31	250.00	17.97	1.91	40.6
11	323,466.3	42.69	250.00	17.97	2.38	24.4
12	458,894.8	60.56	500.00	35.95	1.68	-29.1
1989/1	676,078.9	89.22	700.00	50.32	1.77	5.2
2	963,259.5	127.12	920.00	66.14	1.92	8.4
3	1,368,165.7	180.55	1,440.00	103.52	1.74	-9.3
4	2,033,094.2	268.30	1,810.00	130.12	2.06	18.2

Note: MUC; MERCADO UNICO DE CAMBIOS
Source: INE & SUPERINTENDENCIA DE BANCA Y SEBUROS

2.4 Public Health Condition

2.4.1 General

(1) Health Condition

Sanitary and health conditions in Peru are generally still considered as unsatisfactory. Infectious diseases continue to affect and claim lives of many Peruvians every year.

TABLE 2-13 shows the rates of incidence of cases of infectious disease in Peru for the last nine (9) years.

TABLE 2-13 WATER-BORNE AND OTHER SIGNIFICANT INFECTIOUS DISEASES IN PERU
(per 10,000 people)

Disease / Year	1980	1981	1982	1983	1984	1985	1986	1987	1988
Water-Borne Disease									
Acute Poliomielitis	0.10	0.14	0.12	0.12	0.07	0.03	0.02	0.02	0.02
Typhoid and Paratyphoid	11.73	13.45	13.10	11.23	8.31	9.12	8.40	8.56	7.04
Virus Hepatitis	1.07	4.41	3.95	3.84	3.50	4.02	3.77	4.16	2.81
Infectious Diseases by Salmonella	4.04	4.39	4.40	4.71	3.66	3.46	3.70	3.28	2.12
Bacillary Desenderia	3.63	3.48	4.18	4.09	2.97	3.08	2.83	3.20	2.00
Amebiasis	0.85	1.40	1.14	0.98	1.36	1.56	1.91	2.94	1.50
Sub Total	21.42	27.23	26.89	24.97	19.87	21.27	20.83	22.15	15.49
Other Infectious Disease									
Malaria	8.63	8.34	11.24	15.27	17.57	17.78	18.24	19.25	15.69
Influenza	18.44	12.73	8.58	6.80	6.23	4.85	6.10	5.22	3.30
Pulmonary Tuberculosis	8.13	11.19	10.75	11.34	10.99	11.55	11.29	10.64	10.05
Measles	11.13	5.67	6.97	4.07	6.79	4.77	3.02	3.01	2.13
Gastroenteritis	35.38	61.48	78.37	106.80	91.00	98.25	102.32	112.32	105.56
Chicken Pox	3.34	3.77	2.97	3.73	6.91	5.03	5.29	4.62	4.20
Ascariasis	21.40	23.24	25.78	22.28	24.71	26.54	23.66	26.01	17.33
Escabiosis	2.51	4.49	5.33	5.36	6.33	9.26	15.28	15.43	14.70
Resfrio Comun	12.44	41.54	53.34	60.57	65.02	66.45	67.92	66.24	44.51
Other Infection of Resohaterias Agudas	16.13	58.56	80.06	99.39	115.79	141.90	169.02	196.09	207.05
Others	17.15	18.10	14.98	14.95	17.31	16.78	13.60	13.81	10.22
Sub Total	154.68	249.11	261.98	350.66	368.65	403.16	436.41	412.64	437.73
Total	184.19	281.07	330.43	376.82	392.08	435.13	464.05	497.30	456.08

Note: Population of each year are referred to the estimation by INE.
Source: Ministerio de Salud

Although a number of water-borne diseases have been kept almost at the same levels through the nine years, incidence rates of other infectious diseases before 1982 were considerably smaller than the latter years. Infectious water-borne disease, in Peru are clearly serious problems caused by insanitary water and defective sewage treatment.

Ratio of people showing various disease symptoms more than 15 days until the first medical examination in 1984, is shown in TABLE 2-14, in urban and rural areas and coast, mountain and forest region.

TABLE 2-14 RATIO OF PEOPLE SHOWING VARIOUS DISEASE SYMPTOMS (1984)

Disease Symptom	Total	Area		Geographical Region		
		Urban	Rural	Coast	Mountain	Forest
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0
Respiratory Organ	41.6	44.6	36.7	44.8	39.2	32.2
Digestive Organ	12.5	11.8	13.7	10.8	14.9	14.4
Skin Disease	2.5	3.0	1.8	2.9	1.6	2.7
General Parasitesis	1.1	0.8	1.5	0.6	0.5	4.8
Cefarea Symptom	2.7	2.5	2.7	2.5	2.7	2.4
Arthritis	2.8	2.8	2.9	2.9	3.0	2.1
Dental Disease	9.6	9.7	9.6	10.0	10.0	6.8
Eye Disease	1.5	1.4	1.7	1.4	1.6	1.8
Acute Respiratory and Digestive Disease	7.6	7.0	8.6	7.0	8.0	9.7
Mixed Disease Symptoms	11.5	11.2	14.5	11.6	13.1	15.1
Others	6.6	5.2	6.3	6.9	5.4	8.0

Source: Compendio Estadistico, INE

Disease symptoms of the respiratory organs in the urban area had a higher percentage of occurrence than in the rural area. In the coast region the ratio is higher than in the other two regions. It is conceivable that air pollution in the urban area and high humidity in the coast region caused the high respiratory disease occurrences.

Ratio of general parasitesis in forest region is much higher than in the other two regions. In contrast to the above, dental disease in the forest region occurred in lower percentage than in the other regions.

Ratios of other diseases are almost at the same level in all regions.

Most of the children in Peru are undernourished, with children younger than 6 years under the normal nourished condition only 61.5% (TABLE 2-15) of the total. However, percentages in big cities like Lima and Tacna are higher than 80%.

TABLE 2-15 NOURISHMENT CONDITION OF CHILDREN (1984)

(younger than 6 years old)

Department	Undernourishment Condition			
	Chronic	Acute	More Acute	Normal
Total (%)	37.5	0.6	0.3	61.5
Piura	40.5	0.7	1.1	57.7
Chiclayo	42.0	1.2	0.6	56.2
Cajamarca	63.5	0.3	0.6	35.6
Trujillo	39.9	0.1	0.2	59.8
Huaraz	51.7	1.2	-	47.2
Lima	16.8	0.4	0.6	82.8
Ica	30.9	0.2	-	68.9
Arequipa	24.0	0.1	0.2	75.6
Tacna	18.6	0.1	0.1	81.2
Puno	51.2	0.7	-	48.1
Cusco	54.7	1.3	1.5	42.6
Huancayo	52.8	0.4	0.3	46.5
Huanuco	48.9	1.0	0.2	49.9
Moyobamba	47.5	0.2	1.2	51.1
Iquitos	44.4	0.9	0.5	54.2

Source: Compendio Estadistico, INE

Infantile mortality in Peru is also very high compared to other age groups (TABLE 2-16). Even in 1987, an estimated 88.2 out of 1,000 new-born babies die before reaching the age of one year.

TABLE 2-16 MORTALITY IN PERU

(per 1,000 people)

Year	All age group	Younger than 1 year old
1983	10.7	96.9
1984	10.4	94.9
1985	10.1	92.7
1986	9.7	90.5
1987	9.4	88.2

Source: Compendio Estadistico, INE

TABLE 2-17 shows the infantile mortality (younger than 1 year old) in each department in 1987. The mortality in mountain region departments is found to be about two times high as those in urban areas. It is perceicved that this is brought about by the fact that the medical condition in the mountain regions is not as adequate as that prevailing in the urban areas.

TABLE 2-17 INFANTILE MORTALITY IN EACH DEPARTMENT (1987)
(younger than 1 year old)
(per 1,000 infants)

Department	Mortality	Department	Mortality
Amazonas	96.2	La Libertad	70.7
Ancash	91.6	Lambayeque	77.7
Apurimac	125.5	Lima	61.4
Arequipa	77.3	Loreto	89.5
Ayacucho	121.7	Madre de Dios	94.7
Cajamarca	99.6	Moquegua	77.8
Callao	59.3	Pasco	101.0
Cusco	132.3	Piura	101.2
Huancavelica	138.4	Puno	119.4
Huanuco	97.8	San Martin	84.7
Ica	65.7	Tacna	78.6
Junin	95.9	Tumbes	76.8
		Ucayali	90.2
Average			88.2

Source: Compendio Estadistico, INE

Mortality in Peru caused by various infectious diseases are shown in TABLE 2-18. Children younger than 5 years old die mainly of infectious intestinal diseases and other bacillary diseases.

TABLE 2-18 MORTALITY CAUSED BY INFECTIOUS DISEASE (1982)
(per 100,000 people)

Disease	< 5 years	5 years <=
Infectious Intestinal Disease	224.7	13.9
Pulmonary Tuberculosis	3.8	20.4
Other Tuberculosis	2.3	1.6
Other Bacillary Disease	49.7	5.7
Virus Disease	50.2	2.5
Richettiosis and Other Disease caused by Arthoropods	0.5	0.2
Venereal Disease	1.2	0.1
Other Infectious Disease and Parasitesis	3.7	1.2
Total	336.1	45.6
Mortality by all reasons	1,245.5	339.2
(infectious mortality/all)	(27.0%)	(13.4%)

Source: Compendio Estadistico, INE

(2) Medical Condition

Infantile mortality is obviously correlated to medical condition. High infantile mortality is found in Departments of Apurimac, Ayacucho, Cusco, Huancavelica, Pasco, Piura, Puno and San Martin (TABLE 2-17).

In these departments, the number of beds, medical doctors and nurses are very much less than in other departments. Moreover in some of these departments, the number of hospitals is also insufficient (Apurimac and Cusco, TABLE 2-19).

TABLE 2-19 NUMBERS OF HOSPITALS,BEDS, MEDICAL DOCTORS AND NURSES IN EACH DEPARTMENTS (1986)
(Public and Private)

(per 10,000 People)

Department	Hospital	Bed	Medical Doctor	Nurse
Total	0.17	15.1	9.5	7.4
Amazonas	0.07	3.0	0.4	0.4
Ancash	0.2	9.6	2.5	1.4
Apurimac	0.06	5.2	0.4	1.1
Arequipa	0.3	22.5	12.6	19.4
Ayacucho	0.1	6.0	0.6	1.8
Cajamarca	0.04	2.3	0.7	2.0
Callao	0.2	27.9	-	10.0
Cusco	0.07	9.3	1.8	5.7
Huancavelica	0.2	5.4	0.4	1.0
Huanuco	0.1	6.6	1.8	2.6
Ica	0.2	21.5	10.5	4.9
Junin	0.2	12.8	2.6	7.8
La Libertad	0.2	9.9	3.9	6.1
Lambayeque	0.6	34.2	13.3	21.1
Lima	0.2	24.7	23.8	13.1
Loreto	0.1	12.0	2.6	3.4
Madre de Dios	0.5	21.2	3.0	2.6
Moquegua	0.4	28.4	9.6	11.0
Pasco	0.4	20.4	3.8	3.0
Piura	0.1	8.7	2.7	2.2
Puno	0.1	5.5	0.9	2.5
San Martin	0.2	7.6	1.0	0.6
Tacna	0.2	19.6	5.6	12.0
Tumbes	0.08	9.3	1.6	2.1
Ucayali	0.1	10.5	2.0	0.5

Note: Population of each department are the estimated value of INE based on the Census in 1981.
Source: Compendio Estadistico, INE

Although the present medical condition in Peru is insufficient, it seems to be guradually improving as shown in TABLE 2-20. However, lack of medicine is being caused by current economic regression, and medical condition become worsening.

TABLE 2-20 RATIO OF MEDICAL STAFFS IN PERU (1983-1988)

(per 100,000 people)

Type	1983	1984	1985	1986	1987
Nurse	7.0	6.9	7.1	7.4	7.5
Medical Doctor	9.0	9.0	9.2	9.5	9.7
Dentist	2.2	2.2	2.3	2.3	2.3
Midwife	1.3	1.5	1.6	1.6	1.8
Pharmacist	2.2	2.2	2.3	2.4	2.4

Source: Compendio Estadistico, INE

2.4.2 Present Sanitary Status in Lima

(1) Infectious Diseases in Lima

Although infantile mortality is lower in Lima than in other departments, and nourishment conditions are quite better in comparison to other areas, infectious diseases including water-borne disease occurred at the rate of 371.41 (1987) to 498.17 (1986) cases per 10,000 people during the last four years (TABLE 2-21).

TABLE 2-21 WATER-BORNE DISEASE AND OTHER INFECTIOUS DISEASES IN LIMA DEPARTMENT

(cases/10,000 people)

Disease / Year	1985	1986	1987	1988
Water-Borne Disease				
Acute Poliomoielitis	0.04	0.05	0.03	0.02
Typhoid and Paratyphoid	1.87	11.62	12.53	8.68
Virus Hepatitis	5.31	4.68	6.74	3.49
Infectious Diseases by Salmonella	1.56	1.95	1.50	1.05
Bacillary Desenderia	0.86	1.40	1.03	0.45
Amebiasis	2.80	1.29	0.83	0.13
Sub Total	12.44	20.99	22.66	13.82
Other Infectious Disease				
Influenza	1.87	4.77	4.73	3.42
Pulmonary Tuberculosis	1.74	20.84	18.51	16.01
Measles	5.03	3.90	3.76	3.12
Gastroenteritis	130.79	122.84	144.44	112.32
Chicken Pox	8.96	9.09	7.72	5.59
Ascariasis	27.77	26.41	28.93	17.46
Escabiosis	14.59	25.99	22.51	12.30
Resfrio Comun	66.79	62.06	55.21	21.32
Other Infection of Resohaterias Agudas	159.81	182.66	44.00	198.44
Others	23.22	18.62	18.94	8.97
Sub Total	440.01	477.18	348.75	403.95
Total	453.01	498.17	371.41	417.77

* Population was referred to the estimated value by INE.
Source: Ministerio de Salud

Among the water-borne diseases, cases of Typhoid and Paratyphoid, and Virus Hepatitis occurred at higher rates than other diseases.

Gastroenteritis and other Infections of Resohaterias Agudas had the highest rates of incidence among infectious diseases.

Children in Lima are also victims of infectious diseases (TABLE 2-22). Virus Hepatitis, Amebiasis, Gastroenteritis, Resfrio Comun and Other Infection of Resohaterias Agudas, particularly occurred in high number of cases in children (younger than 4 years old).

TABLE 2-22 WATER-BORNE DISEASE AND OTHER SIGNIFICANT INFECTIOUS DISEASES BY AGE GROUP (1988)

(per 10,000 people in each age group)

Disease / Age Group	0-4	5-14	15-24	25-44	45-64	65+	Ignore
Water-Borne Disease							
Acute Poliomoielitis	0.08	0.05	0	0	0	0	0
Typhoid and Paratyphoid	4.67	12.07	10.70	7.59	6.12	4.58	0.05
Virus Hepatitis	17.44	4.99	2.01	1.78	1.44	1.35	0.02
Infectious Diseases by Salmonella	0.72	1.08	1.31	1.06	1.12	0.40	0
Bacillary Desenderia	1.73	0.28	0.18	0.27	0.56	0.53	0
Amebiasis	29.62	0.12	0.12	0.09	0.14	0.2	0
Sub Total	52.53	18.59	14.32	10.79	9.38	7.13	0.07
Other Infectious Disease							
Influenza	9.99	1.99	1.49	3.26	4.56	3.10	0.05
Pulmonary Tuberculosis	5.37	7.35	22.87	20.17	20.42	30.34	0.17
Measles	17.44	3.68	0.71	0.12	0.04	0	0
Gastroenteritis	688.39	45.72	29.25	31.78	41.94	46.11	0.45
Chicken Pox	21.73	10.46	1.90	0.36	0.12	0.20	0.02
Ascariasis	45.40	28.07	10.20	7.31	9.18	8.43	0.08
Escabiosis	60.94	21.55	10.62	6.07	6.90	9.10	0.07
Resfrio Comun	118.31	14.98	5.95	5.41	8.12	9.71	0.07
Other Infection of Resohaterias Agudas	996.91	174.66	64.82	56.99	73.73	93.71	0.62
Others	12.30	9.37	10.04	8.81	8.58	8.02	0.04
Sub Total	1,981.88	317.83	157.85	140.28	173.59	207.85	1.57
Total	2,034.41	336.42	172.17	151.07	182.97	214.85	1.64

* Number of people in each age group was estimated using the ratio of each age group in the Census of 1981 and the population of 1988 estimated by INE.

Source: Ministerio de Salud

(2) Skin Rash and Other Illness Caused by Sea Water Pollution

SEDAPAL Laboratory Staffs found through a questionnaire survey conducted in 1989 that people who used the marine recreational areas suffered from skin rash caused by seawater pollution in 1989 (TABLE 2-23).

TABLE 2-23 Result of Questionnaire Survey

Contact Frequency	Persons Number	Illnesses Number	Illness					Etiological Agent		
			S	F	D	R	O	Seawater	Sand	Others
Daily	20	5	4	2	3	3	2	5	-	-
Interdaily	5	1	1	0	0	0	0	1	-	-
Weekly	5	0	0	0	0	0	0	-	-	-
Rarely	3	3	1	1	2	1	2	3	-	-
Total	33	9	6	3	5	4	4	9	-	-

Legend: S - Skin Rash, F - Fever, D - Diarrhea, R - Watery Eyes
O - Others

A Professor of epidemiology and his class at the Villarreal University also conducted a questionnaire survey on the relation between the health of the bathers and sea water affected by sewage from the Colector Surco and some other small sewer pipes. He found out that about 53 % of bathers had illness mainly caused by polluted seawater (refer to TABLE 2-24).

Polluted seawater, therefore, have been causing serious problems on human health.

TABLE 2-24 Percentage of Illnesses Relating Swimming-Bathers

Frequency	Percentage of Total	Persons Number (P)	Illnesses Number (I)	Percentage I/P(%)
Daily	1.4	4	4	100
Interdaily	3.2	11	5	45
Weekly	35.6	121	57	47
Rarely	56.6	156	94	60
Only Sun Bathing	2.9	10	0	0
Total	100.0	302	160	52.9

(3) Water Supply and Sewerage Systems in Lima as a Route for Water-Borne Disease

People in Lima obtain water for their daily use from different sources as shown in TABLE 2-25.

TABLE 2-25 DISTRIBUTION OF TYPE OF WATER SUPPLY SOURCE

Type of Water Supply	No. of People Served (%)	Volume of Water Supplied (%)
House Connection		
Treated Water from Plants 1/	52.0	61.5
Groundwater from Wells	25.4	33.1
Communal Faucet	3.3	0.3
Water Vendor 2/	16.7	2.7
Others 3/	2.4	2.6

Note: 1/ 2.1% of this type of source is supplied by government organizations other than SEDAPAL.
2/ Water vending is done either by tank trucks of SEDAPAL or by tank trucks of private company.
3/ Including private wells in SEDAPAL service area and illegal inhabitant (slum/squatter) area.
Source: SEDAPAL

More than 77% of the people in Lima are supplied with water by house-connected piped system. Water consumption of these people represents 94% of the total.

On the other hand, 16.7% of the people buy water from trucks and store it in cement or brick tanks for several days. In comparison to the ratio of people who buy water, the volume of water consumed by them is only 2.5% of the total.

TABLE 2-26 shows the ratios of users and volume supplied of different water sources in new towns located out of the study area in Lima. Compared to figures for Lima, fewer percentage of people in new towns derive water from house-connected piped system. But a bigger percentage of people in new towns buy water.

TABLE 2-26 DISTRIBUTION OF WATER SUPPLY TYPE IN NEW TOWN IN LIMA (1987)

Area	House-connected Piped System (%)	Communal Faucet and Wells (%)	Water Vending (%)	Total No. of People
North	50	32	18	569,331
Center	40	40	20	196,028
South	66	13	21	780,395
East	26	31	43	663,348
West	50	50	-	26,971
AVERAGE	48	26	26	2,236,073

Source: SEDAPAL

The sewerage system in Lima has a capacity more than its water supply system. Most of domestic sewage and industrial wastewater is collected by the sewer pipelines, then drained to the sea and the river without any treatment. However, sewage from some areas is treated in stabilization ponds (San Juan, Parque Zonal No. 26, Jose Galvez, and Chosica). Treated sewage is reused for irrigation for agriculture including vegetable cultivation.

Untreated sewage from some area is directly used for irrigation, a practice which is obviously a route for the transmittal of infectious water-borne diseases.

Several infectious water-borne diseases like Acute diarrhea by rotavirus; entrotoxigenic enteropathogenic E. Coliform; Campylobacter; Salmonella and Shigella; Typhoid and Paratyphoid; Virus Hepatitis, Polio and Amebiasis, affect people who eat vegetables grown in area irrigated with untreated sewage.

2.5 Energy Supply Condition

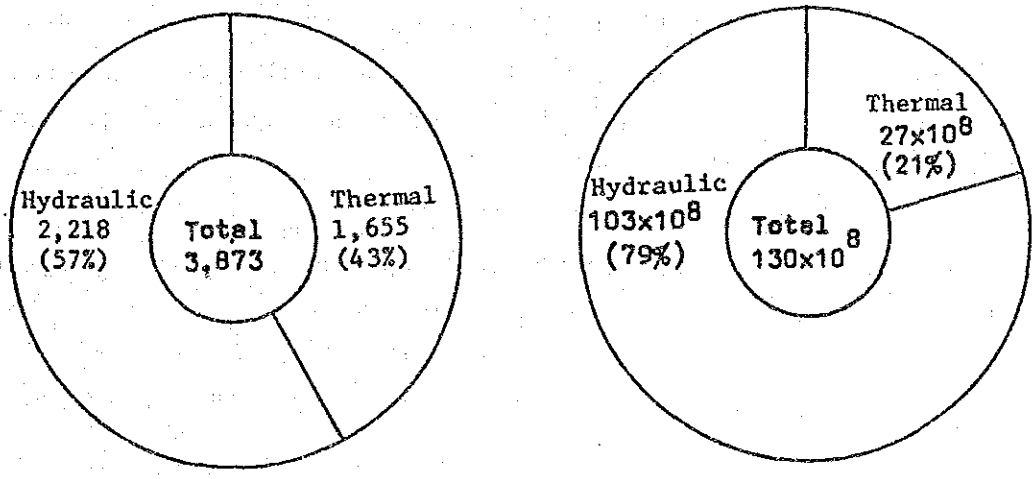
2.5.1 Electric Power

(1) General

a) Outline

The Republic of Peru is one of the most richly endowed in Latin America in terms of hydraulic power resources. Potential resources capable of being developed technically are estimated to generate a total of 58,400 MW.

The installed capacity for generation of power and energy production in Peru as of 1986 are shown below.



Installed Capacity in Peru (MW)

Energy Production in Peru (kWH)

FIGURE 2-7 Electric Power Supply Condition in Peru

Installed electric power generation capacity and electricity production have both shown an increase of just under 5% over the 10-year period between 1977 and 1986. Steam, gas and diesel are used in thermal power

generation.

41% of the country had been electrified in 1986. The per capita consumption of electricity, at 640 kWH per year, is relatively low compared to other Latin American nations.

Major power plants are linked to each other and power is transmitted to cities and other service areas from these plants.

b) Power Supply Enterprises

Power supply enterprises in Peru consist of ELECTROPERU, which is a national agency; local authorities; and private power supply companies. All of them fall under the jurisdiction of the Ministry of Energy and Mining (Ministerio de Energia y Minas).

ELECTROPERU controls approximately 70% of the power supply capacity in the country and, as a national agency, is responsible for decisions on plans for development of power resources, transformation and power supply, and distributes power through 9 local agencies, among which are ELECTROLIMA and ELECTRONORTE.

ELECTROLIMA is responsible for the power supply at the project site in the southern part of Metropolitan Lima.

c) Power Supply Systems

The power supply network that would cover the whole of Peru has not yet been established as of 1989 and power is supplied through 4 major systems and a number of independent systems. ELECTROLIMA belongs to the largest of these systems, covering the northern and central parts of the country. Generation and transmission of power in this system, are carried out in two blocks of the Northern Area and of Mantaro, which are linked to each other and of more or less equal capacities.

A power supply network covering the whole of the country, except the Amazon Region, is planned for completion early in the year 2000.

d) Supply and Demand for Power at Present and Prospects for Future

The relationship between supply and demand for power in the North-Central System in 1987 was as follows:

TABLE 2-27 Relationship between Supply Capacity and Demand

Installed Capacity (1)	Effective Installed Capacity (2)	Maximum Power Demand (3)	(2) - (3) / (3)
2,043.5 MW	1,555.8 MW	1,524.7 MW	Approx. 2.0%

The effective output of the existing facilities, on the actual power supply, is only 76% of the installed capacity. The shortfall is due to lowering of the efficiency of the generation machinery because of age, stoppages or inspection, and, in case of hydroelectric plants, lack of water supply during the dry season.

The effective outputs in the country as a whole and of the North-Central System, which is the largest in the country, exceeded the maximum demand by 7.6% and 2%, respectively. Desirable value for surplus power is normally given at 10%, and the situation of power supply in Peru is unstable according to this criterion.

Power consumption increases during the night and the peak demand occurs during the lighting-up time in the evening from 18 to 24 hours. There is also a period of high demand from 8 to 12 hours due to industrial activities.

According to the long-term forecast by ELECTROPERU on power demand, an increase of just under 5% a year is expected until the year 2012 and the share taken up by the North-Central System is expected to increase. There are plans for developing new sources of power mainly composed of hydroelectricity and plans for generation of electricity using gas, geothermal power and coal, but the progress of these plans have been delayed for economic reasons.

The situation has become critical in the areas covered by the North-Central System, where demand almost equals supply capacity, and the shortage of power supply is expected to become more apparent if the present situation continues.

e) Power Cuts

Planned power cuts lasting for half a day or so occur once or twice a year in the project area and there are no power cuts due to general accidents. There have recently been frequent cases of power transmission lines being cut by terrorists, but as power is transmitted by 2 separate systems, there are no cases when power supply is stopped throughout the area.

(2) Power Supply Condition

Details of the power supply condition at the project site are as follows.

a) Reception Voltage

The voltage of initial reception is decided upon by ELECTROLIMA, according to locations and capacities of the facilities concerned and is usually 10 kV or 6 kV.

b) Working Voltage and Frequency

At low voltage, 220 kV or 440 kV, 60 Hz.

(3) Electricity Charges

The charges of ELECTROLIMA are differentiated in numerous categories according to items such as the uses of the power and reception voltages. Because of the rapid inflation in Peru, charges are raised every month or every few months.

Item No. 53 and No. 54 of the ELECTROLIMA tariff are applied to works related to water supply and sewage. No. 53 is in case the incoming voltage is 220 V to 440 V. No. 54 is for the incoming voltage of 2,300 V to 22,900 V. The tariff consists of basic rate and consumption rate. The consump-

tion rate differs with the season and hours. According to the tariff of ELECTROLIMA for April 1 and October 1, 1989, the average power rate is I/. 36/kWH (US Cents 2.5/kWH, exchange rate: US$ 1.00 = I/. 1,450), and I/. 126/kWH (US Cents 2.4/kWH, exchange rate: US$ 1.00 = I/. 5,351), respectively.

Average electricity charges only cover 36% of the cost of supplying the power and the rest of the cost is made up by subsidy from the government.

(4) Power Consumption by SEDAPAL

The quantities of power consumption by waterworks facilities under the control of SEDAPAL in 1987 and 1988 are shown in TABLE 2-28.

TABLE 2-28 ELECTRICAL POWER CONSUMPTION FOR WATER SUPPLY AND SEWERAGE FACILITY OF SEDAPAL

(kWH/year)

Item	Electrical Power Consumption	
	1987	1988
Water Supply		
- Wells	73,639,706	76,132,178
- Pumping Stations	6,721,370	7,899,862 1/
- Atarjea Water Treatment Plant	2,299,612 1/	2,368,600
Sub Total	82,660,688	86,400,640
Sewerage		
- Pumping Stations	425,064	437,816
- Carapongo Sewage Treatment Plant	-	302,400 2/
Sub Total	425,064	740,216
Total	83,085,752	87,140,856

Source: Gerencia de Planificacion y Presupuesto, SEDAPAL
1/ Estimated value
2/ from July to December

Power demand of SEDAPAL is estimated to make up approximately 1.5% of the total maximum demand on the North-Central System.

For example, in case of sewage treatment plant of Aerated Lagoon

System (capacity 1.0 m^3/sec), power consumption per annum is estimated at around 7,200,000 kWH/year. This value corresponds to approximately 8% of present total power consumption per annum of SEDAPAL.

The proportion of spent electricity charge to SEDAPAL's total expenditure in 1988 was as follows:

- Including reserve costs such as depreciation - approx. 1.6%
- Excluding reserve costs such as depreciation - approx. 3.5%

(5) Application to Present Project

The following considerations need to be borne in mind in making plans for pumping stations and treatment facilities which require electricity:

- There is a power supply shortage in Metropolitan Lima and adequate consultation with ELECTROLIMA is necessary for planning of those facilities.
- Provisions shall be made for power cuts.

2.5.2 Other Energy Supply

There is no city gas supplies in Metropolitan Lima; electricity, kerosene and propane gas are normally used for heating and cooking.