APPENDIX II

METEOROLOGICAL AND HYDROLOGICAL CONDITIONS

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1. METEOROLOGICAL DATA

1.1 Meteorological Observatories

In and around the Rimac river basin, 16 meteorological stations are operated at present of which 12 are managed by SENAMHI, one by DHNM, one by CORPAC and two by ELECTROLIMA. The inventory of the stations is shown in Table II-1-1 and the locations are shown in Fig. II-1-1.

Among these stations, Campo de Marte (Lima) has the longest history of 56 years in the basin though it has been relocated to Cahuide in 1982. In order to grasp the characteristics of climatic feature in the Rimac river basin, Campo de Marte, Nana, Matucana and Milloc are key stations due to their locations and duration fo recorded period. specially, the meteorological record at Matucana station where the observation was started in 1964 might be important to search the mechanism of the huayco occurrence in the middle and upstream areas.

At Matucana station, besides the meteorological measuring instruments, wireless telephone is equipped to communicate with the central station of SENAMHI in Lima.

The period of available rainfall record in each observatory is shown in Fig. II-1-2.

1.2 Available Meteorological Data

As the result of the data collection from SENAMHI, DHNM and ELECTROLIMA, kind of the available meteorological data of each station are summarized as shown in Table II-1-2.

In regard to the rainfall record, an automatic rainfall gage is functioned at only Matucana station and recording chart is stored in the data management section of SENAMHI. However, data processing to convert hourly-basis rainfall record from the collected recording chart is not executed. Thus, processing work is necessary with checking the reliability of the chart to confirm the hourly-basis or more short-duration rainfall record.

Besides the data collected from the concerned governmental institutions, statistical data on meteorology in the basin is available in the report of "Inventario y Evaluacion de los Recursos Naturales de la Zona de Proyecto Marcapomacocha Volumen II Anexos y Mapas" prepared by ONERN.

2. HYDROLOGICAL DATA

2.1 Hydrological Observatories

Seven hydrological stations in total are operated in the Rimac river basin of which four stations are located in the Rimac river and three stations in the Santa Eulalia river. Automatic water level recorder is equipped at Chosica, San Mateo, Rio Blanco and Sheque stations. At other stations only a staff gage is installed for visual reading of water level.

Normally water level is observed for four times a day at 6:00, 10:00 14:00 and 18:00 in all stations.

The longest record of mean daily discharge is available at downstream side of Chosica from 1921 up to present.

The site of station was changed several times in a stretch between 25 km river reach from Chosica to Pte. Huachipa. Period of the available mean daily discharge data at each site can be summarized chronologically as follows:

Site of Station	Period of Data Available
Chacrasana	1921 Jan. - 1948 Aug.
Pte. Los Angeles	1948 Sep. - 1954 Dec.
Yanacoto	1955 Jan. - 1960 Aug.
Pte. Huachipa	1960 Sep. - 1962 Aug.
Chosica R-1	1962 Sep. - 1967 Aug.
Chosica R-2	1964 Sep. - present

Under the present condition that no stream flow gaging station is installed in the urban area of Lima, the discharge record at Chosica is quite important for flood analysis of the downstream area.

The inventory of hydrological station is shown in Table II-2-1. Their location are shown in Fig. II-1-1 with meteorological stations. The periods of available water level records and mean daily discharge data in each station are respectively shown in Table II-2-2 and Fig. II-2-1.

2.2 Available Hydrological Data

Available hydrological data can be classified as follows.

(1) Water level and discharge data
(2) Water utilization data
(3) Tide data
(4) Water quality data

Water level and discharge data were collected from SENAMHI and ELECTROLIMA which operate stream flow gaging stations in the basin.

Instantaneous peak water level data at Chosica R-2 gaging station is available. Those values are estimated based on the relationship between the recorded peak water level data on the automatic recording sheet (limnigraph) and staff gage reading data measured on the same day.

3. METEOROLOGICAL CONDITIONS

3.1 General

The Rimac River basin is located in the range of 11°32'Lat. S and 12°15'Lat. S and in the range of 76°08' Long. W and 77°10' Long. W. The Basin has about 3,300 Km^2 of the drainage area included in the department of Lima located in around central of Peru. The Rimac river originated in the Andean Mountain Range and runs to south-west with gentle meandering to west in the middle reach and flows into the metropolitan area of Lima and reaches to the Pacific Ocean at Callao.

The basin lies in the narrow strip zone in west coast of the South American Continent held between the Andes and the Pacific Ocean. The basin is characterized by quite a large scale of ground relief. Therefore, the climatic feature in the basin is complex though the span of east-west direction of the basin is only 150 km.

Annual total rainfall is ranged from 10 mm in the coastal area to around 1,000 mm in the mountainous area. And annual mean atmospheric temperature varies from approximately 5° C in the coastal area to 20° C in the mountainous area.

General characteristics of climatic feature in the basin is dominated more or less by El Niño. El Niño is a phenomenon of tropical sea water shift to southward along the coast of Ecuador and Peru. Periodically there is a powerful injection of warm water from the north that can reach into the sea area of Chile. In the last two decades, the principal El Niño occurred in 1972-73, 1976 and 1982-83, the last being the severest ever recorded.

3.2 Rainfall

In the coastal area, the rainfall amount is very few throughout the year. Because cold water of the Humoldt Current makes cool the air mass near the sea surface, it is prevented to produce an ascending air current. Thus, the rainfall amount is so few as close to the coastal line of inland. On the contrary, mountainous area of Andes has relatively much rainfall because the influence of the air current from the cold sea is weakened.

The mean annual rainfall at Campo de Marte is 24 mm in the period between 1929 and 1982. The mean annual rainfall from 1965 to 1986 at Milloc is 860 mm. The records at Ñaña located at around 70 km eastward from Callao, the rainfall amount in the coastal is deemed to be much less than that of Milloc. The mean annual rainfall over the whole basin is approximately 400 mm.

A summary of monthly rainfall is shown in Table II-3-1 and historical record at Campo de Marte, Ñaña, Matucana and Milloc are shown in Tables II-3-2 to II-3-5.

Isohyetal map of annual rainfall covering the basin is shown in Fig. II-3-1 with monthly rainfall pattern at representative five stations, that is Campo de Marte, Santa Eulalia, Matucana, Bellavista, Milloc and Carampoma. As shown in the figure, the amount in the downstream area of Chosica is much less than that in the upstream area. The variation of annual rainfall amount in a long term in the basin is presented in Fig. II-3-2 by showing the record observed at Campo de Marte, Milloc and Matucana.

3.3 Temperature

(1) Atmospheric Temperature

In the coastal area (Lima), the mean monthly temperature in ordinary year varies from 15° C in July or August and 22° C in February or March. In the middle stream area from Ñaña to Chosica, mean monthly maximum temperature in summer season might be a little high, because influence of the Humboldt Current to the climate becomes weak and that of inland becomes strong. In upstream area, atmospheric temperature depends on the altitude and the variation of mean monthly temperature between dry (winter) and wet (summer) seasons is not remarkable compared with the coastal area. At Matucana located at El. 2,380 m, the highest mean monthly temperature is 15.2° C in November and the lowest mean monthly temperature is 14.1° C in March. At Milloc, of which altitude is EL. 4,400 m, the variation of mean monthly temperature in a year is less than 2° C as same as at Matucana. A summary of monthly temperature is shown in Table II-3-6. Historical records of monthly mean temperature at Campo de Marte, Ñaña, and Matucana are shown in Tables II-3-7 to II-3-9.

(2) Sea Water Temperature

Sea Water temperature of the Pacific Ocean is measured at Chucuito near the Callao harbor where the Peruvian Navy stations. Measuring record is managed by DHNM hydrological section at Chucuito. The mean monthly record at Chucuito from year 1976 to 1987 are summarized as below.

Unit: °C

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
16.5	17.2	17.6	17.6	173.	17.0	16.3	15.8	15.1	15.0	15.5	15.8	16.2

It is well known that the sea water temperature along the coastal line of Peru and Ecuador is relatively lower than that in the other equatorial sea area. It is mainly caused by the Humboldt Current which transports mass of cold sea water from near the Continent of South Pole. The mass of cold sea water is constantly upwelling to the sea surface due to the influence of the southwestern trade winds. From January to April, however the trade winds temporarily weakens and the sea temperature in that area rises by usually up to 4° C.

3.4 Relative Humidity

Mean monthly relative humidity in the coastal area is constantly higher than 80% throughout the year and normally the highest value is recorded in winter season (July to September) and the lowest value is recorded in summer season (January to March). Mean annual value is around 85% in the coastal area. In the middle reach area, mean monthly values vary in a wide range as seen in the record at Matucana where the maximum value of mean monthly relative humidity is 79% in March and the minimum value is 41% in July. The tendency of the annual variation of the coastal and the other areas seems to be reverse.

Table II-3-10 shows a summary of monthly relative humidity at meteorological stations. Historical records at Campo de Marte, Ñaña and Matucana are tabulated in Tables II-3-11 to II-3-13.

3.5 Evaporation

Table II-3-14 shows a summary of monthly evaporation at six stations. Although the annual total rate varies relatively in wide range among four stations located in Lima, the averaged rate might be approximately 800 mm to 900 mm. The annual rate at Ñaña and Matucana is 880 mm and 1,690 mm respectively.

The seasonal variations at Matucana and the other stations are reverse each other. At Matucana, the largest monthly rage is normally recorded in July and the smallest monthly rate is recorded in February. On the contrary, at the other stations the largest value occurs in January to March and the smallest value occurs in July to September.

Historical records of evaporation at Ñaña and Matucana are respectively shown in Table II-3-15 and II-3-16.

3.6 Wind and Sunshine Hour

(1) Wind

Wind record is summarized in Table II-3-17. The prevailing wind direction in the lower and middle reach basins is south-west to south-east. The direction is almost constant by the influence of the southwestern trade winds throughout the year.

The wind velocity in summer season in the coastal area is a little stronger than in winter season. Annual mean wind velocity in the coastal area is around 2.8 m/sec.

(2) Sunshine hour

Historical data of sunshine hour is available only in the urban area of Lima. The daily sunshine hour is longest in March and shortest in August. The monthly total sunshine hours are around 220 hours in March and 20 hours to 70 hours in August in Lima.

A summary of monthly sunshine hour record is tabulated in Table II-3-18.

4. HYDROLOGICAL CONDITIONS

4.1 General

The Rimac river basin is formulated by two major tributaries, that is the Rimac and the Santa Eulalia rivers, and many small tributaries (called "Quebrada"). The two major rivers meet at just upstream of Chosica which is one of the satellite town of Lima. The catchment areas of the Rimac and the Santa Eulalia rivers at upstream of this confluence are 1,228 km^2 and 1,085 km^2 respectively.

In the most upstream area higher than EL. 4,500 m. above mean sea level, glaciated valleys remain in the skirt of the mountains. In those valleys, a lot of small lakes (called "Laguna") can be seen. The principal feature of major lagunas is summarized in Table II-4-1.

The runoff of the Rimac river is mainly dominated by the rainfall pattern in the upstream area. At Chosica gaging station, annual average runoff is 32 m^3/sec according to the record in the period from 1921 to 1971. Between four months from January to April, around 65% of annual volume was recorded.

Besides the water resources of the Rimac river, water in the Laguna Marcapomacocha diverted by a open canal and a tunnel to the Santa Eulalia river is also utilized in the basin. The annual average diverted water volume is about 4 m^3/sec. The length and capacity of the tunnel are 10 km and 12 m^3/sec. respectively.

Development of hydropower in the Rimac river started in 1920'. Integrated system of five power stations (three in the Rimac and two in the Santa Eulalia rivers) supplies electricity to the metropolitan area. Total capacity of generation on peak time is 540 MW.

At Atarjea about 21 km upstream from the river mouth, a intake weir and treatment plant with storage pond is operated by SEDAPAL. About 70% of urban population is served water from this plant by SEDAPAL at present.

Nowadays, pollution of the Rimac river becomes to be a serious problem in parallel with the growth of the metropolitan area. SEDAPAL and DGASI conduct water quality analysis of the samples at several locations along the river.

4.2 Runoff

SENAMHI operates three stream flow gaging stations at present, that is Rio Blanco, San Mateo and Chosica. Automatic water level recorders are installed at these stations. On the other hand ELECTROLIMA manages four stations at Tamboraque, Milloc, Sheque and Autisha where are key locations of hydropower generation by ELECTROLIMA. At the outlet of the diversion tunnel at Milloc, a water level recorder is functioned to observe the discharge quantity from the Mantaro river basin. At other ELECTROLIMA stations only staff gages are installed.

At Chosica gaging stations, around 2.5 Km downstream of the confluence between the Rimac and the Santa Eulalia rivers, a cableway is equipped with a cage for discharge measurement, rating curves are made periodically. Within three or four months, the curve is renewed by means of the latest measuring result.

Mean daily runoff record at observatories operated by SENAMHI is tabulated in Tables II-4-2 to II-4-10.

According to the record of monthly maximum discharge mean daily values at Chosica, the largest value is 276 m^3/sec in February 1981. Hydrographs at Chosica in characteristic hydrological years of three typical patterns are shown in Fig. II-4-1

4.3 Water Utilization

(1) Hydropower Generation

At five hydropower plants, maximum plant discharge are summarized as below;

Name of Power Station	Max. Discharge (m^3/sec.)
Pablo Boner	13.5
Huinco	24.0
Callahuanca	16.0
Moyopampa	18.0
Huampani	20.0

ELECTROLIMA controls the outflow volume from the major lagunas by the gate operation. Normally the condition of the lagunas is checked twice a month and measurement of relative water level is carried out. The record is available in the hydrological data management section of main office of ELECTROLIMA.

(2) Municipal Water Use

The annual average intake volume at Atarjea is approximately 12 m^3/sec. The treatment capacity of the plant is 20 m^3/sec at present. Beside the Atarjea plant, SEDAPAL controls nearly 300 domestic wells in the Lima-Callao Metropolitan area. Based on the operation record of each well, the monthly total volume of pumping up is approximately 14 x 10^6 m^3 in January 1987 (without Callao area).

(3) Agriculture

As for irrigation use, the surface water of the Rimac river is taken by the farmers inhabited along the river. Irrigation area is developed mainly downstream area from Chosica. According to a map of DGASI showing the location of main irrigation canal, total capacity of 20 intakes is around 18 m^3/sec.

(4) Others

Several mining companies takes water from their own intakes. Two major intakes are located at around 1 km upstream from San Mateo and at just upstream of Pte. Huachipa at right bank. The latter one has a treatment plant with a settling pond.

4.4 Water Quality

Water quality analysis of the surface water in the Rimac river is carried out by DGASI and by SEDAPAL.

DGASI takes water samples at 15 stations in the Rimac river for three or four times a year to check the water quality for irrigation use. The locations of the sampling stations are illustrated in Fig. II-4-2. The water quality analysis is made on total 38 chemical and biochemical items.

On the other hand, SEDAPAL also conducts the water quality tests in the laboratory at Atarjea. Sampling is normally carried out once a month at eight locations along the main stream between Qda. Guayabo and La Atarjea intake weir site. Further at the inlet of the treatment plant, the turbidity of river water is checked every hour. Based on the turbidity record, suspended sediment volume is estimated and the result is compiled in daily-basis.

4.5 Tide

Tidal sea water level is observed at La Punta by DHNM as well as other meteorological observations. The result of observation is managed by hydrological section in DHNM. The monthly mean sea water level at La Punta in the period from 1970 to 1986 is summarized as follows;

Unit : m

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC.
1.12	1.13	1.15	1.14	1.15	1.13	1.10	1.08	1.07	1.08	1.08	1.12

5. RAINFALL ANALYSIS

5.1 Heavy Rainfall Characteristics

In the basin humid atmosphere causing of heavy rain-fall is provided from the Pacific Ocean by south western trade winds. The wind direction is almost constant throughout a year though the wind speed is weakened in summer season. The humid air column is transformed to clouds in mountainous area of middle and upstream areas. In usual heavy rainfall can be observed in valleys because uplifting of air is subject to narrow river course for conveying the air. Thus, extent of rain area is not so wide for ordinary rainfall of which scale is nearly equivalent to average annual maximum amount of 1-day rainfall. In case of more large scale of rainfall, however, it is deemed that rain area might be extended over the basin especially in the middle and upstream areas.

5.2 Probable Rainfall

5.2.1 Probable Rainfall in the Areas of Tributaries

Annual maximum 1-day rainfall was picked up at 10 meteorological stations where daily rainfall data is available in comparatively long term as shown in Table II-5-1. Four distributions, that is Iwai, Hazen, Pearson type III and Gumbel were applied to estimate probable values. As the result by the four methods, Pearson type III was selected because fitness by the theoretical values to the sample was judged sufficient among them. Table II-5-2 shows probable 1-day rainfall values for each station. In Fig. II-5-1 recorded values are plotted on the distribution paper by Thomas plotting position with theoretical frequency curve.

Further in order to estimate the probable rainfall over the drainage area of tributaries, the probable values are plotted in relation to altitude of the stations by respective return periods. A envelop line which shows a limit of considerable rainfall amount at a certain altitude was graphically drawn as shown in Fig. II-5-2. By means of the figures, basin mean probable 1-day rainfall over the tributary was obtained. Average elevation in the tributary area was estimated by the following simple equation.

Average EL. = Lowest EL. + 1/3 (Highest EL. - Lowest EL.)

Obtained result is tabulated in Table II-5-3.

5.2.2 Probable Rainfall over the Whole Basin

First, selection of meteorological stations to estimate areal rainfall over the basin was carried out.
In considering the duration of available daily rainfall record, four stations, that is Santa Eulalia, Matucana Carampoma and Milloc were selected. Although interrupted period of record is included at selected stations, the record during most of the period after 1966 is available.

As for estimation of rainfall over the basin upstream of Chosica, weights were given at the four stations by Thiessen method.

The Thiessen polygon is shown in Fig. II-5-3 and the weights are given as follows.

Station Name	Weight
Santa Eulalia	0.14
Matucana	0.38
Milloc	0.25
Carampoma	0.23
Total	1.00

Basin mean 1-day rainfall for upstream area of the confluence at Chosica was estimated by daily-basis and the annual maximum values was analyzed to estimate probable values. Table II-5-4 shows the annual maximum 1-day basin mean rainfall values. Table II-5-5 shows the probable values estimated by Pearson type III at several return periods.

6. WATER LEVEL-DISCHARGE RELATIONSHIP AT CHOSICA GAGING STATION

SENAMHI conducted a study on relationship of maximum or mean water levels versus instantaneous water level at Chosica R-2 station based on the record between 1971 and 1987. The result is shown in Fig.II-6-1. The top one shows the plotting position of the observed maximum and instantaneous water levels with a theoretical line. The "maximum" means the highest gage reading record on a certain day. The bottom one shows relationship between mean and observed instantaneous water levels with a theoretical line. The "mean" means the average gage reading record on a certain day.

As seen in the figure, it can be judged that the two kinds of water level data has positive correlation. Thus, by mean of these figure, instantaneous water level can be roughly estimated based on the observed maximum or mean water levels.

Table II-6-1 shows the annual maximum daily discharge value and the mean discharge on the same day at closed stations located downstream of Chosica. The "maximum" discharge means the largest value that is corresponded to the highest gage reading record on a certain day. The record is available from 1920 to 1975 in which period the gaging station had been moved different places at five times. Location names of the gaging station are described in the table.

Table II-6-2 shows the instantaneous peak water level and discharge at present station in Chosica town in the period from 1968 to 1986. The instantaneous water level, Hinst, is given by the equation presented in Fig. II-6-1 (top). In this table the value of instantaneous peak discharge is bigger than corresponded mean discharge in some years, though the former value should be bigger than the latter one. It is considered that the rating curve used for conversion from water level to discharge is different each other. As described in the remarks of the table, same rating curve of 1984 is utilized for estimation of the annual maximum instantaneous values.

According to the information up to present, it is hard to judge which value has higher reliability. It is needless to say that reliability of a rating curve mainly depends on accuracy of discharge measurement. Concludingly, it is recommended to store discharge measurement data at flood time as much as possible in order to verify the rating curves for high stage. Further, drawing and arranging cross sectional profile of the river in due order on each discharge measurement is quite essential to examine chronological river bed variation.

7. FLOOD RUNOFF ANALYSIS

7.1 Characteristics of Flood in the Rimac River Basin

Characteristic feature of flood in the basin is mainly dominated to rainfall distribution over the basin. It is deemed that heavy rainfall causing a flood occurs frequently at area above nearly 2,000 m of altitude in considering of rainfall data and vegetation covering outskirts of mountains. Thus, even in case of discussing the flood discharge in Lima (or at the river mouth), rainfall amount in that highland is main source of the flood discharge.

Further, in considering the width along river channel between Chosica and the river mouth, it seems that the peak discharge is more or less regulated in wide river channel stretching about 20 km at upstream of La Atarjea intake weir site, Within the stretch effect of channel storage might be expected under the present situation. Detailed discussion follows in Section 4.

7.2 Method of Analysis

7.2.1 Flood Analysis in Tributary Areas

The flood peak discharge in tributary areas forming the Rimac and the Santa Eulalia river basins were estimated for the study of debris flow. The discharge at the outlet of each tributary joining into the main stream was estimated by Rational formula. The probable rainfall estimated in Section 3 was utilized and effective rainfall was decided to be 80% of total rainfall in all tributary areas.

7.2.2 Flood Analysis over the Whole Basin

Flood peak discharge by various return periods in main stream was estimated based on the result of rainfall analysis. The base point to estimate the probable rainfall over the basin was determined at the confluence of the Rimac and the Santa Eulalia rivers.

In order to estimate flood hydrographs, unit hydrograph method by Nakayasu that provides a synthetic unit hydrograph was applied. The method has been proved valid through many applications in mountainous river basin in Japan.

Unit hydrograph of this method is simply determined by topographical factors and complex calibration of parameters by means of recorded flood hydrographs and storm rainfall is unnecessary. Therefore, in considering from insufficient flood data in the Rimac river basin, it is judged that this method is preferable.

To simplify the runoff simulation by the method, following assumptions were taken into account.

(1) Inflow discharge from the remaining area at downstream of Chosica is neglected because the rainfall amount is negligible small compared with the one in more upstream area.

(2) Retarding effect of peak discharge at two reservoirs of Sheque and Huinco dams in the Santa Eulalia river is neglected and assumed that the inflow volume is equal to outflow volume.

(3) Diverted volume from the Mantaro river basin to the Santa Eulalia river is neglected, because the volume is quite small compared with the natural runoff during flood in the Rimac river basin.

7.3 Flood Runoff in Tributary Areas

Probable flood discharge by various return periods was estimated by the Rational formula as below.

$$Q = (1/3.6)\ CIA$$

Where,
- Q: Discharge (m^3/sec)
- I: Rainfall intensity (mm/hr)
- A: Catchment area (km^2)
- C: Runoff coefficient

The rainfall intensity, and lag time are needed to compute the flood peak discharge by means of the Rational formula.

The rainfall intensity by return periods were estimated by Mononobe's equation expressed as below.

$$I = \left(\frac{R}{24}\right) \times \left(\frac{24}{TC}\right)^{2/3}$$

where,
- I: Maximum rainfall intensity during time of concentration (mm/hr)
- R: 1-day rainfall (mm)
- TC: Time of concentration (hrs)

Time of concentration of flood in the equation above was estimated by means of the Kraven's equation expressed as below.

$$TC = \frac{L}{W}$$

where,
- L: Length of river stretch
- W: Flow velocity of flood

Flow velocity can be roughly defined by the river bed slope as below.

```
I     I 1/100     1/200  I  1/100         1/200  I
W       3.5 m/sec       3.0 m/sec       2.1 m/sec
```

Further, runoff coefficient of 80% in all the tributary areas are applied. In Japan, a value between 0.75 and 0.90 of runoff coefficient in the Rational formula is commonly used in mountainous river basin. It can be pointed out that energy relief of mountainous area in the highland in Japan is also quite large as well as the Rimac river basin. Thus, a medium value in the range of runoff coefficient was applied.

Based on the conditions above mentioned, the probable flood peak discharge in each tributary area was estimated as tabulated in Table II-7-1.

7.4 Flood Runoff in Main Stream

7.4.1 Past Flood Record and Studies

(1) Past Flood Record

According to the mean daily discharge record at Chosica which is stored in SENAMHI, the maximum value of 500 m^3/sec was recorded on Mar. 19 in 1925. The year 1925, is well known that a strong EL NINO event attacked nation-wide over the Peruvian territory. Although no rainfall record is available, the Rimac river basin could have received a copious rainfall during the rainy season in that year.

It is not clear whether the value of 500 m^3/sec is an average discharge on that day or an instantaneous peak discharge. Anyway it can be said that it is an extraordinary big discharge in this basin.

Regarding to the flood record, a report by US Army Corps of Engineers (Feb. 1985) mentions that the discharge might be equivalent to the flood peak discharge occurring one in around 100 year of frequency. When the flood occurred over topping of the river bank could have been happened at comparatively long stretch along the main stream. However, it is deemed that the damage in Lima metropolitan area due to the flood might be not so remarkable because economical damage potential is not so highly concentrated as nowadays. In addition, it can be identified that the river width in Lima is wider than at present especially at the stretch between Pte. Ejercito and Pte. Faucete (narrow sections at present) as far as seeing in the historical city map of Lima. Thus the carrying capacity of the river channel is reduced artificially little by little and resulting more dangerous situation against flood at present.

(2) Flood Runoff Studies

Among several studies on hydrology in the Rimac river basin, especially in the field of runoff analysis, the study result of "The Rimac River Channelizing Project" by PREDES in 1985 involves valuable guideline.

On the data sheet of mean daily discharge at Chosica G/S, instantaneous monthly peak discharge is noted in several months. By means of the data, they tested correlation between the both values of mean daily and instantaneous peak discharges and found parabolic relationship as expressed below.

$$QMD = 0.0017\ (Q\ Inst)^2 - 0.2392\ Q\ Inst + 61.258$$

Where, QMD = Annual maximum mean daily discharge (m^3/sec)

QInst. = Annual maximum instantaneous discharge (m^3/sec)

Then, they estimated a series of annual maximum instantaneous discharge and conducted frequency analysis by two different kind of distribution, that is Gumbel and Pearson-Foster. Further, they checked by normal order statistic method of Weibull. The result can be summarized as below.

Return period (year)	Gumbel (m3/sec)	Pearson-Foster (m3/sec)	Weibull (m3/sec)
5	370	380	380
10	437	440	450
50	570	600	610
100	660	-	680

The study, finally, concluded that 680 m3/sec of 100 year probable peak discharge is to be acceptable for design discharge of channel normalization between Pte. Los Angeles and Pte. Huachipa.

7.4.2 Simulation Model

The basin was divided into total eight sub basins considering from the topographical point of view in terms of runoff condition over the basin. Fig. II-7-1 shows the basin division with schematic diagram of sub basins and river channels. Explanation on unit hydrograph is presented in next clause.

7.4.3 Probable Flood Discharge

(1) Areal Rainfall Pattern

Nearly 30 cases of rainy days when more than 10 mm of daily rainfall was recorded at most of stations in the middle and upstream areas were picked up. Then, isohyetal lines were drawn individually based on the record in order to extract typical areal distribution of heavy rainfall. The isohyetal maps can be divided into three groups by approximate rainfall zone over the basin as follows.

(a) Mainly over the Rimac river basin

(b) Mainly over the Santa Eulalia river basin

(c) Over the whole basin

As for the application of Unit hydrograph method, it is required to select a areal distribution based on the observed record which covers as large area of the interested basin as possible. In this reason, An isohyetal pattern was selected in the group (c) was most preferable. It is shown in Fig. II-5-3 with Thiessen polygon.

(2) Distribution of Rainfall

It is necessary to determine the distribution in duration of rainfall. Hourly rainfall record is available at three meteorological stations, that is Matucana, Rio Blanco and Milloc. However, the rainfall pattern obtained theoretically was applied besides the recorded distribution at the stations for computation of probable flood in considering following reasons.

(a) There is a possibility to occur to create more large peak discharge by other than recorded patterns selected.

(b) It is judged that the data is too few to determine the design rainfall pattern based on the available hourly rainfall data.

Process of the data analysis is explained as below.

The period of the available data at the stations is as below.

Station	Period
Matucana	1977-1983
Rio Blanco	1985
Milloc	1985

Among them, continuous rainfall record having more than 10 mm in total was selected and accumulated rainfall curves were drawn to examine duration and distribution of storm rainfall as shown in Fig.II-7-2 to Fig.II-7-4. At each station comparatively long duration and large amount of total rainfall were further selected and prepared non-dimensional accumulated curves as shown in Fig. II-7-5, which shows approximate curves as well as recorded values by dashed line.

In the course of checking hourly rainfall record, it was clarified that most of storm rainfall keep the duration of rainfall within 24 hours at all the stations. Result of interview survey to inhabitants at the field also supports that fact. Thus, it was concluded that 1-day rainfall was utilized to estimate probable flood discharge.

Fig. II-7-6 illustrates three patterns selected in observed hourly rainfall data (Pattern A, B and C) and one pattern obtained theoretically to place the peak at 80% in 24 hours. Pattern D is obviously known to create the largest peak discharge among the four patterns. Therefore, this pattern was finally applied to estimate probable flood discharge.

In all the sub basins the same pattern was utilized.

(3) Probable Rainfall in Sub Basins

The probable rainfall was estimated over the whole basin in Section 3. To apply the rainfall values in the computation of probable flood discharge, the value over the whole basin was required to break down into each sub basins. In conformity with the values, isohyetal values were estimated by means of the areal pattern as shown in Fig. II-5-3. Then, the areal values in the four sub basins were calculated by the proportion of area as tabulated in Table II-7-2.

(4) Effective Rainfall

In case that recorded both hourly rainfall and discharge data in same period is available, calibration by changing the value of rainfall loss can be carried out until obtaining a simulated hydrograph adequately close to the recorded one. However, such a detailed calibration is not practical due to lack of required data at present.

Concludingly, 10 mm of initial loss and 70% as a constant ratio of discharge after losing by initial loss were applied.

(5) Unit Hydrograph

Synthetic unit hydrographs in each sub basin were estimated by Nakayasu's method. Fig. II-7-7 shows the equations of rising and recession curves of unit hydrographs with notation of parameters. Four unit hydrographs were given for 1 mm in effective rainfall depth of 1 hour in duration.

This method is widely utilized in many river basins where available rainfall and discharge data is quite few or not existed. The several parameters described in Fig.II-7-7 was empirically obtained through at lot of applications in mountainous basins in Japan. Further, this method is applied and yielded sufficient result in other countries out of Japan.

Of course, this method is not absolute tools for computation of flood hydrographs. It is noteworthy that another approach will be required after storing more available data to increase reliability of accuracy of flood analysis.

(6) Probable Flood Discharge

Outflow discharges from sub basins were combined with 3 hours of time lag for upstream basins of the Rimac and the Santa Eulalia rivers (Sub basin No. 1 and No. 3). Because the effect of channel storage might be small due to steep gradient of the river bed, retarding of peak discharge in these sub basins was not taken into account. A constant discharge of 30 m^3/sec for base flow was added. Thus, the probable flood peak discharge at Chosica were obtained as below. And probable flood hydrographs are shown in Fig. II-7-8.

Return period (Year)	Flood peak discharge (m^3/sec)
2	150
5	290
10	380
25	490
50	580
100	660
200	740
500	820
1,000	920

As compared with the flood analysis by statistic method of instantaneous peak discharge by PREDES (Ref. Clause 5.4.1), the values of peak discharge in range of short return period are a little small. However, the peak discharge at 100 year of recurrence frequency is quite close each other.

It is needless to say that further calibration of not only rainfall loss but also unit hydrographs by accurate hourly basis rainfall and discharge data is quite essential in later studies. Especially approximate runoff coefficient of actual floods at scale by scale should be examined to make sure the result of related analysis. Concludingly the peak discharge estimated herein was utilized in the succeeding the channel improvement study. Runoff coefficient, which is a ratio between effective and total rainfall, of flood discharge volume by several return periods in each sub basin is presented as below.

Sub basin No.	10-yr	25-yr	50-yr	100-yr	500-yr
1	0.31	0.36	0.39	0.41	0.45
2	0.23	0.30	0.35	0.37	0.40
3	0.37	0.41	0.43	0.45	0.48
4	0.19	0.28	0.32	0.35	0.41

7.4.4 Retarding Effect of Flood Peak Discharge in Existing River Channel

It is noteworthy that the river stretch lying upstream of La Atarjea intake which is around 20 km in distance has function to retard more or less the magnitude of flood peak discharge due to the broad width of the stretch. In addition, a certain part of sediment material from upstream reach is expected to deposit because the energy of stream flow might be diffused. Thus, this stretch has important function for metropolitan area developing in downstream alluvial fan.

In order to examine the retarding function above, flood routing of the river channel from the confluence with the Santa Eulalia river to the confluence with the Qda. Jicamarca was carried out. Hydrograph of 100-year probable flood at the confluence with Qda. Jicamarca was estimated in considering of the river channel storage.

Both hydrographs at the confluence with Santa Eulalia river and at the confluence with Qda. Jicamarca are shown in Fig. II-7-9. Flood hydrograph at the confluence with Qda. Jicamarca in case of reduced river channel of 60 m constant along the broad stretch is also illustrated.

As seen in the figure, the retarding effect of peak discharge will be decreased 40 m^3/sec from 120 m^3/sec to 80 m^3/sec due to the reduction of river channel assumed.

8. SEDIMENT

In case of the Rimac river basin, it is deemed that bed load material is major component of sediment transport because of the gradient of steep river bed.

Generally total amount of sediment volume depends on comparatively big magnitude of discharge due to heavy rainfall in upstream area. In the Rimac river basin, huaycos occurring in tributary areas flush mass of soil material into the main streams. It is not available to discuss total sediments yield all over the basin, because no direct measurement of bed load and suspended load is carried out in the Rimac river.

However, the record of suspended load estimated based on the turbidity of surface water at La Atarjea intake show a outline of feature on the sediment transport in associated with the rainfall record in the basin. Chronological variation of the monthly amount of suspended load at the intake is shown in Fig. II-8-1 with the record of monthly rainfall at Matucana.

As seen in the figure, most part of annual suspended load is recorded during January to March, in other words in rainy season, in every year from 1976 to 1985. Especially, the monthly amounts in March, 1983 and February, 1984 farther exceed the maximum values in other years. Moreover, the monthly rainfall at Matucana in these two months are also recorded verge large. It is reported that huaycos happened in upstream tributaries in 1983 and 1984. Thus, sediment transport in the Rimac river is closely related to the huayco-occurrence.

Tables

Table II-1-1 METEOROGICAL OBSERVATORIES IN AND AROUND THE RIMAC RIVER BASIN

No.	Station name	Location		Altitude	Institution in charge
		Lat.S	Long.W	(EL.m)	
1	Chosica *	11o55'	76o23'	851	SENAMHI
2	Lince *	12o05'	77o01'	109	SENAMHI
3	Chorrillos *	12o10'	77o01'	37	SENAMHI
4	Nana	11o59'	76o50'	566	SENAMHI
5	La Cantuta *	11o57'	76o42'	850	SENAMHI
6	Matucana	11o50'	76o23'	2,378	SENAMHI
7	La Punta *	12o04'	77o10'	13	SENAMHI
8	Las Palmas *	12o09'	77o00'	65	SENAMHI
9	Santa Clara *	12o01'	76o02'	415	SENAMHI
10	Campo de Marte *	12o02'	77o02'	137	SENAMHI
11	A Von Humboldt *	12o05'	77o00'	238	SENAMHI
12	Hipolito Unanue	12o04'	77o04'	70	SENAMHI
13	Limatambo *	12o02'	77o01'	136	SENAMHI
14	Aerop. International	12o00'	77o07'	13	CORPAC
15	Mina Colque	11o35'	76o29'	4,600	SENAMHI
16	Laguna Quisha	11o31'	76o23'	4,650	SENAMHI
17	Laguna Pirhua	11o41'	76o19'	4,750	SENAMHI
18	Santa Eulalia	11o54'	76o40'	1,030	SENAMHI
19	Carampoma	11o39'	76o31'	3,272	SENAMHI
20	San Jose de Parac	11o48'	76o15'	3,800	SENAMHI
21	Ticlio *	11o36'	76o12'	4,800	SENAMHI
22	Casapalca *	11o39'	74o14'	4,123	SENAMHI
23	Bellavista *	11o41'	76o16'	3,950	SENAMHI
24	Milloc	11o34'	76o21'	4,400	ELECTROLIMA
25	Tamboraque	11o47'	76o19'	3,100	ELECTROLIMA
27	Acobampa *	11o33'	76o30'	4,200	SENAMHI
28	Chucuito	12o03'	77o09'	4	DHNM
29	Marca #	11o24'	76o20'	4,430	ELECTROLIMA
30	Rio Blanco	11o44'	76o15'	3,550	SENAMHI
31	La Molina *	12o05'	76o55'	255	SENAMHI
32	Cahuide	12o05'	77o02'	140	SENAMHI
33	Autisha	11o44'	76o37'	2,300	SENAMHI

Remarks : *, Station abandoned
#, Station located out of the basin

Table II-1-2 AVAILABLE METEOROGICAL DATA

No.	Station name	1	2	3	4	5	6	7	8	9
1	Chosica *	o		o	o	o				
2	Lince *	o	o							
3	Chorrillos *	o	o							
4	Nana	o	o	o	o	o	o	o		
5	La Cantuta *	o								
6	Matucana	o	o	o	o	o	o	o	o	o
7	La Punta *	o		o	o	o	o	o	o	o
8	Las Palmas *	o	o							
9	Santa Clara *	o	o							
10	Campo de Marte *	o	o	o	o	o	o	o	o	o
11	A Von Humboldt *	o	o	o	o	o	o	o	o	o
12	Hipolito Unanue	o	o	o	o	o	o		o	o
13	Limatambo *	o		o	o	o	o		o	
14	Aerop. International	o		o	o	o	o	o	o	o
15	Mina Colque	o	o							
16	Laguna Quisha	o	o							
17	Laguna Pirhua	o	o							
18	Santa Eulalia	o	o							
19	Carampoma	o	o							
20	San Jose de Parac	o	o							
21	Ticlio *	o								
22	Casapalca *	o								
23	Bellavista *	o								
24	Milloc	o	o	o	o	o				
25	Tamboraque	o								
26	Acobampa *	o								
27	Chucuito	o		o	o	o	o	o	o	o
28	Marca #	o	o	o	o	o				
29	Rio Blanco	o								
30	La Molina *	o	o	o	o	o	o	o		o
31	Cahuide	o		o	o	o	o	o	o	o
32	Autisha	o								

Remarks: 1, Monthly rainfall
2, Daily rainfall
3, Monthly mean temperature
4, Monthly maximum temperature
5, Monthly minimum temperature
6, Relative humidity
7, Evaporation
8, Wind velocity and direction
9, Sunshine hours

Table II-2-1 HYDROLOGICAL OBSERVATORIES IN THE RIMAC RIBER BASIN

No.	Station name	Location		Altitude	Institution in charge
		Lat.S	Long.W	(EL.m)	
1	Decembocadura *	12o02'	77o08'	5	SENAMHI
2	Chacrasana *	11o57'	76o44'	750	SENAMHI
3	Pte. Los Angeles *	11o58'	76o44'	700	SENAMHI
4	Yanacoto *	11o56'	76o43'	800	SENAMHI
5	Pte. Huachipa *	12o00'	76o53'	450	SENAMHI
6	Chosica R-1 *	11o56'	76o42'	850	SENAMHI
7	Chosica R-2	11o56'	76o42'	850	SENAMHI
8	San Mateo	11o46'	76o18'	3,200	SENAMHI
9	Rio Blanco	11o44'	76o16'	3,550	SENAMHI
10	Yuracmayo *	11o50'	76o10'	4,350	SENAMHI
11	Cocachacra *	12o54'	76o32'	1,430	SENAMHI
12	Surco *	11o54'	76o26'	2,000	ELECTROLIMA
13	Tamboraque	11o47'	76o19'	3,100	ELECTROLIMA
14	Sheque	11o39'	76o30'	3,200	ELECTROLIMA
15	Milloc	11o35'	76o22'	4,500	ELECTROLIMA
16	Autisha	11o44'	76o37'	2,200	ELECTROLIMA

Remarks : *, Station abandoned

Table II-2-2 PERIOD OF AVAILABLE WATER LEVEL RECORD (AUTOMATIC WATER LEVEL CHART)

Year	Hydrological station		
	Chosica	San Mateo	Rio Blanco
1969			
1970			
1971			
1972	1,2,3,4		
1973			
1974			
1975	3,4		
1976	2,3		
1977	2		1,2,3
1978		1,2,3	1,2,3
1979		1,2,3	1,2,3
1980			2,3
1981	2,3	1,2,3	1,2,3
1982		1,2,3	1
1983	1 3	1,2,3	
1984			
1985	1,2,3	1,2,3	1,2,3
1986	1,2,3	1	1,2,3

Note : Numbers above means name of month.
ex) 1 = January

Table II-3-1 SUMMARY OF MONTHLY RAINFALL RECORD

Unit : mm

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hipolito Unanue 1969-72	4.1	0.0	0.3	0.2	0.4	2.2	3.0	3.1	2.8	0.5	1.1	0.3	18.0
Limatambo 1950-62	1.8	0.9	0.7	0.2	2.0	3.9	6.1	6.9	7.4	4.8	2.2	1.4	38.3
Campo de Marte 1927-82	1.0	0.5	0.5	0.2	1.8	3.3	4.1	5.0	4.6	1.8	0.9	0.6	24.3
A Von Humboldt 1966-72	2.8	0.8	0.8	0.3	1.1	2.3	2.4	2.3	1.7	1.7	0.8	0.7	17.7
La Molina 1930-61	0.8	0.7	0.7	0.8	1.8	2.9	3.0	2.8	2.4	1.1	0.6	0.6	18.2
Ñaña 1964-84	1.5	0.7	1.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	4.7
Chosica 1948-54	4.6	4.6	4.9	0.9	0.1	0.0	0.0	0.0	0.0	0.5	0.4	2.0	18.0
Santa Eulalia 1969-72	29.8	16.3	50.0	0.0	0.0	0.0	0.0	0.0	2.7	0.5	0.6	6.9	106.8
Carampoma 1966-72	85.2	85.6	84.0	24.8	3.5	0.2	0.2	1.2	13.0	29.8	2.5	29.1	359.1
Bellavista 1947-71	114.0	135.0	121.2	46.1	17.6	2.6	2.2	6.6	18.1	37.2	48.6	90.0	639.2
San Jose de Parac 1966-69	80.5	109.1	112.2	9.2	0.5	0.0	0.8	0.0	3.3	48.5	19.3	47.6	431.0
Casapalca 1947-71	117.8	131.8	119.3	59.6	25.8	12.6	8.0	11.8	35.4	51.8	54.5	91.0	719.4
Milloc 1965-86	125.6	149.3	141.2	64.8	22.7	14.9	13.3	16.5	42.7	73.3	76.8	117.1	858.2
Mina Colqui 1969-71	122.4	140.2	144.0	57.2	7.7	0.4	0.3	3.0	29.0	59.2	53.0	180.2	796.6
Lag. Quisha 1969-72	173.2	142.2	175.4	90.1	24.6	1.4	14.6	14.1	61.4	86.2	62.0	175.0	1020.2
Lag. Pirhua 1970-72	177.3	142.1	189.8	70.4	22.4	0.2	13.8	10.1	40.4	83.1	42.2	149.4	946.2
Ticlo 1956-67	92.7	128.3	101.9	58.6	29.7	8.0	10.5	20.6	43.5	61.2	50.8	82.1	687.9
Matucana 1964-85	44.6	64.8	93.7	14.3	2.0	0.2	0.0	0.1	3.5	7.8	7.4	33.8	272.2

Table II-3-2 MONTHLY PRECIPITATION AT CAMPO DE MARTE (1/2)

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1927	–	–	2.4	1.0	1.3	6.4	5.0	9.4	11.2	2.0	3.5	0.2	–
1928	–	–	–	–	–	–	–	5.7	1.9	1.1	0.6	0.5	–
1929	0.8	0.0	2.0	0.0	4.5	6.5	3.5	6.9	7.3	2.0	2.2	1.7	37.4
1930	0.2	0.5	0.4	1.0	3.6	3.5	4.3	5.8	7.9	3.7	1.6	0.3	32.8
1931	0.0	0.0	0.2	0.0	1.5	6.6	13.9	10.2	7.6	2.5	1.8	1.0	45.3
1932	2.5	2.7	0.1	0.3	9.1	2.6	8.4	10.0	9.8	3.1	0.8	0.2	49.6
1933	0.5	0.0	0.4	0.0	0.8	2.1	4.4	11.4	7.1	1.5	0.2	0.2	28.6
1934	0.6	1.2	0.5	0.0	1.0	8.3	7.4	9.4	8.7	2.0	0.6	0.5	40.2
1935	3.6	0.2	0.5	0.0	0.3	6.4	8.8	5.3	8.9	1.6	2.4	0.1	38.1
1936	1.4	0.2	0.1	1.6	4.4	4.4	6.7	7.9	6.1	4.1	3.8	1.9	42.6
1937	0.3	0.1	0.4	0.4	3.2	4.9	9.6	8.1	10.4	0.8	0.6	2.0	40.8
1938	2.2	0.4	0.9	0.1	2.0	5.1	9.0	10.8	6.0	2.8	4.5	2.5	46.3
1939	0.4	0.0	0.5	0.1	3.7	6.0	3.8	4.1	1.3	2.4	0.7	0.0	23.0
1940	0.0	0.4	0.0	0.1	7.1	6.7	3.4	6.5	5.8	4.6	0.4	2.4	37.4
1941	1.0	0.8	1.0	3.0	11.1	11.2	4.3	8.3	5.1	6.9	4.8	1.5	59.0
1942	3.0	0.2	1.1	0.0	2.3	4.1	7.4	8.9	7.3	5.1	1.3	0.0	40.7
1943	1.3	0.0	0.5	0.1	0.7	9.2	12.2	14.1	12.1	1.2	0.1	–	–
1944	0.0	0.4	0.3	0.3	3.3	1.9	9.0	9.4	4.8	0.8	0.4	0.3	30.9
1945	0.0	0.0	0.0	0.0	0.0	0.2	3.8	4.2	2.5	0.5	0.0	0.2	11.4
1946	0.1	1.0	0.3	0.0	0.4	8.6	7.2	4.6	4.2	2.4	1.8	1.5	32.1
1947	0.7	0.0	0.0	0.0	0.2	1.5	2.7	4.0	3.2	2.1	0.4	0.1	14.9
1948	0.0	0.4	0.0	0.7	3.5	2.2	0.8	3.7	4.2	2.0	0.2	0.1	17.8
1949	0.0	0.0	2.1	0.0	0.2	6.3	5.7	5.1	4.1	0.0	0.7	0.0	24.2
1950	–	0.0	0.0	0.0	0.4	4.9	5.3	8.3	7.2	3.1	0.5	1.9	–
1951	0.0	0.0	3.5	0.0	0.0	0.9	1.5	4.1	3.4	4.4	3.2	0.7	21.7
1952	5.2	0.0	0.4	0.0	0.1	5.1	5.5	5.1	2.4	3.2	1.9	0.0	28.9
1953	0.0	0.0	0.0	0.0	10.6	9.2	14.8	12.0	6.4	1.7	2.4	0.7	57.8
1954	0.0	0.0	0.0	0.0	5.0	2.2	2.0	4.1	2.7	1.3	1.0	0.3	18.6
1955	0.5	0.2	0.4	0.0	0.3	2.8	3.6	4.4	3.7	2.3	0.3	0.1	18.6
1956	0.2	1.8	0.6	0.2	2.5	4.4	3.4	1.6	5.6	2.5	0.0	0.0	22.8
1957	0.1	1.5	0.5	0.0	1.0	0.2	2.7	2.7	5.5	3.1	0.7	1.0	19.0
1958	5.3	0.2	0.8	0.0	1.2	5.8	1.7	2.2	3.3	1.1	0.9	0.1	22.6
1959	0.1	0.5	0.0	1.0	2.1	2.4	5.0	6.9	1.5	1.0	0.8	2.4	23.7
1960	0.0	0.0	0.0	0.0	0.5	2.0	1.7	2.9	4.4	3.5	0.5	0.0	15.5
1961	0.0	1.4	0.9	0.2	0.0	3.3	3.8	3.2	8.1	1.3	0.0	0.0	22.2
1962	0.0	0.0	0.0	0.0	0.5	3.2	9.3	5.6	13.9	2.9	0.5	0.0	35.9
1963	0.0	1.5	0.0	0.3	1.4	0.9	0.2	2.5	6.1	2.3	0.8	0.0	16.0
1964	0.1	0.0	0.0	0.0	0.2	0.6	1.3	3.3	0.2	0.1	0.0	0.0	5.8
1965	0.0	0.6	0.0	0.0	3.0	0.2	1.3	0.5	6.5	2.4	0.2	0.1	14.8
1966	0.0	0.0	0.4	0.0	0.0	1.8	0.2	1.3	1.7	0.5	0.5	1.5	7.9
1967	0.9	0.6	1.6	0.0	0.4	0.4	2.3	1.2	1.4	0.3	0.2	0.5	9.8
1968	0.0	0.0	0.0	0.0	0.2	0.0	0.6	1.0	0.9	0.8	0.1	0.1	3.7
1969	0.0	0.0	0.0	0.6	0.5	3.5	1.8	2.9	0.9	0.0	2.3	0.5	13.0
1970	17.4	0.6	0.3	0.0	0.6	2.5	4.4	1.2	1.6	0.1	0.6	0.2	29.5

Table II-3-2 MONTHLY PRECIPITATION AT CAMPO DE MARTE (2/2)

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1971	0.4	0.0	0.0	0.0	1.0	3.1	1.8	6.4	1.8	0.7	0.0	0.0	15.2
1972	0.2	0.0	0.9	0.0	0.0	0.0	0.9	0.6	5.3	1.9	0.3	0.6	10.7
1973	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.5	1.2	0.2	0.6	0.1	3.3
1974	0.0	5.0	0.0	0.1	0.5	2.5	1.4	3.1	0.3	0.3	0.0	1.8	15.0
1975	0.3	1.5	0.0	0.0	1.8	1.1	1.2	1.0	0.2	0.4	0.1	0.1	7.7
1976	0.0	–	–	0.0	1.4	0.3	0.0	0.4	2.5	1.4	0.0	0.2	–
1977	0.0	0.2	0.0	0.0	0.1	0.4	2.6	1.4	4.0	0.6	0.2	0.6	10.1
1978	0.0	0.0	0.4	0.2	0.1	0.1	0.3	1.6	1.2	0.6	0.0	0.0	4.5
1979	0.0	0.0	1.5	0.0	0.0	0.2	0.2	2.0	0.7	1.4	0.1	0.3	6.4
1980	0.0	0.0	0.0	0.0	0.1	1.3	1.3	0.7	1.2	0.1	0.0	0.1	4.8
1981	–	0.1	0.0	0.3	0.0	0.0	0.4	5.0	0.0	0.0	0.0	0.0	–
1982	0.0	0.0	0.0	0.0	0.0	0.2	1.5	–	–	–	–	–	–
Mean	1.0	0.5	0.5	0.2	1.8	3.3	4.1	5.0	4.6	1.8	0.9	0.6	24.1

Table II-3-3 MONTHLY PRECIPITATION AT ÑAÑA

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
1965	0.0	0.6	0.7	0.0	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.7	3.6
1966	2.9	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	1.5	1.5	2.0	8.7
1967	5.0	6.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–
1969	4.5	0.0	0.0	0.0	0.0	–	0.0	–	0.0	0.0	0.0	–	–
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0	0.0	–
1971	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	–
1972	–	–	–	–	–	–	–	0.0	–	0.0	0.0	–	–
1973	–	–	–	0.0	–	–	–	–	–	0.0	0.0	0.0	–
1974	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4
1975	0.8	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7
1976	8.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	10.8
1977	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	2.9
1978	0.0	0.0	1.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
1979	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
1980	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	–
1981	–	–	–	–	–	0.0	0.0	0.0	0.0	–	–	0.0	–
1982	0.0	–	–	–	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	0.0	0.0	0.0	–	0.0	0.0	–	–	–
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Mean	1.5	0.7	1.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	4.6

Table II-3-4 MONTHLY PRECIPITATION AT MATUCANA

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	-	64.6	57.6	61.1	5.1	0.0	0.0	0.0	0.0	4.6	6.0	33.2	-
1965	55.4	82.8	69.8	10.5	2.6	0.0	0.0	0.0	3.8	13.7	6.7	24.8	270.1
1966	61.6	38.7	52.5	22.3	0.2	0.0	0.0	0.0	0.0	18.0	0.0	37.0	230.3
1967	77.3	147.7	97.1	17.2	3.7	0.0	-	-	2.1	15.2	4.3	8.4	-
1968	24.9	24.9	33.3	11.2	7.7	-	-	-	-	-	-	-	-
1969	11.4	54.6	73.3	26.3	0.0	0.0	0.0	0.0	0.9	18.1	24.1	55.2	263.9
1970	106.9	8.9	35.4	29.1	9.1	0.0	0.0	0.0	21.8	14.5	5.4	53.8	284.9
1971	57.4	72.6	116.0	27.4	0.0	0.0	0.0	0.0	0.0	6.6	1.2	43.0	324.2
1972	63.5	106.2	144.8	13.8	0.0	0.0	0.0	0.0	1.5	12.6	5.0	48.2	395.6
1973	82.3	80.8	58.7	5.7	0.0	0.0	0.0	0.0	33.9	8.3	7.5	56.9	334.1
1974	45.3	76.4	75.8	9.4	0.0	0.0	0.0	0.0	0.4	0.6	4.6	21.3	233.8
1975	33.4	59.0	118.3	8.9	6.2	0.8	0.0	0.0	1.3	7.0	12.4	40.1	287.4
1976	70.3	73.4	58.1	0.5	0.5	0.9	0.0	0.0	0.8	0.0	0.0	26.2	230.7
1977	32.9	69.5	37.8	2.7	5.9	0.0	0.0	0.0	2.5	0.6	28.7	26.2	206.8
1978	29.1	29.8	21.0	5.4	0.0	0.0	0.0	0.0	1.5	0.0	7.8	12.6	107.2
1979	15.1	43.2	65.5	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.9	-	-
1980	18.0	8.3	21.0	18.8	0.0	0.0	0.0	0.0	0.0	14.1	0.0	13.7	93.9
1981	62.0	43.4	72.8	0.0	0.0	0.0	0.0	0.0	0.0	4.2	1.5	33.9	217.8
1982	28.2	25.3	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.9	93.7
1983	9.5	62.0	169.2	25.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.7	299.3
1984	34.1	196.8	86.5	10.5	1.0	1.8	0.0	0.0	0.0	20.5	29.2	73.4	453.8
1985	17.9	55.7	67.7	8.7	2.2	0.0	0.0	1.6	2.7	1.7	0.0	-	-
Mean	44.6	64.8	71.0	14.3	2.0	0.2	0.0	0.1	3.5	7.8	7.4	33.8	249.3

Table II-3-5 MONTHLY PRECIPITATION AT MILLOC

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1965	-	-	-	-	-	-	-	-	-	76.0	37.0	146.0	-
1966	196.0	108.0	130.0	72.0	25.0	-	7.0	5.0	68.0	181.0	181.0	146.0	-
1967	177.0	229.0	199.0	60.0	45.0	9.0	27.0	25.0	51.0	138.0	55.0	80.0	1095.0
1968	132.0	108.5	112.0	37.2	27.0	13.5	9.0	38.0	35.5	89.5	80.0	59.0	741.2
1969	68.5	122.0	107.0	117.5	6.0	6.0	19.1	14.5	60.0	55.5	74.5	190.0	840.6
1970	175.0	60.0	100.5	86.0	46.0	3.0	15.5	10.5	97.0	78.0	57.0	171.0	899.5
1971	112.0	177.7	183.0	66.5	20.5	-	-	22.5	15.0	48.5	64.0	183.0	-
1972	129.0	125.0	222.0	76.5	5.0	-	20.5	-	46.5	67.0	34.0	142.0	-
1973	161.7	191.7	175.1	125.6	31.5	4.5	24.4	23.5	61.0	105.2	69.4	156.3	1129.9
1974	167.1	107.0	154.7	49.2	8.0	6.6	3.7	20.6	34.9	47.9	66.9	51.4	718.0
1975	30.8	115.5	171.4	53.6	68.6	15.2	-	21.3	54.4	40.2	59.3	96.1	-
1976	128.7	145.8	95.2	42.8	23.2	48.2	2.7	28.3	27.8	15.9	24.5	68.7	651.8
1977	106.8	166.2	83.7	29.1	44.6	-	2.3	3.5	32.0	24.3	125.8	95.0	-
1978	119.4	155.9	83.3	29.3	2.0	19.1	17.2	5.2	37.2	59.3	69.8	69.0	666.7
1979	53.3	165.9	155.7	55.2	16.0	7.6	14.4	0.0	25.1	36.6	48.4	71.4	649.6
1980	162.0	76.6	130.3	45.0	7.2	20.2	37.0	5.2	16.2	170.1	131.9	122.0	923.7
1981	139.6	219.6	128.8	52.0	3.2	1.2	1.4	22.0	39.4	89.6	152.0	113.0	961.8
1982	145.6	241.0	98.4	68.4	0.0	-	13.2	51.8	41.2	81.2	125.0	103.8	-
1983	97.0	89.6	133.8	97.6	9.0	18.4	2.4	3.6	38.2	65.8	33.2	124.8	713.4
1984	77.2	203.8	131.2	37.0	12.2	29.8	0.0	2.4	-	112.4	112.0	159.6	-
1985	52.5	113.8	143.8	96.4	29.2	21.8	2.4	2.0	30.8	7.2	52.4	111.1	663.4
1986	206.7	212.6	226.7	-	46.9	-	34.2	25.6	-	23.2	36.5	-	-
Mean	125.6	149.3	141.2	64.8	22.7	14.9	13.3	16.5	42.7	73.3	76.8	117.1	819.6

Table II-3-6 SUMMARY OF MEAN MONTHLY ATMOSPHERIC TEMPERATURE RECORD

Unit : oC

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hipolito Unanue 1961-71	21.4	22.4	22.0	20.4	19.4	18.0	16.6	16.3	16.5	17.4	18.9	20.3	19.1
Limatambo 1950-62	21.1	22.0	21.7	20.0	18.0	16.1	15.3	15.1	15.2	16.2	17.5	19.4	18.1
Campo de Marte 1937-82	21.8	22.7	22.2	20.6	18.3	16.5	15.6	15.3	15.5	16.5	18.0	19.8	18.6
A Von Humboldt 1966-72	20.9	22.0	21.6	19.8	17.5	15.8	14.7	14.6	15.1	15.9	17.3	19.2	17.9
La Molina 1930-67	21.8	22.6	22.2	20.3	17.6	15.7	14.9	15.0	15.4	16.3	17.7	19.6	18.3
Ñaña 1964-84	21.3	22.2	22.3	22.2	18.6	17.4	15.3	15.2	15.8	16.8	17.7	16.6	18.5
Chosica 1948-54	22.2	23.2	23.2	21.7	19.1	17.0	16.1	17.2	18.0	19.1	20.0	20.8	19.8
Matucana 1964-71	14.3	14.2	14.1	14.4	14.5	14.2	14.2	14.3	14.5	14.5	15.2	15.0	14.5
Milloc 1969-71	4.5	4.7	5.0	5.5	5.5	4.8	5.4	5.7	4.9	4.4	4.5	4.8	5.0
Aerop. Inter. 1961-86	22.1	22.5	22.2	20.6	18.7	17.5	16.7	16.4	16.5	17.3	18.7	20.6	19.2
Chucuito 1978-86	21.6	22.1	22.0	20.6	18.8	18.1	17.2	16.8	16.8	17.6	19.0	20.6	19.3

Table II-3-7 MEAN MONTHLY TEMPERATURE AT CAMPO DE MARTE

Unit : oC

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1937	-	-	-	20.0	17.2	15.8	15.5	15.4	15.6	16.3	-	-	-
1938	21.6	23.1	22.8	20.1	17.3	15.7	14.5	14.2	14.7	16.5	18.6	-	-
1939	23.3	24.5	23.9	22.4	20.0	18.1	17.4	17.7	18.0	18.8	19.8	22.1	20.5
1940	24.0	23.7	22.9	22.3	19.1	16.8	16.7	16.2	16.6	18.2	19.0	20.9	19.7
1941	23.7	24.2	-	21.3	19.3	16.9	15.5	15.4	16.1	17.7	19.1	-	-
1942	22.8	22.7	21.9	20.1	18.3	15.6	14.6	14.4	15.1	16.2	18.4	-	-
1943	23.2	23.8	23.2	21.3	18.8	17.1	16.6	15.8	15.9	17.3	18.7	-	-
1944	-	22.6	20.7	19.2	17.5	16.2	16.2	15.9	16.2	16.6	17.8	20.5	-
1945	22.0	21.9	22.1	20.9	18.2	16.2	15.8	15.8	16.6	17.9	19.2	19.3	18.8
1946	21.0	22.1	22.0	20.3	17.2	15.5	15.1	14.6	15.3	16.0	17.6	19.2	18.0
1947	22.1	22.8	21.8	20.4	18.2	16.3	15.2	14.7	15.2	15.9	17.5	19.5	18.3
1948	21.9	22.8	22.2	20.3	18.3	16.0	15.5	14.4	15.5	16.3	17.5	19.2	18.3
1949	-	23.4	23.1	20.7	17.5	15.4	14.3	14.3	14.4	15.5	18.2	19.6	-
1950	-	-	21.3	19.7	17.7	14.5	15.0	14.7	15.5	16.4	17.6	19.1	-
1951	21.1	19.9	20.8	20.4	20.0	18.6	17.4	17.8	17.3	18.3	18.9	20.2	19.2
1952	22.6	23.8	23.4	20.4	18.1	15.5	14.9	15.5	16.3	16.7	17.2	19.2	18.6
1953	21.3	23.2	22.8	21.9	18.7	17.2	16.1	16.4	16.9	16.5	17.6	19.1	19.0
1954	20.8	22.5	21.6	19.3	16.0	14.9	13.9	13.4	13.9	14.9	16.8	19.0	17.3
1955	21.5	22.4	21.6	19.6	16.9	15.1	13.9	13.7	13.7	14.7	16.8	18.8	17.4
1956	20.2	21.5	21.2	18.5	15.8	14.8	14.3	14.1	14.1	15.0	16.7	18.5	17.1
1957	20.5	22.5	23.4	22.7	22.0	19.4	17.3	16.3	15.3	16.8	18.3	21.1	19.6
1958	23.9	24.5	24.2	21.8	18.6	16.9	17.0	15.4	15.3	17.0	18.8	20.0	19.5
1959	21.2	23.2	22.9	21.4	18.3	16.4	15.3	15.1	15.8	17.1	18.1	20.1	18.7
1960	21.7	22.7	22.6	20.3	17.7	16.2	15.4	15.1	15.2	16.1	17.5	20.3	18.4
1961	22.9	23.4	22.4	20.7	19.0	15.9	14.3	15.4	15.2	16.5	18.4	20.2	18.7
1962	21.7	23.1	21.8	21.4	18.7	15.8	15.1	15.2	15.1	16.5	17.7	19.9	18.5
1963	21.3	22.4	21.9	20.5	19.1	16.6	16.5	16.0	16.2	16.9	18.0	19.4	18.7
1964	21.5	22.0	21.5	20.2	16.5	14.8	14.2	14.0	14.8	15.6	17.7	19.5	17.7
1965	21.7	21.4	23.4	22.2	19.7	18.9	17.2	17.2	15.3	16.2	18.2	20.5	19.3
1966	22.0	22.2	22.1	20.4	18.0	16.3	15.3	14.5	15.0	16.0	17.5	19.3	18.2
1967	20.3	22.3	21.7	21.0	18.9	15.1	14.3	14.3	14.2	15.3	16.4	19.7	17.8
1968	21.2	22.0	21.1	18.6	16.7	15.0	14.7	15.1	15.4	16.2	17.2	19.7	17.7
1969	21.8	22.2	22.2	20.9	19.8	17.6	15.5	15.2	16.2	17.1	18.2	19.8	18.9
1970	21.5	22.3	22.0	19.8	17.4	15.3	13.9	14.0	14.8	15.6	17.1	18.2	17.7
1971	20.3	21.7	21.0	19.5	16.5	15.2	14.4	14.1	14.6	15.7	17.9	19.5	17.5
1972	21.1	23.5	22.7	20.8	20.3	19.8	18.6	17.6	16.9	16.9	19.1	21.1	19.9
1973	23.3	23.9	22.1	20.1	18.0	16.0	14.6	14.4	14.3	15.1	16.5	18.0	18.0
1974	20.5	22.1	21.1	18.9	18.0	16.1	15.5	14.8	14.9	15.8	17.9	19.1	17.9
1975	21.1	22.1	21.8	20.2	17.1	15.9	15.1	14.5	14.5	15.6	16.6	19.4	17.8
1976	22.0	-	-	20.6	19.7	19.2	18.2	17.0	16.2	17.5	19.3	21.9	-
1977	23.2	23.2	23.1	21.6	19.2	17.7	16.8	15.9	16.1	17.0	18.8	20.3	19.4
1978	21.5	22.6	22.4	20.6	18.5	16.3	15.3	15.2	15.1	16.8	19.1	20.3	18.6
1979	21.8	22.3	22.7	21.1	18.1	16.9	16.4	16.6	16.2	16.8	18.2	20.3	19.0
1980	21.8	22.4	23.2	21.9	18.9	17.5	16.6	15.7	15.6	16.8	18.1	20.0	19.0
1981	-	23.2	22.8	20.8	18.6	16.7	15.5	16.0	16.3	17.0	18.3	19.9	-
1982	21.3	21.6	21.3	20.1	18.8	17.9	16.3	-	-	-	-	-	-
Mean	21.8	22.7	22.2	20.6	18.3	16.5	15.6	15.3	15.5	16.5	18.0	19.8	18.5

Table II-3-8 MEAN MONTHLY TEMPERATURE AT NANA

Unit : oC

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1964	–	–	–	21.0	17.8	15.3	13.6	14.3	16.1	16.5	18.4	19.5	–
1965	22.1	22.6	22.6	21.2	18.7	17.6	16.4	16.1	15.5	16.6	17.9	18.7	18.8
1966	21.2	22.1	21.9	20.7	17.4	15.0	14.2	14.2	15.5	16.7	17.2	19.2	17.9
1967	21.0	22.3	22.6	22.5	19.7	15.5	13.7	14.2	15.8	16.5	17.1	19.8	18.4
1968	20.8	20.5	22.2	22.3	20.0	19.4	16.0	15.4	15.3	17.4	17.8	–	–
1969	20.6	21.0	21.2	22.5	18.7	–	15.2	–	15.8	17.6	17.2	–	–
1970	21.9	22.3	22.5	21.1	18.0	15.7	14.1	15.4	15.9	16.9	17.5	19.2	18.4
1971	21.0	22.0	22.2	20.7	15.8	14.1	13.2	13.5	14.9	15.7	17.9	19.9	17.6
1972	21.4	22.6	22.9	19.8	18.5	18.0	17.2	16.5	16.0	16.8	18.0	20.5	19.0
1973	22.2	23.0	23.0	21.1	18.8	15.7	14.3	15.0	15.1	15.9	16.7	18.1	18.2
1974	20.1	22.1	22.5	21.0	17.4	14.9	14.7	14.6	14.9	16.0	17.8	19.4	18.0
1975	21.2	22.5	22.4	20.4	17.0	15.3	14.1	14.4	14.5	16.3	16.5	18.9	17.8
1976	21.6	22.6	22.1	20.1	18.5	17.3	16.2	15.7	15.1	16.2	17.6	20.9	18.7
1977	22.3	23.2	23.1	21.7	18.7	16.1	15.5	15.2	16.4	16.7	18.0	20.2	18.9
1978	21.7	22.5	22.3	20.1	18.2	15.1	14.5	14.8	15.7	16.7	18.9	20.1	18.4
1979	21.8	22.6	22.2	20.7	18.2	16.0	15.5	16.5	16.2	17.0	17.7	20.2	18.7
1980	21.9	22.5	23.3	23.1	20.1	17.3	15.8	15.5	16.3	17.5	18.0	19.7	19.3
1981	–	23.2	23.5	22.1	18.1	15.7	15.5	15.3	16.2	18.0	18.8	20.6	–
1982	22.2	23.5	22.9	21.3	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	23.3	22.0	19.5	–	17.2	17.8	–	–	–
1984	18.1	18.3	18.4	19.3	–	17.9	17.6	17.6	16.8	–	–	–	–
Mean	21.3	22.2	22.3	22.2	18.6	17.4	15.3	15.2	15.8	16.8	17.7	16.6	18.4

Table II-3-9 MEAN MONTHLY TEMPERATURE AT MATUCANA

Unit : oC

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1964	–	15.0	14.9	14.4	15.1	13.7	13.9	14.6	15.1	15.0	15.4	14.0	–
1965	–	–	–	14.8	14.8	14.8	15.4	14.9	15.7	15.8	15.6	15.6	–
1966	15.8	15.6	14.8	15.2	14.8	13.8	14.2	14.9	15.3	14.9	14.8	14.1	14.9
1967	13.9	13.4	13.4	14.4	15.0	14.0	14.1	14.8	14.9	15.0	14.4	15.4	14.4
1968	14.9	14.6	14.0	14.5	14.5	–	–	–	–	–	–	–	–
1969	15.5	15.2	15.5	15.7	16.1	15.3	15.1	14.8	15.6	15.3	14.9	14.8	15.3
1970	14.4	15.0	15.1	15.6	14.8	15.1	14.6	14.9	15.2	15.2	14.4	14.8	14.9
1971	14.1	14.0	14.0	14.4	14.8	14.1	14.6	14.2	14.2	14.9	14.8	14.1	14.4
1972	14.3	14.4	13.7	15.3	15.5	15.1	15.6	15.1	15.6	16.1	15.9	15.8	15.2
1973	15.9	15.4	15.1	15.2	14.6	14.4	14.2	14.0	14.1	14.4	14.6	13.4	14.6
1974	14.0	13.2	13.4	14.9	14.7	14.2	14.3	14.1	14.4	14.9	15.1	14.6	14.3
1975	14.6	14.1	14.5	14.7	14.7	14.5	14.2	14.2	14.3	14.7	14.7	14.4	14.5
1976	14.5	14.5	14.7	14.9	15.0	15.2	15.7	15.5	15.3	15.6	15.9	15.9	15.2
1977	15.8	15.5	16.2	16.1	15.6	15.5	15.6	15.6	15.5	15.7	15.5	15.8	15.7
1978	15.7	16.1	15.8	15.7	15.4	15.0	14.8	15.0	15.1	15.0	15.4	15.4	15.4
1979	15.6	15.0	15.0	15.3	15.6	15.5	15.8	15.7	15.5	15.5	15.4	–	–
1980	15.5	15.5	15.6	15.5	15.6	15.6	15.6	15.5	15.8	15.4	15.6	15.6	15.6
1981	15.4	15.3	15.2	15.5	15.7	15.7	15.8	15.8	15.8	15.7	15.3	–	–
1982	15.0	16.1	14.9	15.5	15.5	15.6	–	15.6	15.7	15.9	16.3	16.3	–
1983	16.3	15.2	14.9	15.2	15.6	15.9	16.1	16.3	16.4	–	–	15.1	–
1984	14.0	14.1	14.4	14.5	14.7	14.8	14.0	14.1	15.0	15.4	13.9	14.2	14.4
1985	13.6	14.0	14.3	14.1	14.4	15.0	13.7	14.1	15.0	15.0	–	–	–
Mean	14.3	14.2	14.1	14.4	14.5	14.2	14.2	14.3	14.5	14.5	15.2	15.0	14.9

Table II-3-10 SUMMARY OF MEAN MONTHLY RELATIVE HUMIDITY RECORD

Unit : %

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Campo de Marte 1971-82	83	82	83	84	85	86	87	88	88	86	84	83	85
Matucana 1964-85	74	77	78	73	64	60	57	60	61	63	64	70	67
Nana 19645-84	83	81	80	81	87	89	90	89	88	87	86	85	86
Hipolito Unanue 1969-72	86	85	87	88	87	88	88	88	88	87	85	85	87
Limatambo 1950-62	82	81	81	82	84	86	87	88	88	85	83	82	84
A Von Humboldt 1966- 72	82	80	80	82	85	88	88	89	88	86	84	82	85
La Molina 1930-67	82	81	83	86	89	89	89	89	82	85	82	85	85
Chosica 1948-54	71	70	70	73	74	73	71	69	69	69	70	70	71
Mean	92	91	92	93	94	94	94	94	93	93	91	92	93

Table II-3-11 MEAN MONTHLY RELATIVE HUMIDITY AT CAMPO DE MARTE

Unit : %

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1971	-	-	-	-	-	-	-	-	-	-	83.2	82.7	-
1972	84.3	76.5	83.3	81.9	78.1	80.3	83.1	85.8	88.5	88.0	81.2	80.6	82.6
1973	84.5	82.1	84.5	82.2	85.0	87.1	87.7	87.6	89.6	87.1	85.5	85.6	85.7
1974	84.2	79.3	80.6	85.9	84.8	88.3	87.4	88.4	86.8	85.9	81.6	80.2	84.5
1975	80.7	79.3	82.3	83.0	89.9	89.6	87.3	90.3	89.1	88.0	87.4	87.9	86.2
1976	83.3	-	-	85.9	85.1	84.7	84.4	85.8	88.0	82.6	79.9	80.8	-
1977	79.9	82.5	82.3	81.2	83.6	84.0	87.5	86.2	88.3	84.9	85.1	84.5	84.2
1978	84.7	84.1	83.1	83.2	88.3	88.4	88.9	89.6	89.9	86.7	85.2	81.5	86.1
1979	83.2	82.9	84.0	84.0	87.1	87.5	86.4	88.8	88.1	86.8	84.5	85.6	85.7
1980	85.0	85.5	83.6	83.7	86.8	83.4	89.8	88.2	87.7	85.8	82.7	83.5	85.9
1981	-	80.6	81.8	83.2	82.1	84.1	85.1	85.0	84.2	84.2	84.6	84.9	-
1982	83.0	85.2	85.2	85.3	85.4	85.1	88.2	-	-	-	-	-	-
Mean	83.3	81.8	83.1	83.6	85.1	86.1	86.9	87.6	88.0	86.0	83.7	83.4	85.1

Table II-3-12 MEAN MONTHLY RELATIVE HUMIDITY AT ÑAÑA

Unit : %

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1964	–	–	–	75.8	84.6	87.8	90.5	91.2	85.1	85.4	82.7	83.8	–
1965	76.6	75.1	82.5	83.7	86.1	85.7	87.3	85.3	89.1	87.5	84.8	84.8	84.1
1966	83.2	79.2	79.8	79.7	86.5	89.3	91.9	92.5	90.0	90.2	90.2	88.1	86.7
1967	86.9	83.1	81.7	78.9	85.7	88.8	91.2	89.6	84.2	84.3	80.6	79.1	84.5
1968	83.5	76.5	76.2	79.2	81.8	84.6	86.7	84.7	87.9	83.1	82.1	–	–
1969	78.9	85.2	84.4	79.7	85.3	–	88.2	–	84.6	84.1	81.1	–	–
1970	83.5	84.4	82.5	86.4	91.4	94.2	94.5	95.6	94.2	93.5	93.5	92.5	90.5
1971	85.3	80.7	80.7	82.1	90.9	92.0	93.0	92.4	88.0	84.8	84.7	84.0	86.6
1972	79.8	78.1	78.5	85.6	86.3	88.4	90.8	92.5	92.4	92.7	90.1	88.4	87.0
1973	90.4	86.6	82.9	82.6	85.8	91.2	91.5	89.6	87.3	86.4	85.5	84.8	87.1
1974	84.5	81.4	73.8	76.1	86.7	92.9	90.6	91.9	92.5	90.4	91.8	90.9	87.0
1975	86.8	81.9	82.8	86.9	89.4	89.6	87.8	90.7	89.2	87.2	87.9	86.4	87.2
1976	82.9	81.1	80.1	86.5	88.3	90.0	87.6	85.7	90.9	89.6	90.8	87.9	86.8
1977	88.6	85.3	84.2	84.7	90.4	92.2	91.6	90.6	89.9	88.4	89.0	83.6	88.2
1978	80.9	81.8	81.2	84.6	86.9	90.8	89.9	91.9	88.9	90.3	87.0	84.5	86.6
1979	83.8	79.4	84.4	83.4	88.0	89.4	90.6	89.9	90.2	87.7	86.5	84.3	86.5
1980	81.1	78.5	77.2	77.8	83.2	87.0	88.4	86.4	83.4	82.6	83.8	81.4	82.6
1981	–	73.0	73.8	75.2	80.9	86.2	90.4	90.7	88.5	82.6	83.2	78.4	75.2
1982	77.4	74.7	73.7	75.7	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	85.3	86.9	85.5	–	83.9	82.0	–	–	–
1984	83.4	84.7	84.2	76.7	–	82.8	85.8	77.2	80.5	–	–	–	–
Mean	83.2	80.6	80.2	81.1	86.5	89.0	89.7	89.4	88.0	87.0	86.4	85.2	85.5

Table II-3-13 MEAN MONTHLY RELATIVE HUMIDITY AT MATUCANA

Unit : %

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1964	–	81.6	81.0	80.5	52.6	52.5	43.1	46.8	52.6	56.1	61.6	66.7	–
1965	–	–	–	–	–	–	–	–	–	–	–	–	–
1966	–	74.6	77.0	74.0	58.8	42.4	43.3	48.6	49.8	65.7	58.7	67.5	55.0
1967	85.1	87.7	84.7	81.1	64.5	47.5	42.8	44.6	54.5	64.3	58.8	61.7	64.8
1968	73.8	74.0	78.2	66.1	57.1	–	–	–	–	–	–	–	–
1969	70.0	80.3	82.5	77.7	60.5	57.8	72.1	72.5	61.8	63.7	70.2	79.5	70.7
1970	85.6	83.2	79.4	78.8	70.4	65.6	54.3	71.0	67.4	66.0	72.0	79.8	72.8
1971	80.0	80.1	87.0	76.7	62.1	67.3	46.5	59.1	62.2	58.1	57.5	74.1	67.6
1972	77.5	78.9	86.9	76.8	54.5	46.4	44.9	48.2	51.4	59.4	56.8	73.5	62.9
1973	60.8	82.1	85.7	82.6	76.6	65.4	52.0	53.2	60.2	64.3	68.0	74.4	70.4
1974	82.3	86.7	86.8	79.0	74.6	61.8	56.1	53.6	57.9	59.7	67.6	72.0	69.8
1975	77.7	81.9	82.5	77.2	69.8	65.6	62.5	62.4	61.0	60.0	61.0	62.6	68.7
1976	66.0	66.6	64.4	62.0	60.5	61.5	54.4	57.3	60.7	58.4	57.2	56.7	60.5
1977	63.9	68.8	64.9	65.8	64.2	60.5	63.0	61.1	63.5	61.9	67.6	65.5	64.2
1978	71.2	71.2	72.6	68.7	65.3	62.1	60.9	59.0	60.1	62.7	63.0	66.4	65.3
1979	67.5	74.0	75.0	66.2	63.0	60.5	60.6	60.3	62.3	63.4	64.5	–	–
1980	66.6	67.1	67.5	63.3	59.5	61.4	64.8	64.6	66.2	67.5	65.0	64.3	64.8
1981	65.4	66.0	65.9	65.2	62.1	60.9	63.0	62.4	62.6	63.3	65.5	–	–
1982	66.2	70.5	67.1	63.6	65.7	64.3	–	63.4	64.9	65.5	63.4	63.6	–
1983	64.3	66.0	70.5	67.6	64.0	62.6	63.1	62.5	62.6	–	–	81.0	–
1984	82.6	89.1	86.1	79.3	69.9	67.9	70.5	64.1	66.2	74.0	65.2	73.8	74.1
1985	80.3	83.5	85.0	83.4	75.0	71.9	73.2	78.6	71.4	69.8	–	–	–
Mean	74.0	76.9	77.7	73.1	64.3	60.3	57.4	59.7	61.0	63.4	63.5	69.6	66.7

Table II-3-14 SUMMARY OF MONTHLY EVAPORATION RECORD

Unit : mm

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hipolito Unanue 1969-72	48.3	47.6	52.2	42.4	47.4	36.4	36.5	34.0	33.0	38.6	48.2	51.1	515.7
Campo de MARTE 1929-72	83.6	78.7	82.3	68.6	52.0	39.3	38.4	37.2	38.6	51.9	65.6	74.7	710.0
La Molina 1930-67	116.6	110.7	112.5	97.5	70.0	51.5	50.5	53.4	60.3	78.7	90.8	102.9	995.0
Ñaña 1964-84	97.8	88.7	101.5	91.7	74.5	60.5	53.6	61.0	63.8	74.9	76.9	75.8	920.7
Matucana 1964-85	98.2	77.9	76.5	97.5	143.4	165.9	189.5	186.9	183.5	169.4	164.8	136.6	1690.1
Mean	88.9	80.7	85.0	71.1	77.5	70.7	73.7	74.5	75.8	82.7	89.3	88.2	958.1

Table II-3-15 MONTHLY EVAPORATION AT ÑAÑA

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	91.7	92.5	51.1	90.2	63.5	59.8	36.7	42.1	79.7	69.9	6.1	80.4	763.7
1965	106.0	129.5	96.6	79.8	47.1	40.3	34.0	37.1	0.3	52.0	56.5	64.1	743.3
1966	75.7	78.8	83.1	84.6	64.5	60.1	50.4	59.0	89.3	54.7	49.4	70.1	819.7
1967	72.9	81.9	99.6	105.9	86.6	81.8	46.4	66.9	72.4	94.6	92.4	92.6	994.0
1968	103.2	97.2	114.6	109.2	87.8	98.9	89.3	100.2	78.2	81.4	102.6	–	–
1969	114.4	101.6	111.8	111.6	104.8	–	80.4	–	71.3	80.4	68.9	–	–
1970	89.0	56.7	72.9	74.1	52.5	25.1	22.9	45.7	49.2	57.7	53.8	79.6	679.2
1971	92.9	106.3	103.6	58.2	41.1	30.0	28.6	29.1	41.7	56.4	64.7	82.0	734.6
1972	92.1	109.2	86.2	86.0	39.7	47.4	39.6	33.8	16.7	8.8	61.7	70.6	691.8
1973	51.4	69.2	96.9	102.5	90.0	56.0	45.0	60.1	62.0	81.6	68.3	58.3	841.3
1974	60.0	102.4	146.0	115.3	50.7	25.0	35.6	42.0	46.4	55.0	69.3	83.1	830.8
1975	89.8	116.0	104.5	82.4	40.1	36.3	44.6	34.7	47.9	72.8	61.0	58.4	788.5
1976	82.7	102.5	105.7	60.8	46.8	36.9	50.8	37.4	35.8	55.4	66.3	85.7	766.8
1977	87.5	97.0	98.7	110.5	54.7	39.9	34.6	41.6	56.5	74.4	61.2	92.0	848.6
1978	99.8	77.5	76.8	56.7	60.0	38.8	35.4	40.4	52.8	71.4	83.5	102.5	795.6
1979	95.2	76.4	77.5	77.1	51.7	37.7	43.4	49.0	40.6	49.0	68.9	91.6	758.1
1980	–	–	–	–	–	–	39.1	45.3	52.1	72.8	83.7	68.0	–
1981	–	102.7	121.5	80.1	54.7	65.7	45.3	52.6	72.0	85.4	83.5	97.2	–
1982	104.2	96.8	146.8	118.9	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	58.4	54.0	48.1	–	46.1	52.3	–	–	–
1984	45.0	43.5	42.0	63.1	–	40.5	32.7	46.1	–	–	–	–	–
Mean	91.4	96.5	102.0	92.6	64.4	51.4	46.5	50.8	56.2	68.1	70.7	85.1	875.6

Table II-3-16 MONTHLY EVAPORATION AT MATUCANA

Unit : mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	-	61.2	68.8	78.1	184.9	208.8	283.7	264.3	243.0	233.9	172.2	108.2	-
1965	69.2	51.6	43.5	62.9	92.2	133.2	126.1	-	178.2	184.5	216.3	149.4	-
1966	86.3	94.9	92.3	105.5	177.4	207.1	256.3	259.2	223.4	162.7	184.5	153.4	2,003.0
1967	59.6	42.1	59.5	-	143.1	207.4	234.2	236.3	208.7	169.9	198.4	194.7	1,753.9
1968	123.9	126.7	98.8	170.7	217.3	-	-	-	-	-	-	-	-
1969	151.9	72.8	76.4	98.8	-	-	184.8	200.5	219.1	168.7	134.5	101.8	-
1970	69.2	84.5	109.8	109.9	135.9	199.1	227.8	232.8	164.7	170.0	161.2	126.9	1,791.8
1971	92.6	75.0	50.9	93.1	197.3	203.5	262.7	233.6	222.0	232.0	219.3	122.7	2,004.7
1972	97.5	85.4	48.1	99.5	211.8	267.7	290.3	269.0	241.9	186.2	176.2	132.7	2,106.3
1973	94.9	68.8	57.2	79.2	119.1	156.8	188.2	161.3	133.4	135.0	136.9	80.4	1,411.2
1974	84.9	52.2	53.4	116.9	175.3	211.7	210.1	221.3	217.5	233.6	178.7	155.0	1,910.6
1975	105.7	75.7	74.5	92.9	144.4	177.0	210.6	175.7	184.5	164.3	149.0	125.5	1,679.8
1976	77.7	68.9	75.2	79.8	119.3	110.5	160.5	161.1	171.5	174.1	173.1	182.8	1,554.5
1977	142.7	101.5	129.6	106.8	115.0	131.5	145.7	173.0	142.2	189.4	136.2	140.1	1,653.7
1978	106.1	125.1	105.9	113.6	128.9	145.0	137.2	145.9	132.0	142.1	138.5	155.0	1,575.3
1979	144.0	100.0	100.5	124.9	134.7	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	129.6	113.9	141.4	138.5	139.4	-
1983	133.7	116.0	93.7	99.6	101.5	108.5	102.6	93.7	93.6	-	-	-	-
1984	54.9	26.7	40.5	53.6	83.4	93.4	109.0	111.9	134.0	98.9	124.0	117.4	1,047.7
1985	72.2	51.4	74.9	69.0	99.6	93.6	91.8	107.6	95.7	92.7	-	-	-
Mean	98.2	77.9	76.5	97.5	143.4	165.9	189.5	186.9	183.5	169.4	164.8	136.6	1,707.7

Table II-3-17 SUMMARY OF PREVAILING WIND DIRECTION AND MEAN MONTHLY WIND VELOCITY RECORD

Unit : km/hour

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Se	Oct	Nov	Dec	Mean
Hipolito Unanue	S	S	S	S	S	S	S	S	S	S	S	S	S
1969-72	10.8	10.8	14.4	10.8	10.8	7.2	7.2	7.2	7.2	7.2	10.8	10.8	9.6
Limatambo	S	S	S	S	S	S	S	S	S	S	S	S	S
1950-62	20.4	13.0	13.0	13.0	11.1	11.1	11.1	11.1	11.1	13.0	11.1	13.0	11.9
Campo de Marte	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
1961-72	14.8	13.0	13.0	11.1	11.1	11.1	11.1	9.3	9.3	11.1	11.1	11.1	11.4
A.Von Humbolt	W	W	W	W	W	W	W	W	W	W	W	W	W
1966-72	10.3	8.3	9.8	5.2	5.4	4.8	5.0	5.1	5.9	6.3	6.4	6.4	6.6
Matucana	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
1964-71	16.0	15.0	13.0	15.2	13.2	13.0	16.0	4.0	15.8	16.0	15.8	17.2	15.6

Table II-3-18 SUMMARY OF MONTHLY SUNSHINE HOUR RECORD

Unit : hours

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hipolito Unanue 1969-72	151	181	211	145	78	30	25	19	28	47	92	132	1139
Campo de Marte 1955-72	198	205	225	211	129	51	34	30	36	71	114	165	1469
A.Von Humbolt 1966-72	183	193	222	213	142	73	81	71	99	118	134	183	1712
La Molina 1930-50	180	193	228	228	158	70	60	64	94	135	162	187	1759
Mean	178	193	222	199	127	56	50	46	64	93	126	167	1520

Table II-4-1 PRINCIPAL FEATURE OF MAJOR LAGUNAS

Name of Lagunas	Altitude (El.m)	Effective storage volume (MCM)
Santa Eulalia river basin		
Quisha	4648	8.7
Carpa	4544	17.8
Huansa	4361	6.3
Sacsa	4382	14.9
Quila	4530	1.8
Piti-Piti	4625	6.5
Huamper	4628	3.3
Huachua	4570	5
Chiche	4491	2.2
Pucro	4435	2
Misha	4650	0.7
Canchis	4421	2.1
Huallunca	4510	1.6
Pirhua	4740	0.9
Manca	4530	1.6
Sub-total		75.4
Marcapomacocha river basin		
Antacoto		62.5
Marcacocha		10.7
Marcapo macocha		14.8
Sangarar		9.0
Sub-total		97.0
Grand total		172.4

Source : ELECTROLIMA

Table II-4-2 MEAN MONTHLY DISCHARGE AT CHACRASANA

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1920-21	-	-	-	-	47.4	61.7	73.4	45.3	23.2	14.2	11.1	8.5	-
21-22	12.4	10.5	12.7	25.6	27.0	47.1	68.7	42.0	27.6	10.6	10.2	8.2	25.2
22-23	11.7	14.0	15.2	31.7	52.6	41.0	65.6	54.9	23.3	13.2	10.2	7.6	28.4
23-24	12.5	15.1	18.0	36.0	35.3	42.9	66.4	45.4	20.9	12.6	10.5	11.7	27.3
24-25	13.6	14.8	15.7	18.7	30.0	50.1	54.7	-	21.6	7.0	7.5	9.6	-
25-26	14.4	13.2	12.8	21.4	34.7	89.2	105.1	58.9	27.5	9.0	8.4	11.6	33.9
26-27	14.8	13.6	15.2	22.4	46.1	67.3	104.0	43.6	29.4	11.9	6.7	9.2	32.0
27-28	14.2	12.9	13.4	25.5	38.6	81.9	91.5	52.5	24.1	8.5	9.0	11.5	32.0
28-29	12.9	12.4	14.5	18.1	60.4	104.7	94.7	35.4	13.2	7.4	7.5	8.2	32.5
29-30	13.6	14.3	20.3	23.4	44.5	35.5	96.4	73.9	46.2	21.9	8.8	9.7	34.0
30-31	9.8	9.9	13.6	16.2	25.9	40.1	39.8	28.9	21.8	17.1	11.8	9.2	20.3
31-32	12.5	13.3	17.1	35.8	46.3	136.1	69.3	49.5	27.8	12.8	12.2	13.2	37.2
32-33	11.0	12.8	17.3	19.1	28.7	68.3	102.2	56.5	29.2	18.0	12.5	12.5	32.3
33-34	12.7	12.3	12.9	21.0	50.0	83.5	118.6	54.8	32.8	22.4	15.4	12.1	37.4
34-35	12.0	12.9	13.2	12.8	59.4	62.5	145.7	45.8	25.4	13.4	12.4	12.6	35.7
35-36	13.2	13.1	13.5	34.8	55.3	42.4	45.3	29.7	18.9	13.1	12.5	12.5	25.4
36-37	13.0	12.7	13.1	13.4	22.4	27.7	69.1	26.0	17.2	13.1	12.0	11.9	21.0
37-38	13.1	13.6	14.2	22.8	32.6	97.8	59.1	44.6	22.9	13.4	13.1	12.7	30.0
38-39	13.1	12.6	13.0	13.8	23.5	64.7	128.1	48.4	20.9	13.3	12.0	12.3	31.3
39-40	13.0	13.0	13.1	21.4	44.2	33.5	75.3	33.9	16.7	13.4	12.1	12.6	25.2
40-41	13.1	13.0	13.6	13.2	43.3	79.7	101.2	16.9	13.5	12.1	11.8	12.2	28.6
41-42	12.6	14.1	17.2	29.0	53.9	82.1	53.1	31.1	19.1	14.1	13.8	13.5	29.5
42-43	12.9	12.8	12.7	17.3	38.7	112.5	69.2	53.1	17.4	13.0	12.9	13.1	32.1
43-44	13.2	13.6	13.8	23.8	47.5	59.1	67.1	32.0	18.2	14.0	13.0	13.0	27.4
44-45	13.0	13.4	13.7	16.0	29.4	44.1	57.0	37.5	18.8	13.9	12.4	12.0	23.4
45-46	12.0	13.1	18.1	32.1	70.0	60.4	119.5	53.4	26.4	15.6	12.7	12.3	37.1
46-47	13.1	13.2	18.5	36.0	40.0	39.5	68.2	33.0	21.4	13.8	11.6	12.1	26.7
47-48	13.0	15.1	14.7	17.7	56.6	47.6	54.9	36.3	25.4	19.5	15.3	12.6	27.4
Mean	12.8	13.2	14.9	22.9	42.3	64.4	80.8	43.1	23.2	13.7	11.4	11.4	29.7

Table II-4-3 MEAN MONTHLY DISCHARGE AT PTE.LOS ANGELES

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1948-49	13.1	22.8	22.7	17.1	29.4	27.5	62.1	31.7	17.8	14.4	13.8	13.3	23.8
49-50	13.0	13.3	16.0	11.9	38.0	47.9	45.4	40.3	20.8	14.9	13.3	12.8	24.0
50-51	12.5	12.4	14.4	39.9	44.5	76.3	114.8	45.1	21.0	18.1	13.6	12.6	35.4
51-52	13.0	14.5	29.5	31.8	66.5	88.4	86.5	51.9	20.1	17.6	14.7	12.7	37.3
52-53	13.7	13.1	18.0	25.2	35.0	105.6	81.5	50.2	23.2	17.8	15.5	14.0	34.4
53-54	14.6	14.3	26.6	28.7	47.7	96.6	94.7	31.8	23.2	17.5	14.9	13.9	35.4
Mean	13.3	15.1	21.2	25.8	43.5	73.7	80.8	41.8	21.0	16.7	14.3	13.2	31.7

Table II-4-4 MEAN MONTHLY DISCHARGE AT YANACOTO

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1954-55	13.6	14.7	20.7	20.2	43.6	75.8	114.0	39.3	22.0	18.3	17.7	13.4	34.4
55-56	13.3	12.2	11.6	15.2	18.4	75.1	67.9	37.4	16.7	12.2	10.9	11.9	25.2
56-57	15.6	11.8	11.4	12.0	16.0	43.0	48.8	30.9	14.2	10.3	9.8	10.7	19.5
57-58	11.5	11.4	11.9	13.1	17.4	40.9	48.4	17.8	12.3	10.6	10.4	10.6	18.0
58-59	11.1	12.0	12.4	12.5	12.2	68.8	70.6	58.0	19.1	12.9	12.2	11.8	26.1
59-60	12.7	16.3	15.3	24.0	32.0	39.6	40.5	22.4	14.3	12.2	11.7	11.6	21.1
Mean	13.0	13.1	13.9	16.2	23.3	57.2	65.0	34.3	16.4	12.8	12.1	11.7	24.1

Table II-4-5 MEAN MONTHLY DISCHARGE AT PTE. HUACHIPA

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1960-61	12.5	13.2	13.7	13.2	27.2	50.9	44.7	39.5	21.7	14.3	12.7	12.5	23.0
61-62	13.1	12.9	19.4	33.8	41.3	41.9	61.7	32.1	18.2	13.9	14.0	14.2	26.4
Mean	12.8	13.1	16.6	23.5	34.3	46.4	53.2	35.8	20.0	14.1	13.4	13.4	24.7

Table II-4-6 MEAN MONTHLY DISCHARGE AT CHOSICA

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1962-63	13.9	13.7	13.1	17.2	48.2	49.4	60.7	35.5	21.4	15.5	14.6	14.1	26.4
63-64	14.8	15.5	19.1	34.7	22.9	36.9	53.5	42.4	22.7	15.4	14.7	14.8	25.6
64-65	15.4	15.5	13.7	13.2	18.5	51.4	43.9	20.7	16.0	11.9	11.5	11.1	20.2
65-66	12.1	13.0	13.4	16.1	32.1	28.7	37.7	25.0	18.6	14.3	14.8	13.9	20.0
66-67	14.3	20.1	19.6	16.1	29.7	65.1	58.9	32.6	21.5	18.1	18.5	17.8	27.7
67-68	18.9	24.0	21.2	20.4	24.6	22.4	32.0	20.8	16.5	15.1	14.4	14.0	20.4
68-69	14.7	16.3	17.7	18.8	16.8	23.7	34.2	30.3	17.6	16.8	15.6	15.4	19.8
69-70	15.6	16.4	17.3	37.0	64.8	35.6	42.4	28.8	23.6	19.5	18.1	18.1	28.1
70-71	19.3	19.8	19.7	28.3	38.2	44.3	69.9	36.2	22.2	20.3	19.8	18.8	29.7
71-72	19.7	18.6	17.8	24.9	38.5	44.3	83.5	52.9	23.3	17.5	16.7	17.1	31.2
72-73	17.2	17.7	17.7	26.1	57.2	82.7	91.5	70.7	35.3	19.8	20.7	20.2	39.7
73-74	18.5	19.8	23.3	38.6	50.7	57.3	62.4	39.7	20.0	19.5	17.1	18.1	32.1
74-75	13.1	15.6	15.1	11.6	18.8	18.7	100.4	39.3	28.5	23.6	21.3	22.3	27.4
75-76	18.8	18.6	21.5	23.3	38.1	-	-	-	-	-	-	-	-
Mean	16.2	17.5	17.9	23.3	35.7	43.1	59.3	36.5	22.1	17.5	16.8	16.6	26.8

Table II-4-7 MEAN MONTHLY DISCHARGE AT RIO BLANCO

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1968-69	-	1.2	2.0	4.1	1.8	6.0	7.1	5.2	1.5	1.1	0.8	0.8	-
69-70	0.8	1.4	1.8	7.2	10.5	6.5	5.4	4.2	2.7	1.1	0.7	0.6	3.6
70-71	1.5	1.9	1.4	4.6	6.1	7.8	9.1	5.2	1.8	1.0	0.7	0.6	3.5
71-72	0.7	0.8	0.8	4.2	5.8	7.5	11.9	7.1	2.2	1.1	0.8	0.7	3.6
72-73	0.8	1.6	1.2	3.0	7.5	8.4	8.3	5.7	1.4	0.7	0.5	0.4	3.3
73-74	0.5	0.9	1.4	3.9	6.1	7.6	7.0	4.1	1.3	0.8	0.5	0.5	2.9
74-75	0.5	0.7	0.8	2.1	4.3	4.6	9.1	4.8	3.4	1.5	1.0	0.9	2.8
75-76	1.4	1.4	1.8	3.3	8.6	12.8	11.2	4.7	2.6	1.0	0.7	0.7	4.2
76-77	-	-	-	-	-	-	-	-	-	-	-	-	-
77-78	-	-	-	-	-	-	-	-	-	-	-	-	-
78-79	0.8	1.1	-	3.6	2.3	13.7	14.7	5.7	2.2	1.0	0.8	0.8	-
79-80	0.8	0.9	1.2	1.3	6.1	5.3	6.7	3.6	1.2	0.9	0.8	0.7	2.5
80-81	0.8	3.8	5.7	9.2	14.3	30.3	23.6	7.5	6.5	-	-	-	-
Mean	0.9	1.4	1.8	4.2	6.7	10.0	10.4	5.3	2.5	1.0	0.7	0.7	3.3

Table II-4-8 MEAN MONTHLY DISCHARGE AT SAN MATEO

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1968-69	-	6.9	9.2	11.3	9.8	14.5	18.3	17.8	10.1	7.6	5.9	6.4	-
69-70	6.9	7.8	9.4	16.8	27.3	20.0	17.3	15.9	13.2	9.1	7.5	6.6	13.2
70-71	8.0	8.8	8.9	13.8	16.6	21.9	26.8	16.5	10.6	8.0	6.7	6.1	12.7
71-72	5.9	7.6	7.2	12.7	15.8	18.6	31.1	22.9	12.7	9.0	8.1	6.8	13.2
72-73	7.5	9.1	8.5	12.2	21.0	27.1	26.2	20.5	11.6	7.7	5.6	4.6	13.5
73-74	4.6	6.1	7.4	13.8	20.0	24.2	24.8	16.8	9.1	6.9	5.0	4.2	11.9
74-75	4.5	6.0	7.8	10.3	14.1	15.3	26.7	16.4	13.4	8.8	7.3	7.0	11.5
75-76	7.5	8.8	14.6	15.5	19.5	26.4	23.9	16.8	12.1	9.3	8.2	7.2	14.2
76-77	-	-	-	-	-	-	-	-	-	-	-	-	-
77-78	-	-	-	-	-	-	-	-	-	-	-	-	-
78-79	9.7	10.8	-	-	16.3	23.2	25.4	19.0	13.5	10.4	8.8	8.0	-
79-80	8.5	9.2	10.3	10.9	15.6	16.3	17.3	14.3	10.1	8.8	8.4	7.2	11.4
80-81	7.6	11.9	12.5	14.5	18.0	29.2	25.9	16.8	11.8	9.1	7.4	7.0	14.3
81-82	6.1	9.0	11.9	14.5	17.4	29.1	21.4	16.4	11.7	9.3	6.9	6.4	13.3
Mean	7.0	8.5	9.8	13.3	17.6	22.2	23.8	17.5	11.7	8.7	7.2	6.5	12.9

Table II-4-9 MEAN MONTHLY DISCHARGE AT CHOSICA R-2

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1969-70	15.6	15.9	17.3	43.2	85.6	36.4	45.6	37.5	25.2	20.8	18.7	17.4	31.6
70-71	18.7	18.2	17.5	23.7	40.2	48.1	78.0	40.4	22.3	21.8	20.1	20.2	30.8
71-72	19.7	18.7	15.9	26.7	48.0	65.3	140.6	66.3	22.4	17.0	15.3	15.6	39.3
72-73	13.3	14.5	16.6	26.0	56.8	61.8	76.0	59.5	20.7	12.9	11.8	11.0	31.7
73-74	9.6	11.6	13.1	23.3	36.8	47.1	56.2	32.2	15.1	11.6	9.6	11.2	23.1
74-75	13.1	15.6	15.1	11.6	18.7	18.7	100.4	39.3	28.5	23.6	21.3	22.3	27.4
75-76	21.6	20.4	21.9	22.9	41.4	76.1	65.0	36.8	20.9	19.3	16.6	16.8	31.6
76-77	17.5	17.6	18.6	18.2	20.8	71.0	57.0	33.8	25.0	19.4	19.0	19.3	28.1
77-78	19.2	19.6	29.9	31.1	37.8	78.1	45.3	30.3	18.4	17.2	18.3	17.0	30.2
78-79	16.4	17.6	17.8	21.1	19.8	75.3	96.2	36.3	18.1	17.9	16.7	17.1	30.9
79-80	18.3	18.4	18.3	18.6	28.7	29.1	39.2	31.9	17.5	18.0	14.8	14.7	22.3
80-81	18.1	17.6	18.3	22.7	36.9	86.8	72.6	43.7	21.9	21.3	19.8	21.1	33.4
81-82	21.0	14.6	16.7	23.0	29.0	53.6	51.0	45.4	38.8	33.4	29.7	30.6	32.2
82-83	23.3	23.6	28.1	26.3	31.3	28.9	58.6	71.4	28.9	28.2	22.9	19.0	32.5
83-84	15.5	26.3	25.5	35.3	32.0	67.6	53.7	34.4	25.2	31.1	28.8	27.8	33.6
84-85	25.7	26.9	27.2	-	-	-	-	-	-	36.6	26.9	30.6	-
85-86	24.8	24.3	27.9	39.7	84.0	92.4	103.5	74.1	55.3	23.9	24.1	23.8	49.8
86-87	21.6	18.8	23.5	-	-	-	-	-	-	-	-	-	-
Mean	18.5	18.9	20.5	25.8	40.5	58.5	71.2	44.6	25.3	22.0	19.7	19.7	31.8

Table II-4-10 MEAN MONTHLY DISCHARGE AT PUENTE DESEMBOCADURA

Unit : CMS

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1968-69	-	0.6	1.1	1.4	0.7	4.6	32.3	26.2	4.8	5.5	4.4	4.1	7.8
69-70	4.1	2.9	4.6	41.0	-	-	-	-	-	-	-	-	13.2
Mean	4.1	1.8	2.9	21.2	0.7	4.6	32.3	26.2	4.8	5.5	4.4	4.1	10.5

Table II-5-1 ANNUAL MAXIMUM 1-DAY RAINFALL AT METEOROLOGICAL STATIONS

Unit : mm

Year	Station name									
	Campo de Marte	Hipolito Unanue	Nana	Santa Eulalia	Matucana	San Jose de Parac	Mina Colqui	Carampoma	Milloc	Marca
1927	(2.9)(Sep. 8)	-	-	-	-	-	-	-	-	-
1928	(1.4)(Aug. 3)	-	-	-	-	-	-	-	-	-
1929	1.5 (Jun. 9)	-	-	-	-	-	-	-	-	-
1930	3.5 (Sep.14)	-	-	-	-	-	-	-	-	-
1931	2.0 (Jul.22)	-	-	-	-	-	-	-	-	-
1932	2.4 (Jan.18)	-	-	-	-	-	-	-	-	-
1933	1.9 (Aug.12)	-	-	-	-	-	-	-	-	-
1934	1.9 (Sep.25)	-	-	-	-	-	-	-	-	-
1935	1.5 (Sep.16)	-	-	-	-	-	-	-	-	-
1936	1.9 (Aug.23)	-	-	-	-	-	-	-	-	-
1937	2.2 (Sep.19)	-	-	-	-	-	-	-	-	-
1938	1.7 (Jul. 4)	-	-	-	-	-	-	-	-	-
1939	1.5 (May.19)	-	-	-	-	-	-	-	-	-
1940	1.3 (Aug.19)	-	-	-	-	-	-	-	-	-
1941	2.7 (Jul.14)	-	-	-	-	-	-	-	-	-
1942	1.8 (Aug.18)	-	-	-	-	-	-	-	-	-
1943	3.0 (Jul. 4)	-	-	-	-	-	-	-	-	-
1944	1.6 (Jul.12)	-	-	-	-	-	-	-	-	-
1945	0.6 (Sep. 1)	-	-	-	-	-	-	-	-	-
1946	2.2 (Jun. 3)	-	-	-	-	-	-	-	-	-
1947	0.9 (Aug.16)	-	-	-	-	-	-	-	-	-
1948	1.4 (Sep.27)	-	-	-	-	-	-	-	-	-
1949	2.1 (Mar.29)	-	-	-	-	-	-	-	-	-
1950	1.3 (Dec.18)	-	-	-	-	-	-	-	-	-
1951	1.8 (Dec.22)	-	-	-	-	-	-	-	-	-
1952	4.0 (Jan.14)	-	-	-	-	-	-	-	-	-
1953	2.7 (Jun.30)	-	-	-	-	-	-	-	-	-
1954	1.2 (Aug. 6)	-	-	-	-	-	-	-	-	-
1955	0.9 (Jun. 9)	-	-	-	-	-	-	-	-	-
1956	1.7 (Feb.12)	-	-	-	-	-	-	-	-	-
1957	1.1 (Sep.24)	-	-	-	-	-	-	-	-	-
1958	5.0 (Jan.13)	-	-	-	-	-	-	-	-	-
1959	2.0 (Dec.27)	-	-	-	-	-	-	-	-	-
1960	1.3 (Aug.28)	-	-	-	-	-	-	-	-	-
1961	1.4 (Feb, 3)	-	-	-	-	-	-	-	-	-
1962	2.7 (Jul.12)	-	-	-	-	-	-	-	-	-
1963	1.5 (Feb. 8)	-	-	(1.1)(Nov.22)	-	-	-	-	-	-
1964	3.3 (Aug. 4)	-	0.6 (Dec.26)	(5.4)(Feb.25)	15.9 (Dec.27)	-	-	-	-	-
1965	2.2 (May. 7)	-	0.6 (May.18)	(1.2)(Dec.12)	14.9 (Jan. 8)	-	-	9.0 (Dec.30)	25.0 (Feb. 5)	-
1966	1.4 (Dec. 8)	-	2.0 (Dec.15)	25.0 (Jan.30)	11.9 (Jan.28)	12.5 (Feb.21)	-	10.6 (Feb.23)	23.0 (Mar. 7)	-
1967	1.4 (Mar.19)	-	3.6 (Mar.18)	29.8 (Feb. 7)	16.7 (Mar.19)	24.0 (Oct.30)	-	22.2 (Mar.18)	36.0 (Mar.18)	-
1968	0.7 (Sep. 8)	-	0.0 -	(0.5)(May.16)	12.8 (Feb. 2)	10.0 (Jan.27)	(13.6)(Dec. 5)	15.5 (Jan.13)	26.0 (Nov.10)	24.0 (Mar.27)
1969	1.1 (Jan.17)	1.7 (Jul. 1)	3.0 (Jan.25)	10.6 (Mar.10)	12.0 (Feb.12)	17.0 (Feb.27)	21.6 (Oct.15)	21.3 (Mar.17)	30.0 (Apr.14)	27.0 (Dec.19)
1970	17.0 (Jan.15)	16.0 (Jan.15)	0.0 -	30.8 (Jan.14)	31.7 (Jan.15)	-	24.9 (Feb.24)	30.2 (Jan.14)	17.5 (Apr. 5)	18.4 (Sep. 2)
1971	1.3 (Aug.19)	1.5 (Jun. 8)	-	14.5 (Mar.27)	23.3 (Feb.22)	-	32.5 (Feb.16)	30.4 (Feb.23)	18.0 (Feb.22)	25.0 (Jan. 9)
1972	0.9 (Jul.20)	2.0 (Sep. 5)	-	20.0 (Mar.12)	18.1 (Mar. 5)	-	(13.8)(Dec. 6)	27.5 (Mar.23)	21.0 (Mar. 6)	25.0 (Mar.22)
1973	0.4 (Nov.14)	0.3 (Aug.21)	-	19.2 (Jan. 9)	25.2 (Feb.10)	-	-	32.6 (Feb.11)	27.0 (Feb. 4)	20.2 (Feb.16)
1974	5.0 (Feb.24)	1.3 (Jun. 4)	0.8 (Dec.23)	6.0 (Mar.11)	11.9 (Feb.19)	-	-	28.2 (Jan. 5)	26.7 (Apr. 4)	20.6 (Dec.23)
1975	1.5 (Feb.28)	0.5 (Jun.20)	4.5 (Mar.10)	14.5 (Mar. 1)	10.8 (Mar.23)	-	18.4 (Jan, 6)	17.0 (Mar.18)	30.0 (Mar.11)	15.8 (Dec.27)
1976	1.2 (May.13)	1.7 (Sep. 8)	8.0 (Jan.30)	20.0 (Feb. 2)	15.8 (Jan.30)	-	14.4 (Mar. 2)	24.5 (Jan.11)	21.8 (Jun. 9)	20.2 (Mar. 2)
1977	2.0 (Sep.30)	0.9 (Jul. 5)	1.6 (Jan. 1)	8.0 (Mar.19)	35.2 (Feb.18)	-	12.0 (Nov. 6)	23.8 (Feb.14)	22.0 (Dec. 8)	23.4 (Dec.15)
1978	0.6 (Aug.17)	1.0 (Aug. 2)	1.5 (Mar.22)	6.8 (Mar. 6)	7.8 (Nov.23)	-	16.0 (Mar.29)	14.8 (Feb.12)	22.4 (Feb.14)	21.6 (Feb.18)
1979	1.2 (Aug.14)	-	2.9 (Mar. 5)	10.0 (Mar. 8)	12.3 (Feb.18)	-	18.2 (Feb.12)	20.3 (Mar. 1)	24.6 (Feb. 7)	27.4 (Mar. 4)
1980	0.9 (Jul. 4)	1.0 (May.16)	-	10.0 (Mar.15)	8.8 (Apr. 3)	17.4 (Nov.19)	17.4 (Mar.14)	20.6 (Nov.25)	23.0 (Oct. 5)	36.2 (Mar.14)
1981	2.5 (Aug.10)	2.3 (Aug.10)	-	10.0 (Feb. 2)	12.5 (Feb.12)	42.0 (Jan.30)	18.2 (Jan.31)	30.3 (Jan.20)	22.4 (Feb. 5)	41.2 (Jan.31)
1982	(0.6)(Jul.10)	0.7 (Nov. 9)	-	5.6 (Dec.11)	9.5 (Nov.17)	25.5 (Feb.19)	16.4 (Feb. 4)	15.5 (Feb. 4)	24.6 (Feb.11)	48.8 (Oct.25)
1983	-	2.3 (Apr. 6)	-	8.0 (Mar.12)	25.0 (Feb.22)	27.7 (Feb.19)	16.4 (Oct. 2)	26.2 (Dec.21)	31.2 (Apr. 7)	48.8 (Jan.18)
1984	-	2.0 (Feb.16)	-	10.5 (Feb.19)	21.5 (Mar. 7)	29.1 (Mar.13)	18.4 (Jan.24)	20.8 (Feb. 2)	23.4 (Oct.22)	38.8 (Apr.16)
1985	-	0.3 (Mar.15)	-	-	19.6 (Nov.17)	24.3 (Feb.23)	-	21.4 (Feb.23)	20.8 (Mar.14)	34.6 (Feb. 1)
1986	-	3.3 (Sep.29)	-	-	-	21.8 (Jan.27)	-	-	22.8 (Feb.26)	32.6 (Jan.29)

Unit : mm

Table II-5-2 PROBABLE 1-DAY RAINFALL AT METEOROLOGICAL STATIONS

Return period (Year)	Campo de Marte				Hipolito Unanue				Nana				Santa Eulalia				Matucana			
	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel
2	1.7	2.5	1.5	1.8	1.4	3.4	1.2	1.9	2.0	2.0	2.0	2.4	12.9	13.6	12.5	13.8	15.6	15.5	15.3	15.9
3	2.2	2.8	2.0	2.8	2.2	3.8	1.9	3.6	2.9	2.8	2.8	3.5	16.5	17.2	16.1	18.1	18.8	18.7	18.3	19.5
4	2.6	3.0	2.4	3.5	2.9	4.1	2.4	4.7	3.6	3.4	3.4	4.3	18.9	19.6	18.6	20.9	20.9	20.7	20.4	21.8
5	2.8	3.1	2.7	4.0	3.6	4.3	2.9	5.6	4.2	3.9	4.0	4.8	20.9	21.4	20.6	23.0	22.5	22.3	22.0	23.5
8	3.4	3.4	3.4	5.0	5.2	4.7	4.1	7.3	5.6	4.9	5.1	5.9	25.0	25.0	25.0	27.0	25.8	25.4	25.3	26.9
10	3.7	3.5	3.8	5.4	6.1	4.8	4.8	8.1	6.4	5.4	5.7	6.4	26.9	26.7	27.2	29.1	27.4	26.9	26.9	28.5
15	4.3	3.7	4.6	6.3	8.0	5.1	6.3	9.6	7.9	6.4	6.9	7.3	30.6	29.8	31.4	32.5	30.3	29.6	29.8	31.3
20	4.7	3.8	5.2	6.8	9.6	5.3	7.6	10.6	9.0	7.2	7.8	8.0	33.3	31.9	34.5	34.9	32.4	31.5	31.9	33.3
25	5.0	3.9	5.7	7.3	10.9	5.4	8.7	11.4	10.0	7.8	8.5	8.5	35.5	33.6	37.0	36.8	34.1	33.0	33.6	34.8
30	5.3	4.0	6.2	7.7	12.1	5.5	9.7	12.0	10.8	8.4	9.1	8.9	37.2	34.9	39.1	38.3	35.4	34.2	35.0	36.1
40	5.7	4.1	7.0	8.2	14.2	5.7	11.5	13.0	12.2	9.2	10.2	9.5	40.1	37.1	42.5	40.7	37.6	36.1	37.2	38.0
50	6.1	4.2	7.6	8.7	16.0	5.8	13.1	13.7	13.4	9.9	11.0	10.0	42.4	38.7	45.3	42.5	39.3	37.6	39.0	39.5
80	6.8	4.4	9.2	9.6	20.3	6.0	17.1	15.3	16.1	11.4	12.9	11.0	47.3	42.2	51.5	46.4	43.0	40.8	42.9	42.7
100	7.2	4.5	10.0	10.0	22.6	6.2	19.3	16.1	17.5	12.2	13.8	11.5	49.7	43.9	54.6	48.2	44.8	42.4	44.8	44.2
200	8.4	4.7	13.0	11.4	31.1	6.5	27.8	18.4	22.3	14.8	17.1	13.0	57.6	49.0	65.1	53.8	50.6	47.3	50.9	48.9
500	10.2	5.1	18.0	13.2	45.6	6.9	44.1	21.6	30.0	18.7	22.0	15.0	68.9	55.8	80.8	61.3	58.6	54.0	59.7	55.0
1000	11.7	5.3	23.0	14.5	59.8	7.2	61.7	23.9	36.7	22.0	26.3	16.5	61.0	61.0	94.2	66.9	65.0	59.3	67.0	59.6

Return period (Year)	San Jose de Parac				Mina Corqui				Carampoma				Milloc				Marca			
	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel	Iwai	Hazen	Third type of Pearson	Gumbel
2	21.5	22.0	21.5	21.9	18.3	17.2	17.6	18.1	20.9	22.1	20.9	21.1	24.2	23.8	23.9	23.9	27.5	27.5	27.0	27.6
3	25.5	25.9	25.7	26.7	20.4	19.2	19.7	20.8	24.3	24.8	24.3	24.3	26.0	25.7	25.8	26.0	31.8	31.9	31.3	32.6
4	28.0	28.3	28.4	29.7	21.8	20.6	21.1	22.5	26.4	26.4	26.4	26.4	27.1	26.9	27.0	27.4	34.5	34.6	34.1	35.7
5	29.9	30.1	30.4	31.9	22.8	21.8	22.2	23.8	28.0	27.5	28.0	27.9	27.9	27.8	27.8	28.4	36.5	36.7	36.3	38.1
8	33.6	33.6	34.5	36.5	24.8	24.3	24.4	26.3	31.1	29.5	31.1	31.1	29.3	29.6	29.6	30.4	40.5	40.8	40.7	42.9
10	35.3	35.1	36.4	38.6	25.8	25.6	25.5	27.5	32.6	30.4	32.6	32.5	30.0	30.4	30.3	31.3	42.3	42.6	42.7	45.1
15	38.4	37.9	39.9	42.3	27.5	28.0	27.5	29.6	35.2	31.9	35.2	35.1	31.1	31.9	31.7	33.0	45.6	46.0	46.5	49.0
20	40.4	39.8	42.3	44.9	28.7	29.8	29.0	31.1	36.9	32.9	36.9	36.9	31.8	33.0	32.7	34.2	47.9	48.3	49.2	51.7
25	42.1	41.3	44.2	46.9	29.7	31.3	30.2	32.2	38.3	33.6	38.3	38.2	32.4	33.8	33.4	35.1	49.6	50.0	51.3	53.8
30	43.4	42.5	45.7	48.6	30.5	32.5	31.1	33.2	39.4	34.2	39.4	39.4	32.8	34.4	34.0	35.8	51.1	51.5	53.0	55.6
40	45.4	44.3	48.1	51.1	31.7	34.5	32.7	34.6	41.2	35.1	41.2	41.1	33.5	35.4	34.9	37.0	53.3	53.7	55.8	58.3
50	47.0	45.7	50.0	53.1	32.6	36.1	33.9	35.7	42.6	35.7	42.6	42.5	34.0	36.2	35.6	37.9	55.1	55.5	57.9	60.4
80	50.3	48.7	54.0	57.3	34.6	39.8	36.6	38.1	45.4	37.0	45.4	45.4	35.0	37.9	37.1	39.8	58.7	59.1	62.6	64.8
100	51.9	50.1	56.0	59.3	35.6	41.6	37.9	39.2	46.8	37.6	46.8	46.7	35.5	38.7	37.8	40.6	60.4	60.9	64.8	66.8
200	56.7	54.3	62.0	65.4	38.6	47.7	42.1	42.7	51.0	39.3	51.0	51.0	36.9	41.2	39.9	43.4	65.9	66.3	72.0	73.3
500	63.2	59.8	70.2	73.5	42.6	57.0	48.2	47.3	57.0	41.3	56.6	56.5	38.7	44.5	42.8	47.0	73.1	73.4	82.0	81.8
1000	68.1	63.9	76.6	79.6	45.8	65.1	53.2	50.7	60.9	42.7	60.9	60.7	40.0	47.1	44.9	49.8	78.6	78.9	90.0	88.2

Table II-5-3 PROBABLE 1-DAY RAINFALL IN TRIBUTARY AREAS OF GROUP "A"

*1 No.	*2 Name of tributaries	*3 Area (km2)	*4 Elevation(m) Highest	*5 Lowest	*6 Average	Return Period (year) 2	3	5	8	10	15	20	30	40	50	100 (Unit : mm)
Qda. (R-6)	Q. Quirio	10.4	2,010	805	1,207	13.3	16.9	20.5	25.9	27.9	31.9	34.9	38.9	43.3	46.7	54.7
(R-7)	Q. Pedregal (San Antonio)	10.6	2,330	820	1,323	13.8	17.4	21.1	26.5	28.5	32.5	35.5	39.4	43.8	47.1	55.1
(R-8)	Q. Carosio (Moyopampa)	0.4	1,675	840	1,118	13.0	16.5	20.1	25.5	27.5	31.5	34.5	38.5	43.0	46.4	54.4
(R-9)	Q. Corrales (Rayus de Sol)	1.4	2,000	850	1,233	13.4	17.0	20.7	26.1	28.1	32.1	35.1	39.0	43.4	46.8	54.8
(R-19)	Q. Rio Seco	49.3	4,630	1,520	2,557	19.0	22.8	27.1	32.0	34.2	38.0	41.0	44.8	48.5	51.2	59.2
(R-32)	Q. Paihua (Llanahualla)	14.9	4,760	2,400	3,187	21.6	25.5	30.1	34.8	37.7	40.8	43.8	47.5	50.9	53.3	61.3
(S-1)	Q. Cashahuacra	15.1	2.600	980	1,520	14.6	18.3	22.0	27.3	29.4	33.3	36.3	40.3	44.5	47.8	55.8

Remarks : Ave.elevation = Lowest + 1/3 * (Highest - Lowest)

Table II-5-4 ANNUAL MAXIMUM BASIN MEAN 1-DAY RAINFALL

Unit: mm

Year	Basin mean 1-day Rainfall
1966	11.6
1967	18.7
1968	9.8
1969	10.3
1970	22.4
1971	17.6
1972	13.6
1973	17.2
1974	10.1
1975	11.4
1976	11.5
1977	19.7
1978	8.9
1979	10.4
1980	7.0
1981	12.7
1982	10.5
1983	12.0
1984	16.5
1985	17.3

Table II-5-5 PROBABLE BASIN MEAN 1-DAY RAINFALL

Unit : mm

Return period (year)	Basin mean 1-day rainfall
2	12.8
3	14.6
4	15.8
5	16.6
8	18.4
10	19.1
15	20.6
20	21.5
25	22.3
30	22.9
40	23.9
50	24.6
80	26.2
100	26.9
200	29.2
500	32.3
1000	34.7

Table II-6-1 ANNUAL MAXIMUM DISCHARGE AT CLOSED HYDROLOGICAL STATIONS (1/2)

Hydro-logical year	Date	Name of gaging station	Maximum /1 disch. (m^3/sec)	Mean /2 disch. (m^3/sec)
1920-21	Mar.13	Chacrasana	95.0	73.4
21-22	Mar. 7	- do -	99.0	68.7
22-23	Mar. 5	- do -	97.0	65.9
23-24	Mar.16	- do -	90.5	66.4
24-25	Feb.20	- do -	56.6	50.1
25-26	Mar.20	- do -	187.1	105.1
26-27	Mar. 7	- do -	137.6	104.0
27-28	Mar.18	- do -	183.5	91.5
28-29	Feb. 9	- do -	139.8	104.7
29-30	Mar.21	- do -	320.1	96.4
30-31	Mar. 2	- do -	97.6	39.8
31-32	Feb.17	- do -	480.0	136.1
32-33	Mar.19	- do -	225.0	102.2
33-34	Mar.13	- do -	200.0	118.6
34-35	Mar.16	- do -	250.0	145.7
35-36	Dec.27	- do -	98.8	36.1
36-37	Mar.10	- do -	105.0	69.1
37-38	Feb.26	- do -	175.0	97.8
38-39	Mar. 7	- do -	205.0	128.1
39-40	Mar.28	- do -	254.5	75.3
40-41	Mar. 9	- do -	385.4	101.2
41-42	Feb. 4	- do -	315.8	82.1
42-43	Feb.21	- do -	261.0	112.5
43-44	Feb.12	- do -	130.0	59.0
44-45	Feb. 2	- do -	94.5	44.1
45-46	Mar.15	- do -	185.0	109.8
46-47	Mar.19	- do -	130.0	69.9
47-48	Jan.29	- do -	130.0	56.6

Remarks: /1. Corresponded to the maximum water level among 4 times of routine gage reading on the same date.
/2. Values mean the annual maximum mean daily discharge.

Source: SENAMHI

Table II-6-1 ANNUAL MAXIMUM DISCHARGE AT CLOSED HYDROLOGICAL STATIONS (2/2)

Hydro-logical year	Date	Name of gaging station	Maximum/1 disch. (m^3/sec)	Mean/2 disch. (m^3/sec)
1948-49	Mar.28	Pte. Los Angeles	108.0	62.1
49-50	Feb.13	- do -	98.5	47.9
50-51	Mar.14	- do -	316.0	114.8
51-52	Mar.28	- do -	164.0	86.5
52-53	Feb.21	- do -	175.0	105.6
53-54	Feb. 7	- do -	202.0	96.6
54-55	Mar.20	Yanacoto	380.0	114.0
55-56	Mar.16	- do -	155.0	69.3
56-57	Feb.22	- do -	100.0	43.0
57-58	FEb.27	- do -	99.8	43.1
58-59	Feb.25	- do -	175.0	68.8
59-60	Mar.25	- do -	77.4	40.5
60-61	Feb.26	Pte.Huachipa	70.5	50.9
61-62	Mar. 9	- do -	84.1	61.8
62-63	Mar.12	Chosica R-1	92.2	60.7
63-64	FEb. 7	- do -	78.8	36.9
64-65	Feb.23	- do -	108.1	51.4
65-66	Mar. 7	- do -	100.6	37.7
66-67	Mar.21	- do -	100.5	58.9
67-68	Mar.13	- do -	46.4	31.4
68-69	Mar. 9	- do -	69.3	34.2
69-70	Jan.16	- do -	124.8	64.8
70-71	Mar.17	- do -	109.1	68.9
71-72	Mar.12	- do -	135.9	86.7
72-73	FEb. 6	- do -	143.6	82.7
73-74	Mar.74	- do -	88.4	62.4
74-75	Mar.11	- do -	111.3	66.3

Remarks: /1 Corresponded to the maximum water level among 4 times of routine gage reading on the same date.
/2 Values mean the annual maximum mean daily discharge.

Source: SENAMHI

Table II-6-2 ANNUAL MAXIMUM DISCHARGE AT CHOSICA R-2 STATION

Hydro-logical year	Date	Gage height (m) Hmax /1	Hmed /2	Hinst /3	Discharge (m^3/sec) Qmax /4	Qinst /5
1968-69	Mar. 3	1.57	1.56	1.72	81.4	113.2
69-70	Jan.16	2.13	2.06	2.17	158.0	161.0
70-71	Mar.17	1.87	1.82	1.96	139.0	138.0
71-72	Mar.11	1.38	1.35	1.56	210.0	95.6
72-73	FEb. 5	1.75	1.72	1.86	115.0	128.0
73-74	Mar. 3	1.60	1.56	1.74	79.1	115.4
74-75	Mar.24	1.70	1.66	1.82	144.0	124.0
75-76	Feb. 7	1.50	1.41	1.66	116.0	106.6
76-77	Feb.19	1.72	1.62	1.84	162.0	126.0
77-78	Feb.24	1.70	1.66	1.82	151.0	124.0
78-79	Mar. 8	1.69	1.66	1.81	144.0	123.0
79-80	Jan.27	1.44	1.31	1.61	91.5	101.1
80-81	Feb. 7	1.80	1.74	1.90	216.0	132.0
81-82	Feb. 5	1.16	1.14	1.38	72.0	76.2
82-83	Apr. 8	1.32	1.30	1.51	108.0	90.1
83-84	Feb.13	2.20	2.08	2.23	103.5	167.3
84-85	-	-	-	-	-	-
85-86	Jan.29	1.41	1.24	1.59	164.2	98.9

Remarks:
/1. Maximum gage reading record on the day when mean discharge is the largest in certain year.
/2. Mean gage height on the day when mean discharge is the largest in certain year.
/3. Instantaneous peak water level estimated from Hmax.
/4. Annual maximum mean daily discharge.
/5. Instantaneous peak discharge estimated by the rating curve established in 1984. (Rating table No. 02909 in SENAMHI).

Source: SENAMHI

Table II-7-1 PROBABLE PEAK DISCHARGE OF TRIBUTARY AREAS OF GROUP "A"

No.	Name of tributaries	Catchment Area (km2)	Return Period (year) 2	3	5	8	10	15	20	30	40	50	100 (Unit : m3/sec)
Qda. (R-6)	Q. Quirio	10.4	18	23	28	36	38	44	48	54	60	64	75
(R-7)	Q. Pedregal (San Antonio)	10.6	18	23	28	35	38	43	47	52	58	62	73
(R-8)	Q. Carosio (Moyopampa)	0.4	2	2	3	4	4	4	5	5	6	7	8
(R-9)	Q. Corrales (Rayus de Sol)	1.4	4	6	7	8	9	10	11	13	14	15	18
(R-19)	Q. Rio Seco	49.3	71	85	101	119	127	141	153	167	180	191	220
(R-32)	Q. Paihua (Llanahualla)	14.9	40	47	56	65	69	76	82	88	95	99	114
(S-1)	Q. Cashahuacra	15.1	26	33	39	49	53	60	65	72	80	86	100

Table II-7-2 MEAN BASIN RAINFALL IN SUBBASINS BY RETURN PERIODS

Unit : mm

Return Period	Isohyetal values				Sub basin No.1			Sub basin No.2				Sub basin No.3			Sub basin No.4				
	A	B	C	D	A 0.15	B 0.85	Total	A 0.08	B 0.4	C 0.52	Total	A 0.83	B 0.17	Total	A 0.09	B 0.4	C 0.28	D 0.23	Total
2	16.5	11.5	6.5	1.5	2.5	9.8	12.3	1.3	4.6	3.4	9.3	13.7	2.0	15.7	1.5	4.6	1.8	0.3	8.3
3	18.1	13.1	8.1	3.1	2.7	11.1	13.9	1.4	5.2	4.2	10.9	15.0	2.2	17.3	1.6	5.2	2.3	0.7	9.9
4	19.1	14.1	9.1	4.1	2.9	12.0	14.9	1.5	5.6	4.7	11.9	15.9	2.4	18.3	1.7	5.6	2.5	0.9	10.9
5	19.9	14.9	9.9	4.9	3.0	12.7	15.7	1.6	6.0	5.1	12.7	16.5	2.5	19.1	1.8	6.0	2.8	1.1	11.7
8	21.4	16.4	11.4	6.4	3.2	13.9	17.2	1.7	6.6	5.9	14.2	17.8	2.8	20.6	1.9	6.6	3.2	1.5	13.2
10	22.0	17.0	12.0	7.0	3.3	14.5	17.8	1.8	6.8	6.2	14.8	18.3	2.9	21.2	2.0	6.8	3.4	1.6	13.8
15	23.2	18.2	13.2	8.2	3.5	15.5	19.0	1.9	7.3	6.9	16.0	19.3	3.1	22.4	2.1	7.3	3.7	1.9	15.0
20	24.0	19.0	14.0	9.0	3.6	16.2	19.8	1.9	7.6	7.3	16.8	19.9	3.2	23.2	2.2	7.6	3.9	2.1	15.8
25	24.7	19.7	14.7	9.7	3.7	16.7	20.4	2.0	7.9	7.6	17.5	20.5	3.3	23.9	2.2	7.9	4.1	2.2	16.5
30	25.2	20.2	15.2	10.2	3.8	17.2	21.0	2.0	8.1	7.9	18.0	20.9	3.4	24.4	2.3	8.1	4.3	2.3	17.0
40	26.0	21.0	16.0	11.0	3.9	17.9	21.7	2.1	8.4	8.3	18.8	21.6	3.6	25.2	2.3	8.4	4.5	2.5	17.8
50	26.6	21.6	16.6	11.6	4.0	18.4	22.4	2.1	8.6	8.6	19.4	22.1	3.7	25.8	2.4	8.6	4.6	2.7	18.4
80	27.8	22.8	17.8	12.8	4.2	19.4	23.6	2.2	9.1	9.3	20.6	23.1	3.9	27.0	2.5	9.1	5.0	2.9	19.6
100	28.4	23.4	18.4	13.4	4.3	19.9	24.2	2.3	9.4	9.6	21.2	23.6	4.0	27.6	2.6	9.4	5.2	3.1	20.2
200	30.2	25.2	20.2	15.2	4.5	21.4	26.0	2.4	10.1	10.5	23.0	25.1	4.3	29.4	2.7	10.1	5.7	3.5	22.0
500	32.6	27.6	22.6	17.6	4.9	23.5	28.4	2.6	11.0	11.8	25.4	27.1	4.7	31.8	2.9	11.0	6.3	4.0	24.4
1000	34.4	29.4	24.4	19.4	5.2	25.0	30.2	2.8	11.8	12.7	27.2	28.6	5.0	33.6	3.1	11.8	6.8	4.5	26.2