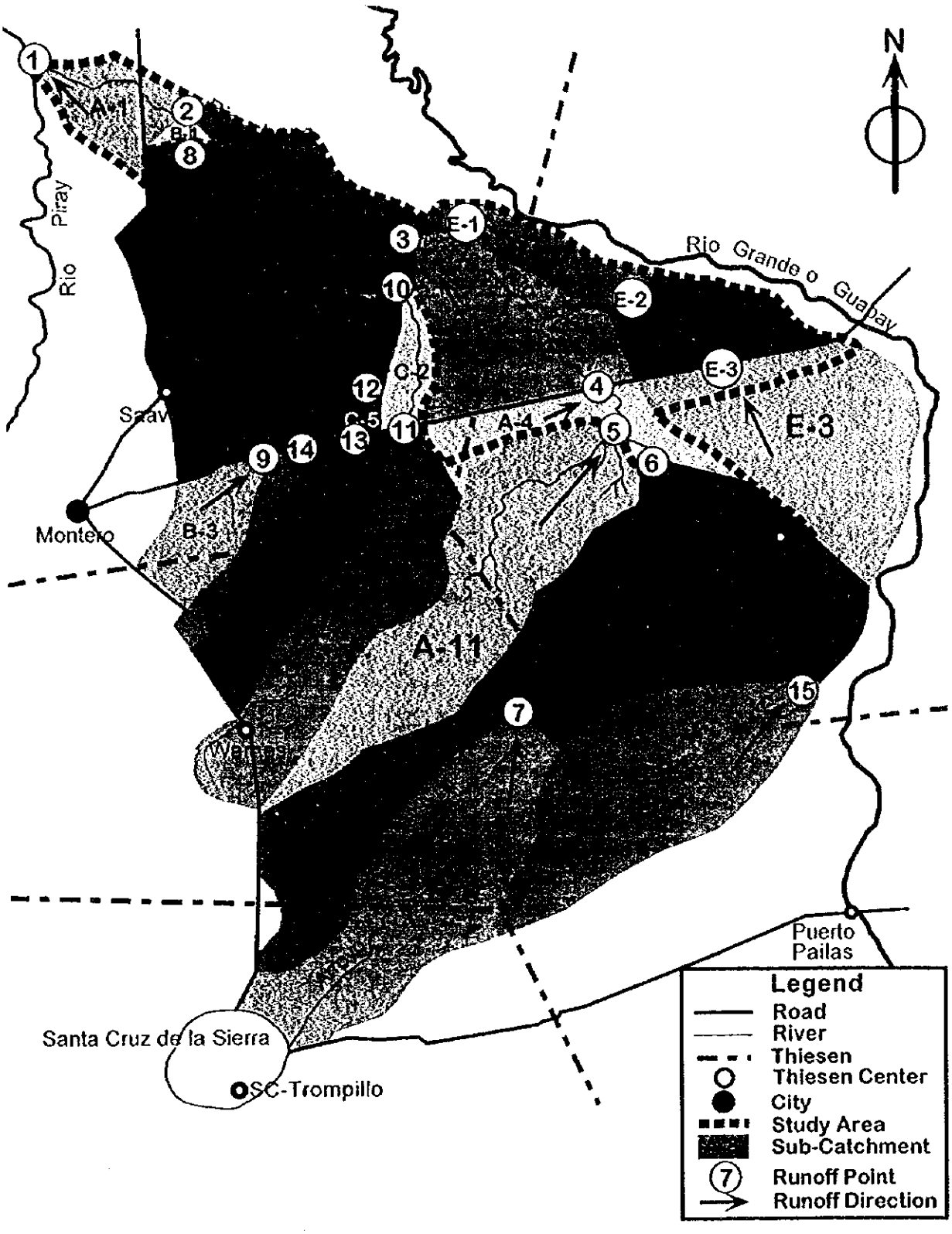


FIG.B.8.1 CATCHMENT AREAS FOR THE RUNOFF ANALYSIS
(OKINAWA/CHANE-PAILON)

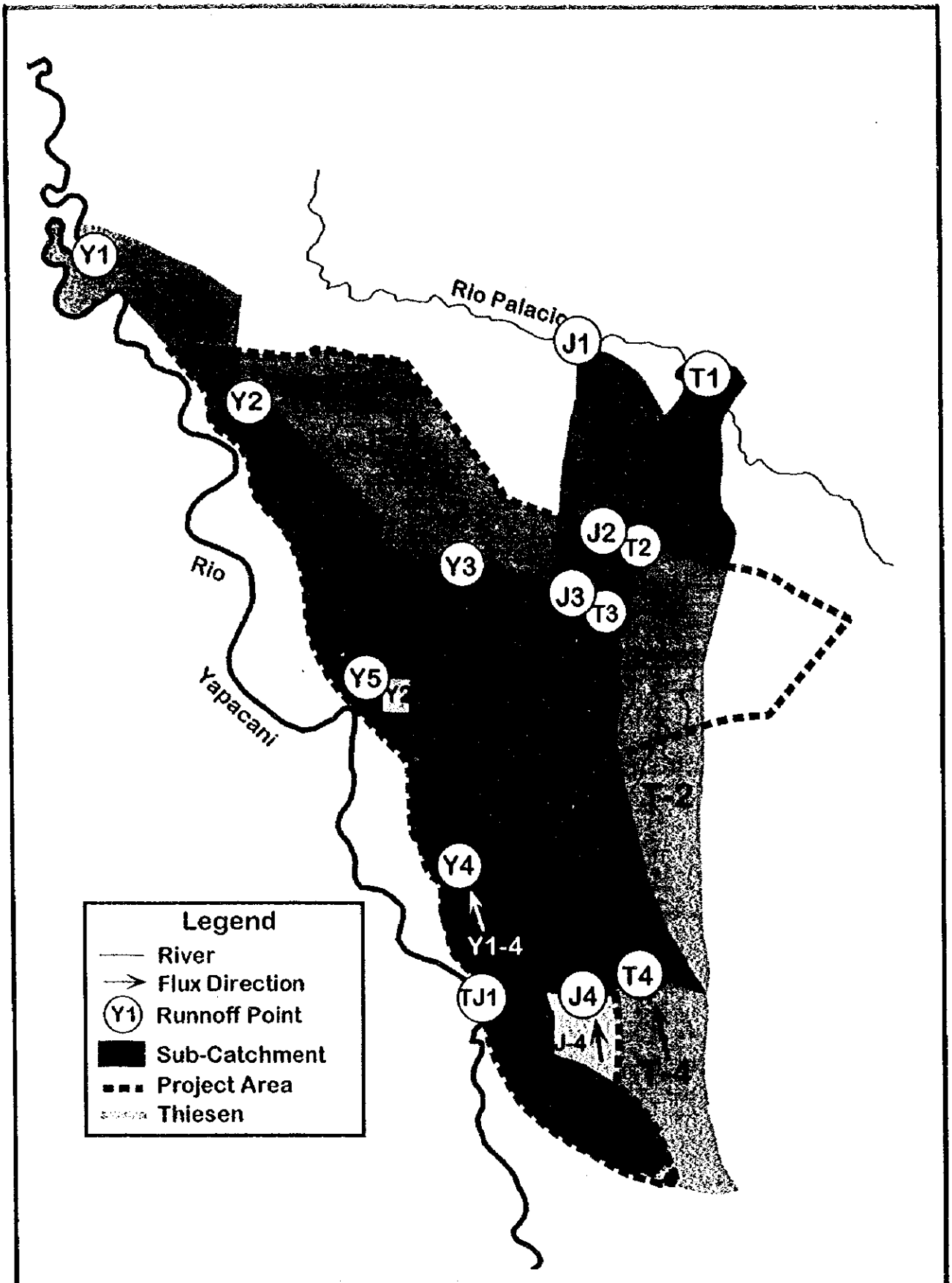


FIG.B.8.2 CATCHMENT AREAS FOR THE RUNOFF ANALYSIS
SAN JUAN/ANTOFAGASTA AREA

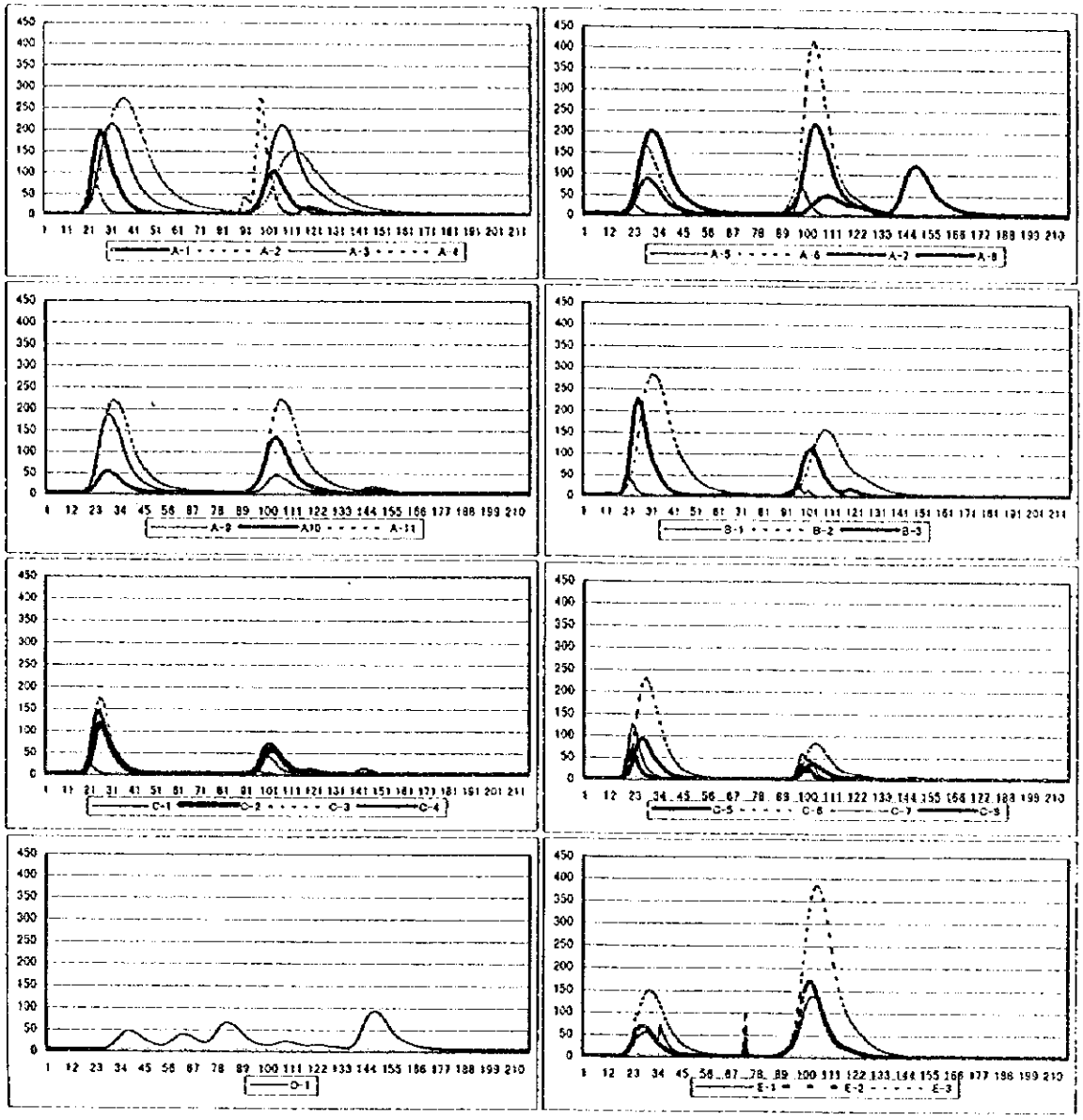


FIG.B.8.3(1) RUNOFF RESULTS FOR OKINAWA/CHANE-PAILON AREA (30/11-05/12/97)

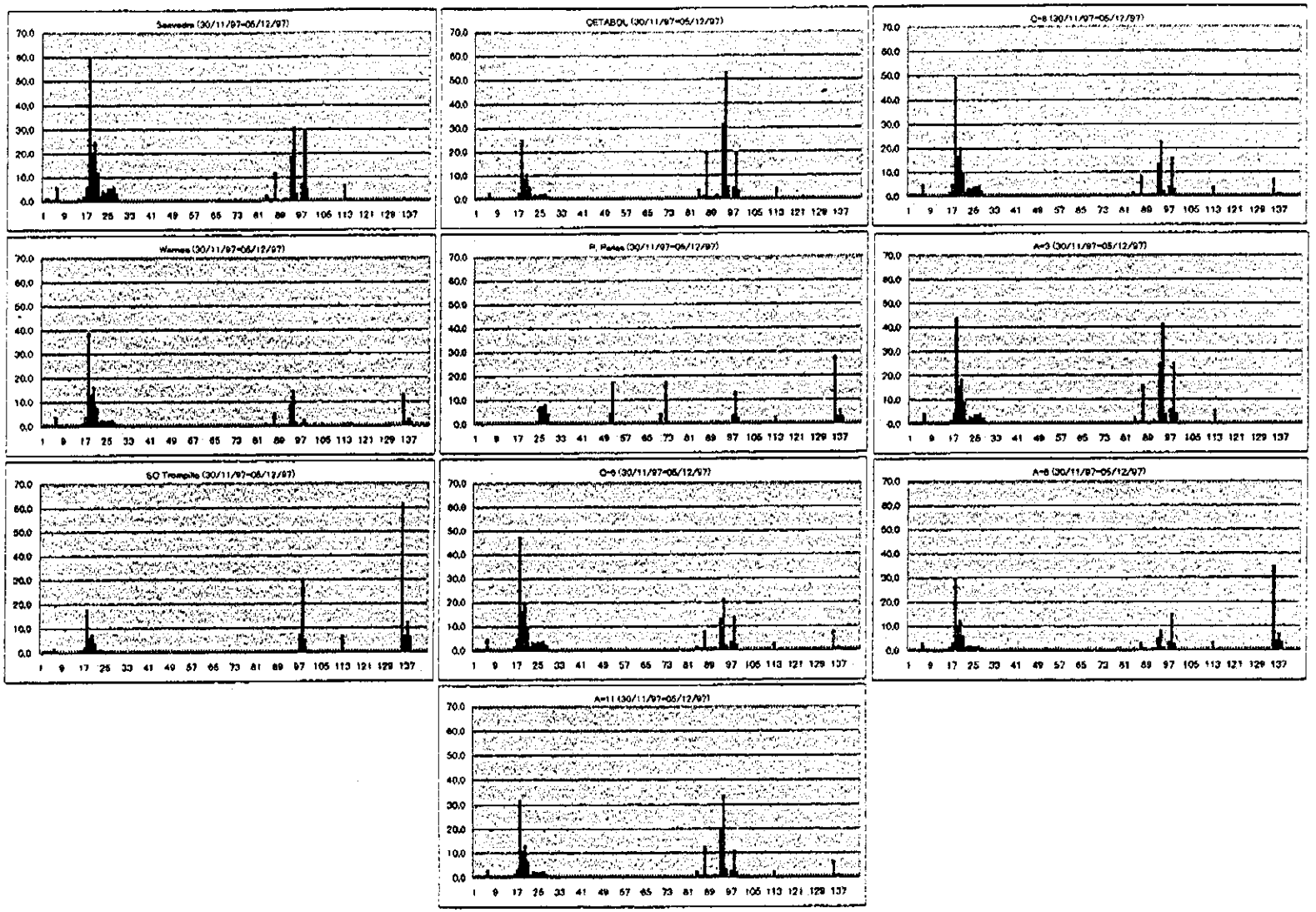


FIG.B.8.3(2) RAINFALL FOR THE RUNOFF SIMULATION IN OKINAWA/ CHANE-PAILON AREA

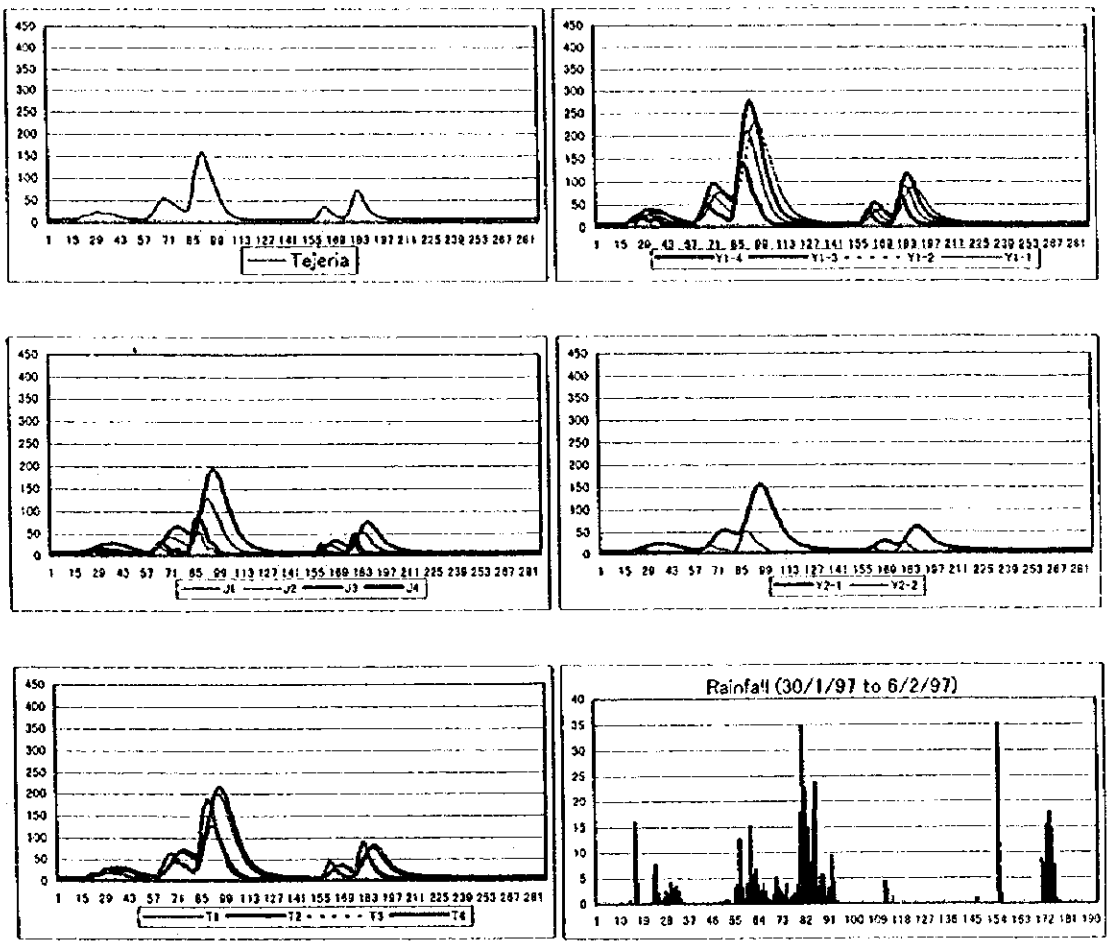


FIG.B.8.4 RUNOFF RESULTS FOR SAN JUAN/ANTOFAGASTA AREA

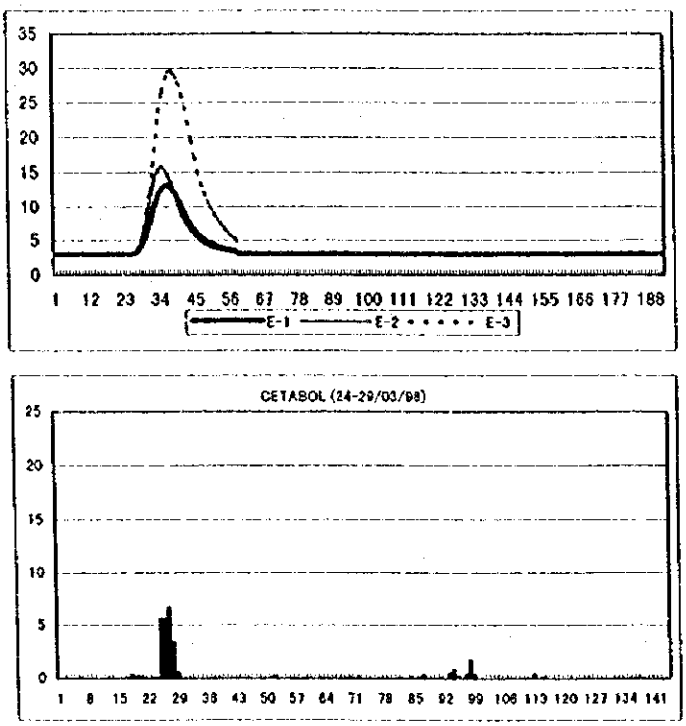


FIG.B.8.5 RUNOFF RESULT FOR THE GRANDE RIVER CONTRIBUTIOR

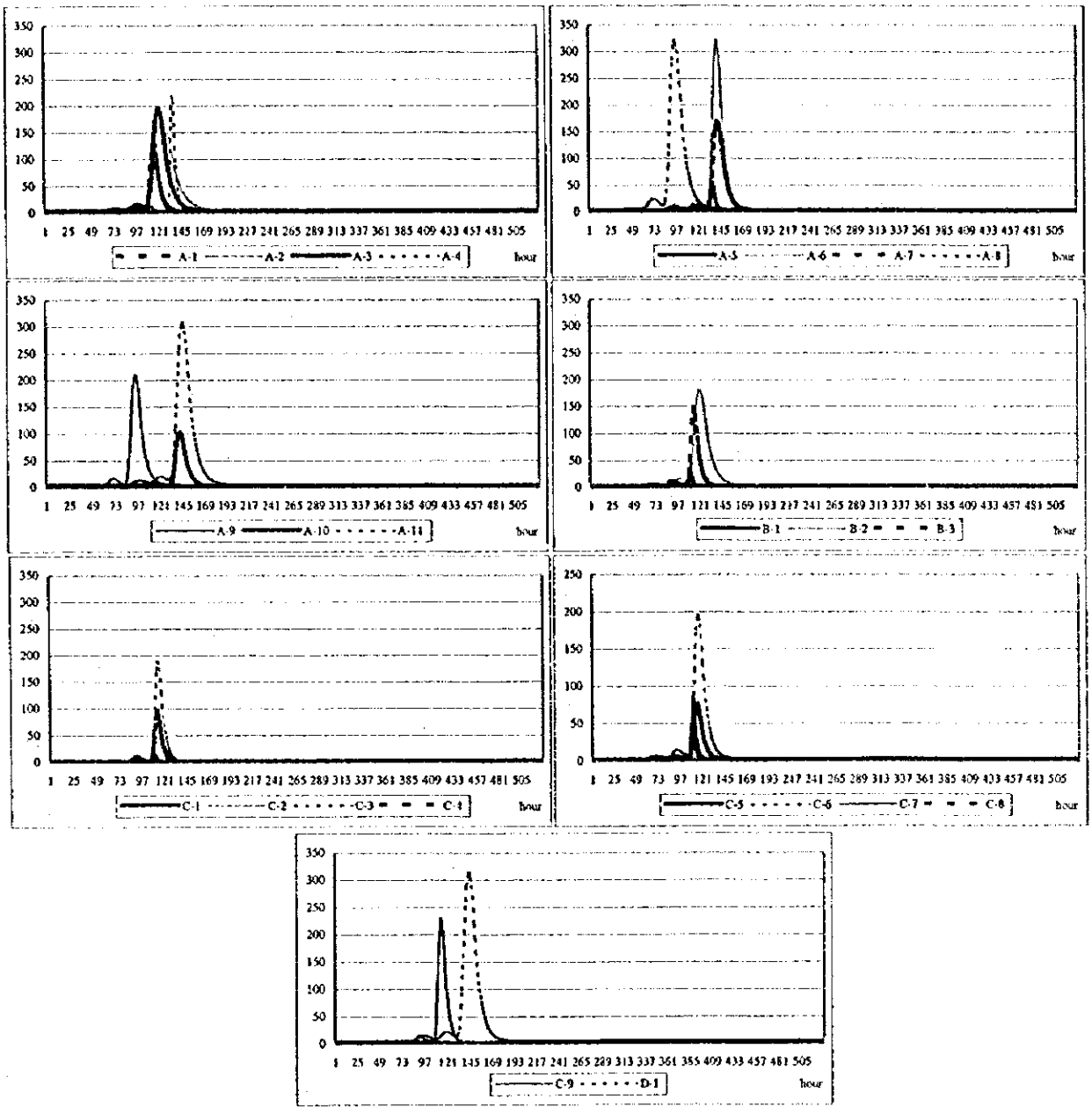


FIG.B.8.6(1) RUNOFF FOR RETURN PERIOD OF 2 YEARS(CHANE-PAILON)

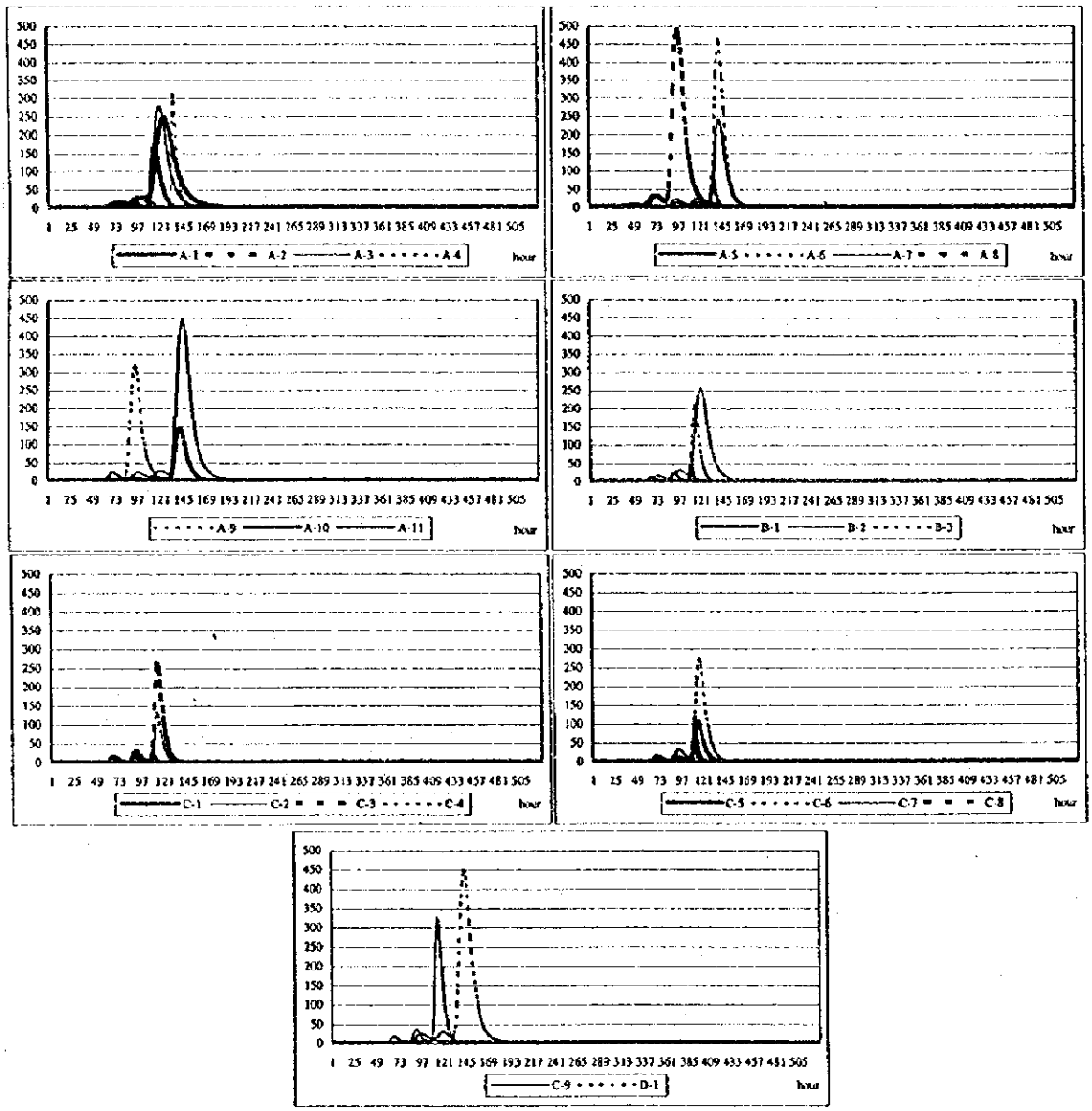


FIG.B.8.6(2) RUNOFF FOR RETURN PERIOD OF 5 YEARS(CHANE-PAILON)

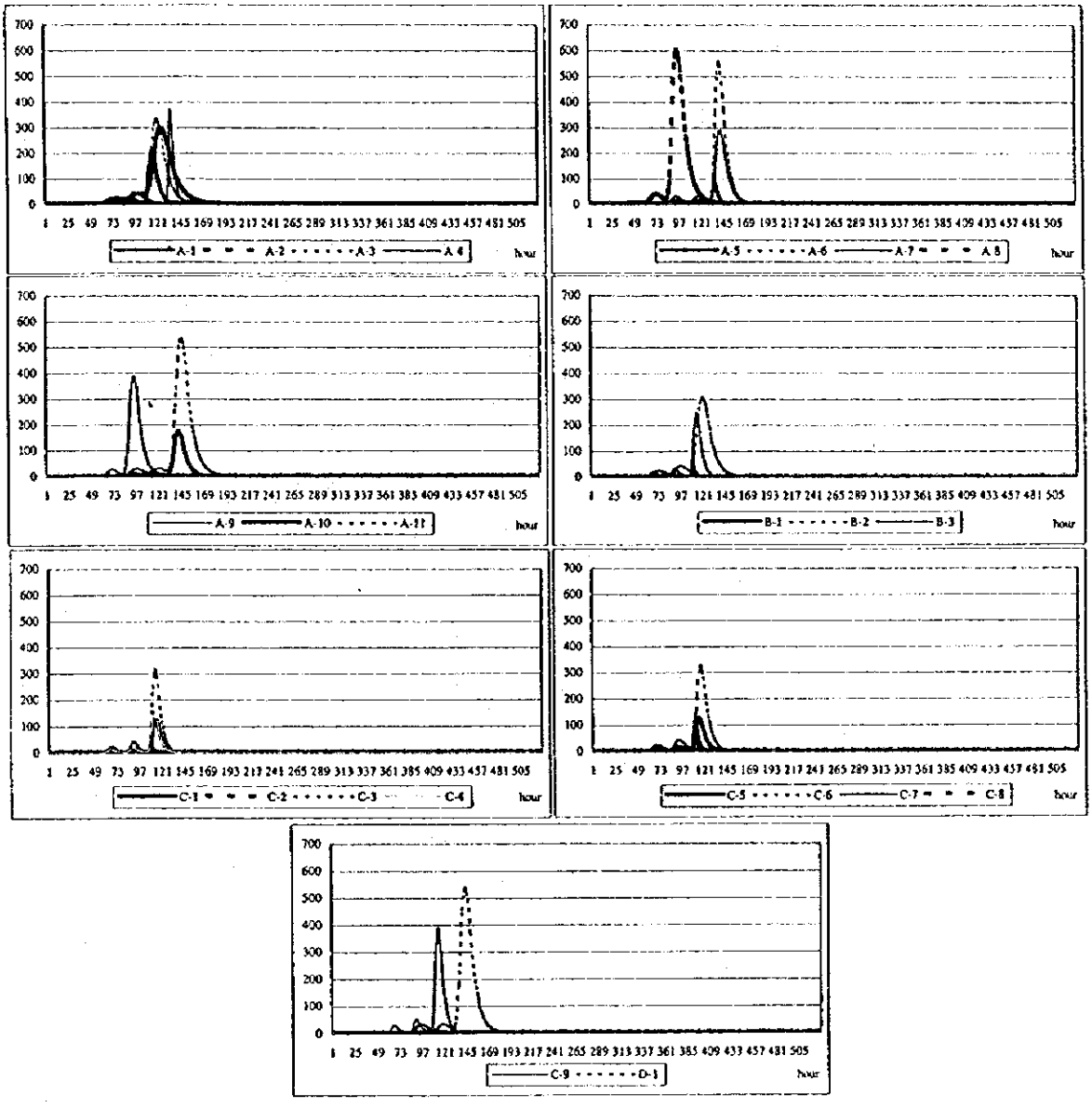


FIG.B.8.6(3) RUNOFF FOR RETURN PERIOD OF 10 YEARS(CHANE-PAILON)

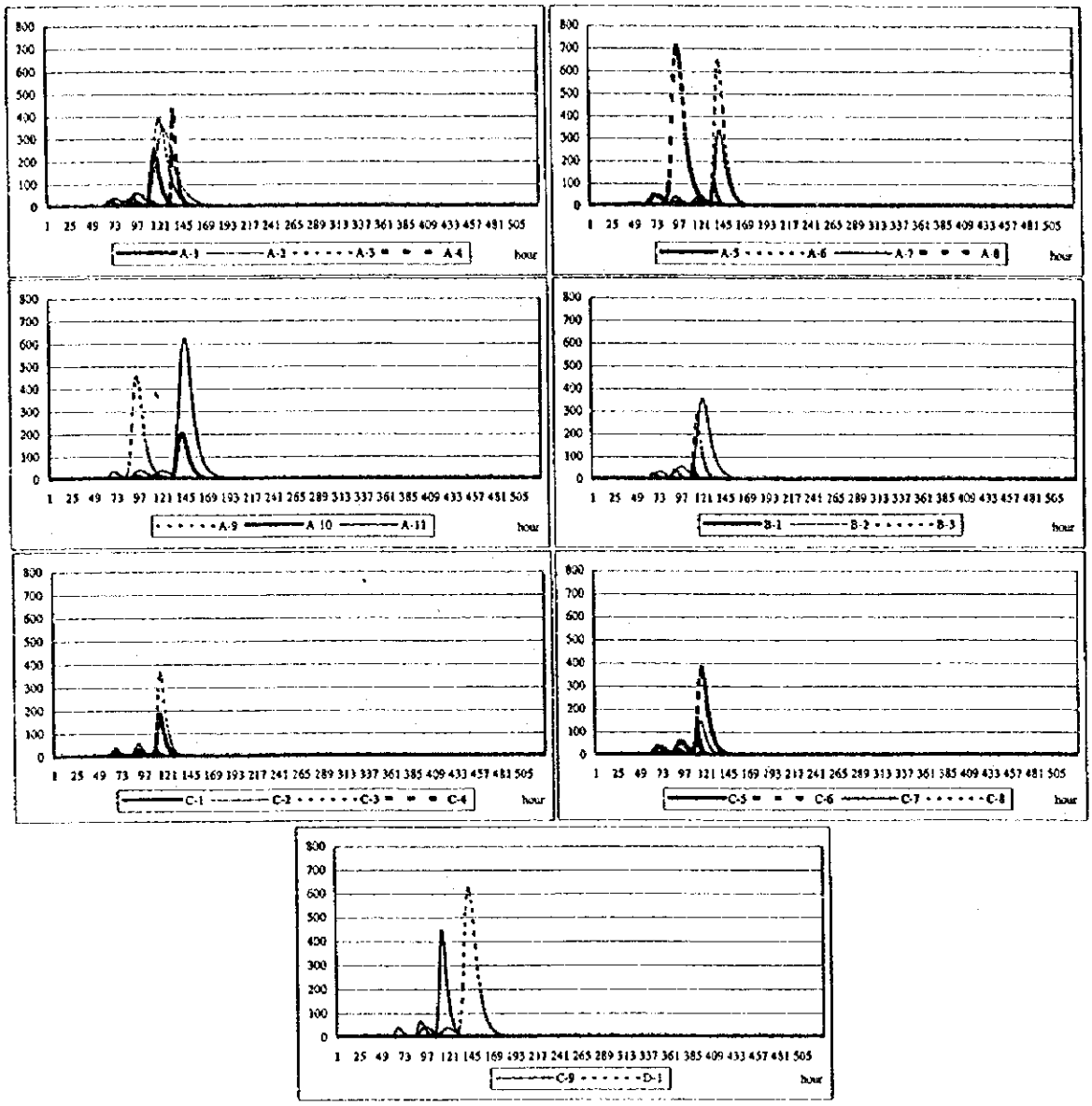


FIG.B.8.6(4) RUNOFF FOR RETURN PERIOD OF 20 YEARS(CHANE-PAILON)

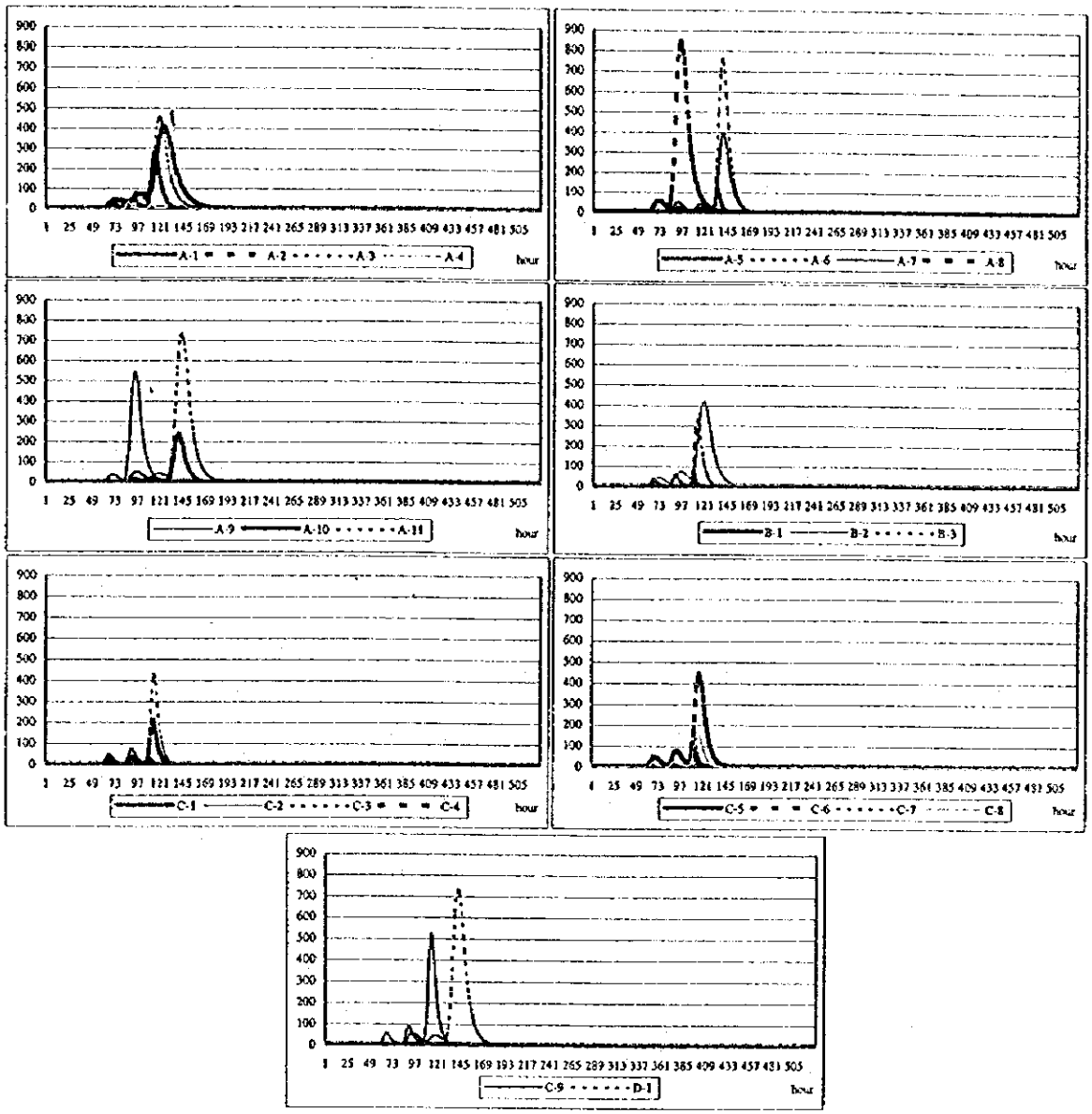


FIG.B.8.6(5) RUNOFF FOR RETURN PERIOD OF 50 YEARS(CHANE-PAILON)

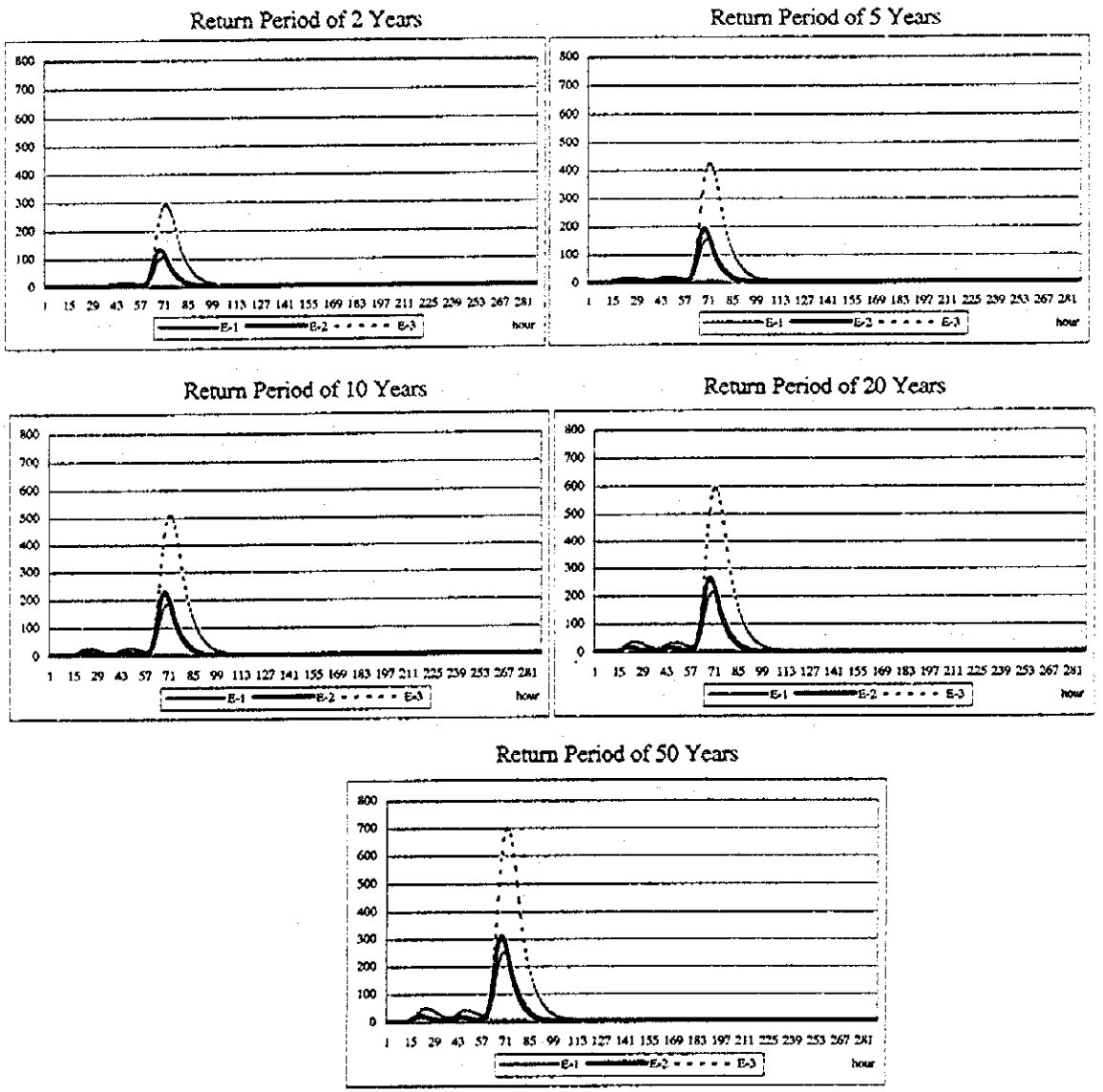


FIG.B.8.6(6) RUNOFF(OKINAWA)

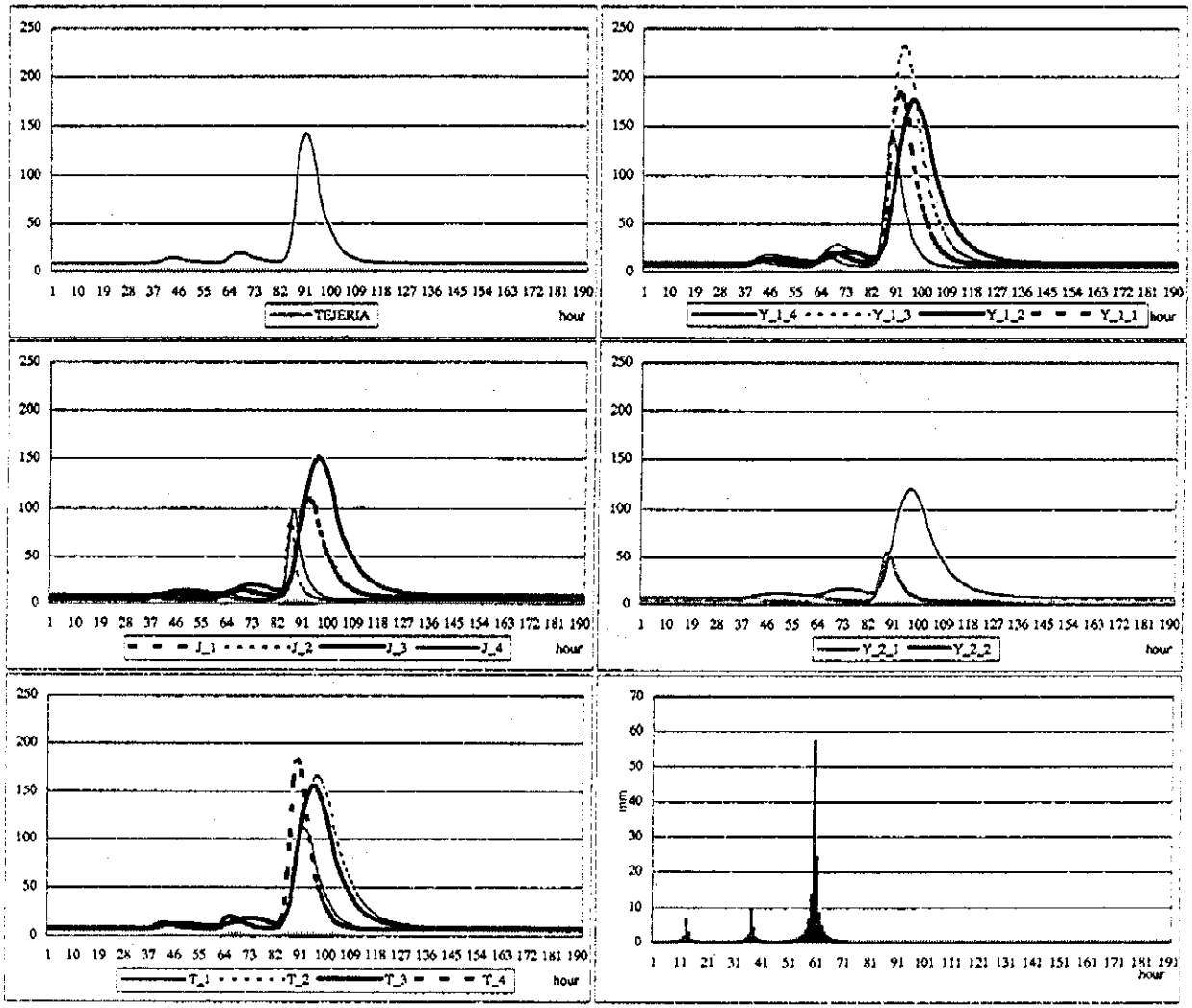


FIG.B.8.6(7) RUNOFF FOR RETURN PERIOD OF 2 YEARS
(SAN JUAN-ANTOFAGASTA)

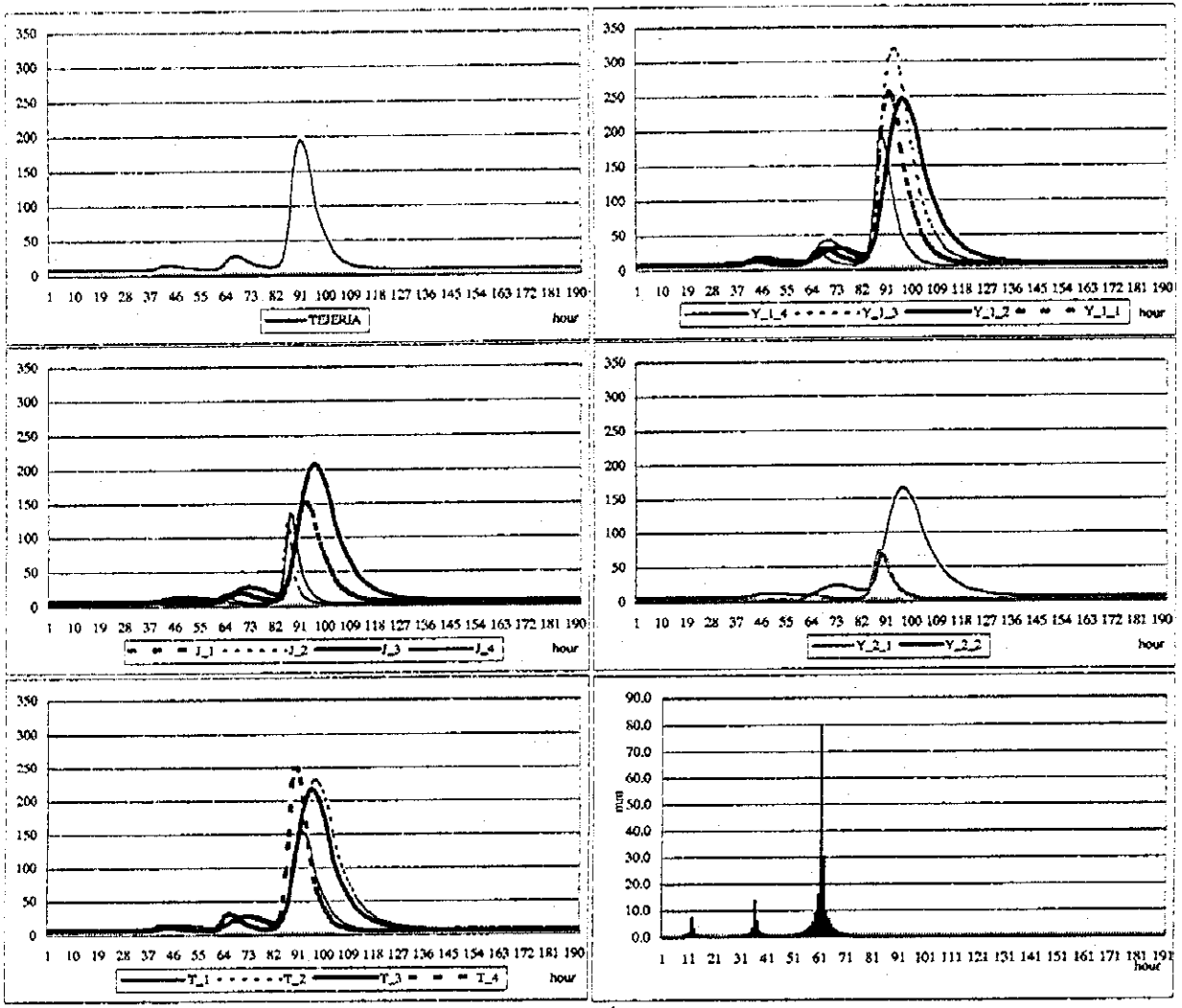


FIG.B.8.6(8) RUNOFF FOR RETURN PERIOD OF 5 YEARS
(SAN JUAN-ANTOFAGASTA)

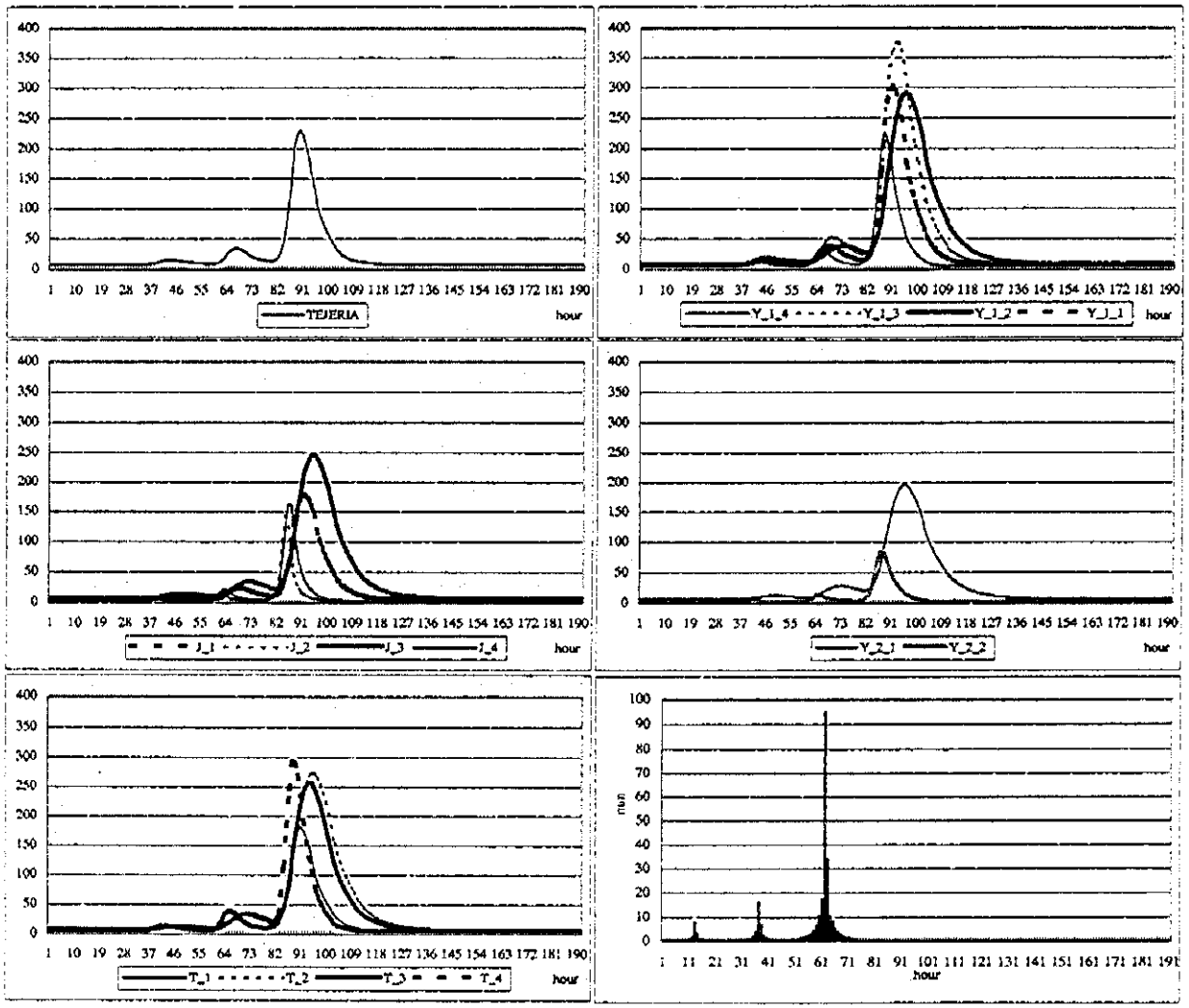


FIG.B.8.6(9) RUNOFF FOR RETURN PERIOD OF 10 YEARS
(SAN JUAN-ANTOFAGASTA)

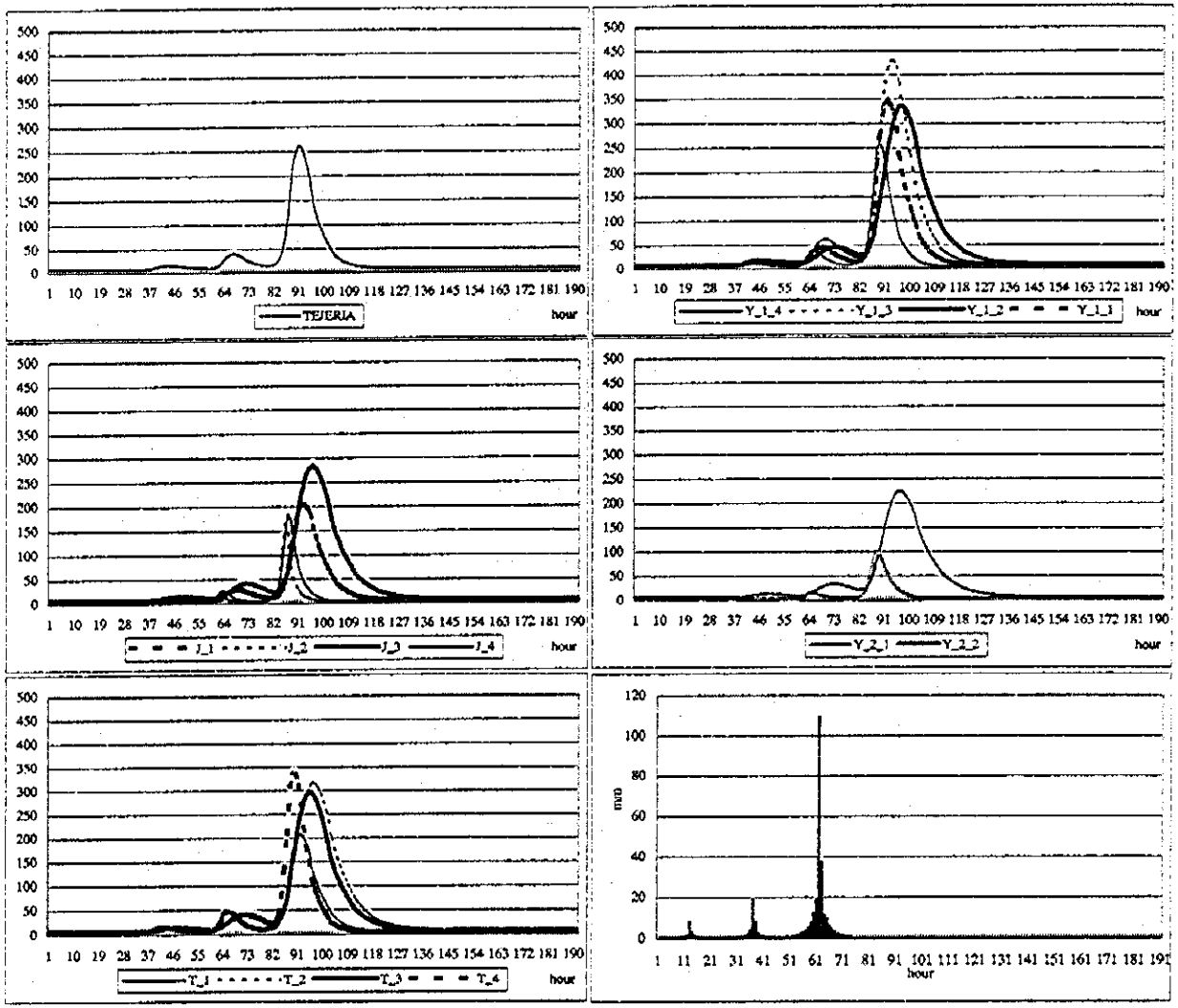


FIG.B.8.6(10) RUNOFF FOR RETURN PERIOD OF 20 YEARS
(SAN JUAN-ANTOFAGASTA)

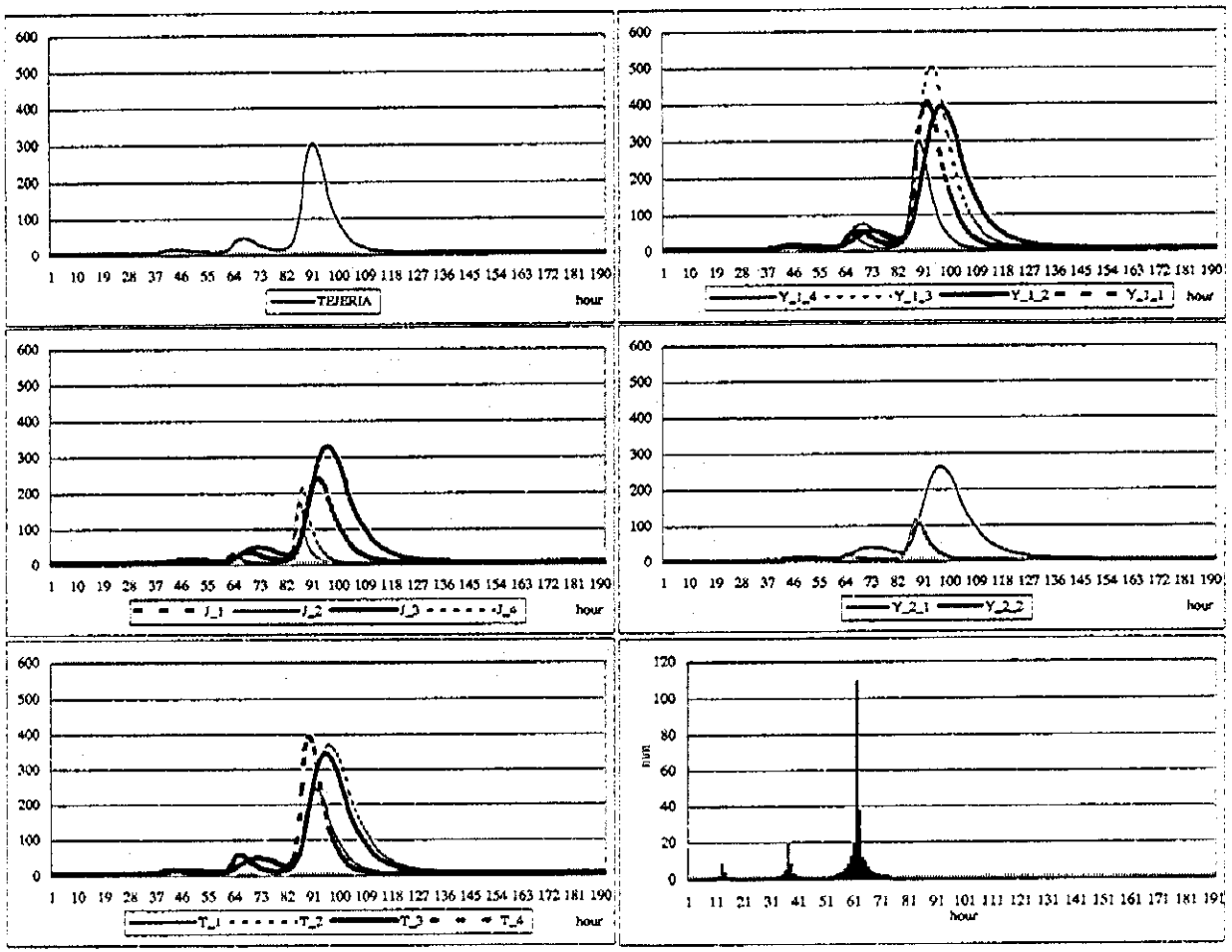
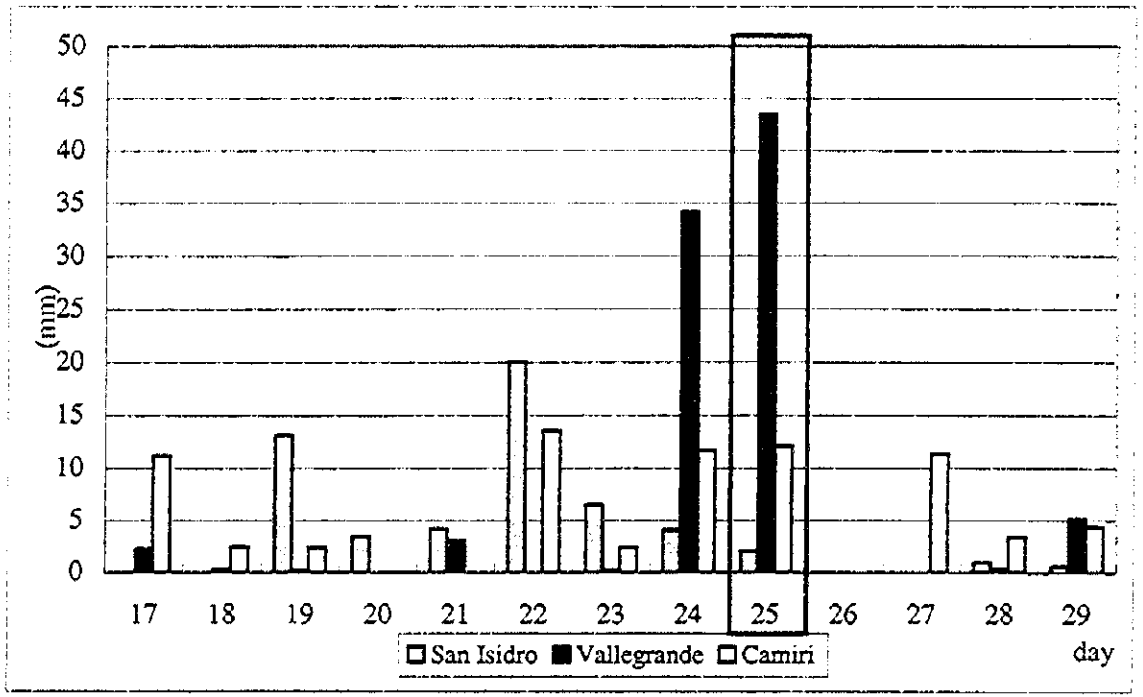


FIG.B.8.6(11) RUNOFF FOR RETURN PERIOD OF 50 YEARS
(SAN JUAN-ANTOFAGASTA)



Obs.: 25/03/98 = date that the water level reached 9.2m in Abapo.

FIG.B.9.1 RAINFALL IN GRANDE BASIN(17 TO 29/03/98)

SUPPORTING REPORT C

PRELIMINARY DESIGN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUPPORTING REPORT C PRELIMINARY DESIGN

1. Review of the Proposed Structures

1.1 River Improvement

Structural measures for the flood mitigation plan were proposed in the Master Plan Study as follows:

- River improvement
  River improvement works are to increase conveyance capacities of channels by widening, deepening and improving channels.

- Road-cum-embankment
  Road-cum-embankment is to have the function of both flood embankment and roads

As the flood hazard area is mainly composed of agricultural lands, the complete mitigation of flood and drainage problems is unlikely feasible physically and economically. Therefore, the reduction of the required scale of the flood mitigation and drainage improvement facilities is needed. In order to reduce the required scale, the effective use of the natural retarding basin of the marshy area etc. was proposed in the Master Plan Study in 1996.

(1) The Chane – Pailon Area

The target areas for the structural measures were set up according to the river and drainage basins. A total of 6 rivers and tributaries' drainage basins were identified in the master plan study as follows:

1) The Rio Chane basin
2) The Rio Pailon basin
3) The Quebrada Chane basin
4) The Quebrada El Toro basin
5) The Quebrada Las Chacras basin
6) The Okinawa Drainage basin

The structural measures proposed were the river improvement. This river improvement was mainly the enlargement of the existing river cross-sections to

increase the flow capacity. The proposed cross sections were all trapezoidal shapes, but the width and depth varied along the river based on the suitability from the technical and economical aspects. A summary of the improvement was shown as follows:

RIVER		IMPROVEMENT PLAN	
I	Rio Chane	Jct. Rio Piray	Downst. Road Bridge
		Downst. Road Bridge	Jct. Rio Pailon
II	Rio Pailon	Jct. Rio Chane	Jct. Arroyo Los Sauces
III	Qda. Chane	Jct. Rio Chane	Road No.9 Bridge
IV	Qda. El Toro	Jct. Qda. Chane	Road No.9 Bridge
V	Qda. Las Chacras	Jct. Rio Chane	Road No.9 Bridge

However, a priority order was set up for the basins. The drainage basins for the improvement were divided into the first, the second and the third priority areas for the implementation of the project by considering the technical, economic, social and environmental aspects. The first priority areas were identified as follows:

- Rio Chane Area
- Rio Pailon Area
- Okinawa Drainage Area

(2) The San Juan – Antofagasta Area

The target areas for the structural measures identified in the Master Plan Study for this basin were 2 areas, those are:

1) The San Juan area
2) The Antofagasta area

The structural measures proposed were the river improvement and road-cum embankment. This river improvement was mainly the enlargement of the existing river cross-sections to increase the flow capacity while the road-cum embankment was to increase the height of the embankment to protect the overflow across the basins. The proposed cross sections were all trapezoidal shapes. A summary of the improvement was shown as follows:

RIVER		IMPROVEMENT PLAN	
I	Arroyo Yapacanicito	Downstream	Road Bridge
II	Arroyo Jochi	Downst. Swamp	Midstream
III	Arroyo Tacuaral	Downst. Swamp	Midstream
IV	Road-cum-embankment	Antofagasta Road	San Juan Road

A priority order was also set up for the basins. The areas for improvement were divided into the first and the second priority areas for the implementation of the project by considering the technical, economic, social and environmental aspects. A summary of the improvement in these priority areas is shown as follows:

- San Juan Area
- Antofagasta Area

1.2 Drainage Improvement

In order to solve the drainage problems, flood mitigation measures and drainage improvement measures are proposed to implement in tandem in the Master Plan Study. The items of structural measures of drainage improvement proposed in the master plan study are:

- Improvement of existing and new main drainage
- Rehabilitation of existing drainage
- Development of secondary drainage networks

The proposed drainage improvement in the target area of the Feasibility Study are summarize as below:

(1) Rio Chane Basin

For the Rio Chane basin, only river improvement of the Rio Chane was selected to be the target area in the feasibility study. Hence, no drainage improvement measure is proposed in the project.

(2) Rio Pailon Baisn

Rio Pailon is planned to improve in the river improvement plan. To collect water and discharge to the drained river, secondary drainage network is proposed in the drainage problem area.

In addition, the connecting drainage to the bridges constructed in 1997, i.e., Rnacha Chico, El Chaco and El Empalme II, are proposed to improve to cope with the increase of discharge by the development of those bridges.

(3) Okinawa Drainage Basin

Rainwater in the Okinawa Drainage Basin is planned to discharge to the low lying area that is recognized as the Rio Grande's former course through Okinawa Drainage Main. Discharge at Route 9 is planned to limit by cross drain and regulating effect at road embankment is anticipated in the plan so as to mitigate a burden of the lower reach. Secondary drainage network is also proposed to enhance the effect of the drainage main.

(4) San Juan Area

The channel improvement of the Aroyyo Tejeria and replacement of cross drains at San Juan Main Road were proposed in order to discharge water and prevent water stagnating.

The San Juan Main Drainage Canals were proposed to rehabilitate by clearing in the canal section and area for maintenance, slope reforming and dredging canal bed. Those existing canals were expected take charge of the runoff up to their existing discharge capacity, and excess water is planned to overflow to the lower reach and the Arroyo Yapacanicito.

The Arroyo Yapacanicito is to be improved in the river improvement plan. Secondary drainage network is planned to apply.

(5) Antofagasta Area

The Arroyo Jochi and Tacuaral are planned to improve in the river improvement plan. In the east part of Antofagasta area, drainage main is to be set up using existing natural stream so that the density of drained river / drainage main is to be supplemented. Secondary drainage network is also planned to introduce.

The proposed structural measures are:

(1) Main Drainage

- The Okinawa Main Drainage : Improvement of the existing drainage canal
- The Arroyo Tejeria : Improvement of the river
- The San Juan Main Drainage : Rehabilitation of the existing drainage canals
- The Antofagasta Main Drainage: Development of new drainage canals using natural courses

(2) The Secondary Drainage

- The Secondary Drainage : Development in the areas where river and main drainage are improved

(3) Drainage Channels for Crossing the National Road No.9

- The El Rancha Chico : Improvement of the natural courses
- The El Chaco : Improvement of the natural courses
- The El Empalme II : Improvement of the natural courses

In the Study, the facility plan proposed in the Master Plan Study has been reviewed and concluded that there is no major change or modification.

2. Existing Structures

The existing facilities along the rivers and tributaries in the Rio Chane – Pailon basin and the San Juan – Antofagasta area are mainly bridges and culverts and there is no dyke, headwork or intake along the rivers. There were also some revetments along the rivers made of gabions and rocks for bank protection, but the quantity and length were comparatively small.

The bridges and culverts in and around the distance proposed for the improvement are listed as shown in Table C.2.1.

3. Design Scale and Criteria

3.1 Design Scale

The optimum design scale of river improvement measures are studied based on the results of the analysis in technical, economical and social terms in the Master Plan Study. The relation between the design scale and the ratio of the annual average

protected area to the required excavation volume of river improvement is shown Fig. C.3.1. The results of the analysis are as follows:

(1) The results of the analysis in the Chane - Pailon Area show that the most effective design scale for flood mitigation measures is between 5-year and 10-year flood frequencies.

(2) The results of the analysis in the San Juan - Antofagasta Area show that the most effective design scale is about 10-year flood frequency.

Based on the above results of the analysis, the design scale of river improvement is decided to be 10-year frequency flood. For the drainage improvement, 5-year frequency flood is applied for the design scale in consideration with the scale of the drainage basin and the flood damage. Those design scales are succeeded in the Feasibility Study.

3.2 Design Criteria

Design criteria for the structural measures set up in the Master Plan Study was used in this Study. The criteria were established based on the suitability from the technical and economical aspects. A summary of the design criteria is shown as follows:

(1) River Improvement

1) Design flood scale
The design flood scale was decided from the optimum value of the ratio of the benefit from the flood mitigation and the cost of construction as follows:
The flood mitigation facilities : 10-year return period.

2) Allowable inundation depth
The allowable inundation depth was decided by considering the tolerance and damages of the crops in the study area as follows:
Allowable inundation depth : 30 cm

3) Design cross sections
The design cross sections for the flood mitigation were decided by the concept to utilize the flood plains as the natural retarding basins during the flood period with the allowable inundation depth and to stand for the erosion and scour during flood period. Therefore the design cross section was a single section with a trapezoidal shape.

(2) Drainage Improvement

1) Design flood scale

The design flood scale for the drainage improvement is proposed as follows:

The flood mitigation facilities : 5-year return period.

2) Allowable inundation depth

The allowable inundation depth was decided by considering the tolerance and damages of the crops in the study area as follows:

Allowable inundation depth : 30 cm

3) Design cross sections

The design cross section is proposed to be a single section with a trapezoidal shape in consideration with the shape of existing drainage canal. The roughness coefficient of 0.035 is applied to the proposed cross sections in the hydraulic analysis.

4. Preliminary Design of the River Improvement

4.1 River Improvement

The proposed items of the river improvement works are :

(1) Chane – Pailon Area

- Rio Chane (length: 26.350 km)
- Rio Pailon (length: 31.410 km)

(2) San Juan – Antofagasta Area

- Arroyo Yapacanicito (length: 17.360 km)
- Arroyo Jochi (length: 11.800 km)
- Arroyo Tacuaral (length: 5.800 km)

The project items and design cross section of the river improvement works are shown in Table C.4.1. The design cross sections and longitudinal profiles are set based on the results of the hydro-dynamic modeling mentioned in the SUPPORTING REPORT F. The design discharge distribution is shown in Fig. C.4.1. The proposed river bed elevations are set for the excavation works to be minimized under the condition that the 5-year frequency flood will run off without overflow on the bank and 10-year frequency flood will run off within 30 cm depth of overflow on the bank. The proposed

longitudinal profiles are shown in Fig. C.4.2 and Table C.4.2, and the proposed standard cross sections are shown in Fig C.4.3.

The summary of each river improvement is as follows:

(1) Rio Chane

The proposed distance of the river improvement is from the Chane Bridge located around the lowest reach of the river (accumulated distance 0.000 km in the river survey) to the Junction of Rio Pailon (accumulated distance 26.354 km in the river survey), of which the total length is 26.35 km. The existing channel width is from 30 m to 75 m and its flow capacity is from 70 m^3/s to 530 m^3/s. This channel is proposed to widen to 75 m to 100 m with design discharge from 1,600 m^3/s to 1,900 m^3/s. In that distance, 4 existing bridges will be reconstructed due to the channel widening.

(2) Rio Pailon

The proposed distance of the river improvement is from the lowest reach, which is the Junction of Rio Chane (accumulate distance 26.354 km of the river survey), to the Junction of Qda. Los Sauces (accumulate distance 58.032 km of the river survey), of which the total length 31.68 km. This river crosses the National Road No.9 at the Okinawa – Pailon Bridge constructed on 1997 (accumulated distance 49.986 km in the river survey). The existing channel width is around 15 m with flow capacity from 10 m^3s to 180 m^3/s at the upper reach of the bridge and around 30 m width with flow capacity from 70 m^3/s to 210 m^3/s at the lower reach. This channel is proposed to widen from 65 m to 75 m with design discharge 760 m^3/s to 900 m^3/s. Within the distance, 1 existing bridge will be reconstructed due to the channel widening.

(3) Arroyo Yapacanicito

The proposed distance of the river improvement is from the downstream (accumulated distance 0.000 km in the river survey) to the downstream of the road bridge of San Juan Main Road (accumulated distance 17.363 km in the river survey), of which the total length is 17.36 km. The existing channel width is from 20 m to 25 m and its flow capacity is from 70 m^3/s to 170 m^3/s. This channel is proposed to widen to 30 m to 35 m with design discharge from 165 m^3/s to 215 m^3/s. In that distance, 1 existing bridges will be reconstructed due to the channel widening.

(4) Arroyo Jochi

The proposed distance of the river improvement.is from the downstream swamp (accumulated distance 0.000 km in the river survey) to the upstream (accumulated distance 11.800 km in the river survey), of which the total length is 11.80 km. The existing channel width is from 13 m to 40 m and its flow capacity is from 40 m^3/s to 410 m^3/s. This channel is proposed to widen to 22 m to 30 m with design discharge from 175 m^3/s to 195 m^3/s. In that distance, 2 existing bridges will be reconstructed due to the channel widening.

(5) Arroyo Tacuaral

The proposed distance of the river improvement is from the downstream swamp (accumulated distance 0.000 km in the river survey) to the upstream (accumulated distance 5.799 km in the river survey), of which the total length is 5.80km. The existing channel width is around 15 m and its flow capacity is from 50 m^3/s to 60 m^3/s. This channel is proposed to widen to 26 m with design discharge of 195 m^3/s. In that distance, 1 existing bridges will be reconstructed due to the channel widening.

4.2 Road-cum-embankment

The road-cum-embankment is planned to apply in the San Juan – Antofagasta area. The proposed route of the road-cum-embankment is from the San Juan Main Road to the Antofagasta Main Road along the boundary of the river basins of Arroyo Yapacanicito and Arroyo Jochi, of which the total length is 9.83 km. That will separate the river basins physically and prevent the water flow from the upper reach of Arroyo Jochi into the Arooyo Yapacanicito basin during the food.

(1) Road Elevation

The average elevation of the road-cum-embankment was set as 80 cm from the ground level or higher, which is 30 cm of allowable inundation depth at the 10-year frequency flood in addition to 50cm of the free board.

(2) Road Structure

The road structure is planed to be an one-lane gravel road. The pavement structure is set to be 3.50 m wide with 15 cm thick base course and 20 cm thick sub-base course. The width of the embankment is set to be 5.00 m.

(3) Embankment Structure

The road body is planed to embank by side borrow using soil along the proposed road alignment. The side slope of the embankment was set to be 1/2.0 in consideration with the soil condition.

The proposed longitudinal profile and standard cross section of the road-cum-embankment are shown in Fig. C.4.4 and C.4.5.

4.3 Related Structures

Due to the channel widening, some of the existing bridges along the rivers to be improved are to be replaced by new ones. Nine (9) bridges are planned to replace as follows:

Chane – Pailon Area

- Rio Chane 4 bridges
- Rio Pailon 1 bridge

San Juan Antofagasta Area

- Arroyo Yapacanicito 1 bridge
- Arroyo Jochi 2 bridges
- Arroyo Tacuaral 1 bridge

The design criteria for the bridges are summarized as follows:

(1) Bridge Type

Post pre-stressed concrete bridge is selected as a bridge type for the proposed bridge improvement by the following reasons:

- Concrete materials are easy to procure in the Department of Santa Cruz because cement materials are produced and high quality aggregate is easy to procure in the Department.
- Concrete bridge has an advantage to steel bridge in the construction cost and the operation and maintenance.

- Pre-stressed concrete bridge has an advantage in the maximum span which can be around 40 m while reinforced concrete bridge is maximum around 15 m of span.
- Pre-stressed concrete bridge with from 20 m to 30 m of span is popular in recent years in the country.

(2) Bridge Width

The proposed bridges are categorized into 2 types based on the existing road condition and expected traffic amount. The 8 m wide bridge will be applied for the Type A bridge, which has a heavy traffic, and 5.5 m wide bridge will be applied for the Type B, which has a light traffic.

(3) Bridge Elevation

- Design Flood Scale
  50-year frequency flood is applied for the design flood condition of bridges in consideration with the importance of the structures.

- Freeboard
  The freeboard between the bottom of beam and the design water level was set to be from 0.8 m to 1.0 m depending on the discharge.

The location, dimension and design water level of the proposed bridges are listed in Table C.4.3.

4.4 Bill of Quantity for River Improvement

The bill of quantities of the river improvement works and the road-cum-embankment are shown in Table C.4.4.

5. Preliminary Design of the Drainage Improvement

5.1 Items of Drainage Improvement

The proposed structural measures for the drainage improvement is composed of improvement, development and rehabilitation of main drainage, development of secondary drainage and improvement of drainage channels for crossing the National Road No.9.

The proposed drainage improvement works are:

1) Chane – Pailon Area

Main Drainage

- Okinawa Main Drainage (length : 21.650 km)

Drainage Channels for Crossing the National Road No.9

- El Rancha Chico (length : 3.600 km)
- El Chaco (length : 1.470 km)
- El Empalme II (length : 5.290 km)

Secondary Drainage

- Pailon Basin

2) San Juan – Antofagasta Area

Main Drainage

- San Juan Main Drainage (total length : 34.950 km)
- Arroyo Tejeria (length : 8.160 km)
- Antofagasta Main Drainage (length : 8.800 km)

Secondary Drainage

- San Juan Area
- Antofagasta Area

The project items of drainage improvement plan are shown in Table C.5.1.

5.2 Main Drainage

The proposed cross sections of the drainage improvement are set under the conditions that the internal run off of the basin at the 2-yaer frequency flood will run off without overflow on the bank and the internal run off of the basin at the 5-year frequency will run off within 30 cm depth of overflow of the bank. The proposed longitudinal profiles are shown in Fig. C.5.1 and Table C.5.2. The standard cross section of the main drainage is shown in Fig. C.5.2.

In the hydraulic design of main drainage, the Okinawa Main Drainage, the Rancha Chico, the Arroyo Tejeria and the Antofagasta Main Drainage were studied based on the hydro-dynamic modeling because of the scale of those basins and flow condition during flood. The remains were set based on the steady flow analysis. The design

discharge of frequencies and the hydraulic condition of those drainage are shown in Table C.5.3 and C.5.4.

The summary of each drainage improvement are as follows :

(1) Okinawa Main Drainage

The improvement of the Okinawa Main Drainage is proposed to improve the existing drainage channel runs through Colonia Okinawa – 1, of which the channel width is from 6.6 m to 39.0 m. The proposed improvement distance is from the road crossing at the lower marshy area to the oxbow lake at the upper reach, of which total length is 21.65 km. The proposed channel width is from 25.0 m to 28.0 m and channel depth from 3.0 m to 4.0 m.

(2) Drainage Channels for Crossing the National Road No.9

El Rancha Chico Drainage is a bypass of Rio Pailon, of which the length is 3.60 km. El Rancha Chico Drainage improvement is proposed to deepen and widen existing natural course to 42.0 m of the channel width with 4.0 m of channel depth.

El Chaco and El Empalme II Drainage are branches of Rio Pailon, of which the length is 1.47 km and 5.29 km. Those drainage channels are branches of Rio Pailon connecting to the bridges crossing the National Road No.9. They are proposed to deepen and widen existing natural courses to 18.0 m - 35.0 m of the channel width with 3.0 m - 4.0 m of channel depth.

(3) San Juan Main Drainage

San Juan Main Drainage composes of 6 existing drainage channels, i.e., km 11, km 13, km 15, km 17, km 24 and km 28 drainage. The channel improvement including the removal of drop works and the adjustment of longitudinal profile is proposed to the km 13 drainage and km 17 drainage. The rehabilitation of channel composing of the repair of collapsed channel and the slope forming is proposed to the km 11, km 15, km 24 and km 28 drainage. The length of proposed drainage channel improvement and rehabilitation are shown below :

Drainage Channel	Proposed Distance (km)	Type of Works
km 11 Drainage	2.410	Channel rehabilitation
km 13 Drainage	3.660	Channel improvement
km 15 Drainage	8.930	Channel rehabilitation
km 17 Drainage	3.840	Channel improvement
km 24 Drainage	5.560	Channel rehabilitation
km 28 Drainage	10.550	Channel rehabilitation
Total	34.950	

(4) Arroyo Tejeria

Arroyo Tejeria is proposed to improve as a drainage channel for the upper reach of San Juan area. The proposed distance of the improvement is from the junction with Rio Yapacani to the eastern side of the San Juan Main Road, of which the length is 8.16 km. The drainage is proposed to widen and deepen of the existing river channel to 20.0 m - 22.0 m of width with 4.0 m of channel depth.

(5) Antofagasta Main Drainage

The Antofagsta Main Drainage is proposed to construct new drainage channel by improving the existing small river which is a branch of the Arroyo Tacuaral. The proposed distance of the improvement is from the junction with Arroyo Tacuaral nearby the swamp area to the upstream the Antofagasta road bridge, of which the total length is 8.80 km. The existing channel width is from 8.1 m to 26.8 m. This drainage is proposed to be widen and deepen from 25.0 m to 28.0 m of channel width with 3.0 m of channel depth.

5.3 Secondary Drainage

The development of secondary drainage network is proposed in order to maximize the effect on the flood mitigation of the river improvement and the main drainage improvement through collecting the rain water into the river and main drainage.

The proposed target areas of the secondary drainage development are :

- Rio Pailon Baisn
- Okinawa Drainage Basin
- San Juan Area
- Antofagasta Area

Secondary drainage canals are planned as follows:

- Each canal length: 2-3 km long from drainage main or drainage river,
- Drainage area of each drainage canal: 5.0 sq. km,
- Canal density: 0.4 km/sq. km

The total length of drainage canal at each drainage area is estimated based on the case study in the master plan study.

$L\ km = A_{BASIN}\ km^2 \times 0.40\ km/km^2 \times 0.75$

whereby,

L: Canal Volume of Length (km)

A_{BASIN}: Area of Basin (km^2)

The secondary drainage network development is planned based on above condition and topographic conditions. The target area of the secondary drainage improvement is shown in Table C.5.5.

5.4 Related Structures

5.4.1 Bridge

Due to the channel widening, some of existing bridges along the proposed drainage improvement will be renovated. Seven (7) bridges are proposed to reconstruct for the river improvement, which is summarized as follows :

Chane - Pailon Area

- Rio Pailon Basin 1 bridge
- Okinawa Drainage Basin 1 bridge

San Juan - Antofagasta Area

- San Juan Area 3 bridge
- Anatofagasta Area 2 bridges

The dimension criteria for the bridge construction are same with the bridge of the river improvement works. The location, dimension and design water level of the proposed bridges are listed in Table C.5.6.

5.4.2 Culvert

During the secondary drainage network development, culverts are necessary to be constructed.

The location and dimension of proposed bridge and culvert reconstruction are listed in Table C.5.5.

5.5 Bill of Quantity for Drainage Improvement

The bill of quantities of the drainage improvement works and the road-cum-embankment are shown in Table C.5.7.

6. Inundation Area

Due to the river and drainage improvement works, the study area will be significantly improved in both of inundation area and inundation depth. However, some of the inundation area will be remained. The impacts of the structural measures are evaluated by the reduction of inundation area. The inundation area before and after implementation of structural measures is estimated based on the flood survey and the hydro-dynamic model simulation.

The estimated inundation area and depth with and without project in each frequency flood are shown in Table C.6.1 and Fig. C.6.1. The remaining inundation periods with project are shown in Table C.6.2, which are estimated based on the results of hydraulic analysis.

(1) Rio Chane Basin

The area which suffers from the inundation depth of more than 30 cm will be reduced from 91.8 % of the total area to 88.8 % in the 10-year frequency flood. The reduction rate of inundation area is small comparing with other area. The reason is that this area is affected by the backwater effect of the Rio Piray and also affected by the increase of discharge due to the improvement of upper reach. The remaining inundation period of the lower reach of Rio Chane is around 1 day, and the period of the midstream Rio Chane is 7 hours at the 10 year frequency flood.

(2) Rio Pailon Area

The area which suffers from the inundation depth of more than 30 cm will be reduced from 77.6 % of the total area to 15.2 % in the 10-year frequency flood.

This area has a significant reduction of inundation by the project both in the rate and the amount of area. That impact is coursed by the improvement of Rio Pailon. The remaining inundation period is from 7 to 9 hours at the 10 year frequency flood.

(3) Okinawa Drainage Basin

The area which suffers from the inundation depth of more than 30 cm will be reduced from 48.9 % of the total area to no inundation in the 10-year frequency flood. This area will have a mitigation of inundation coursed by the basin runoff by the improvement of the Okinawa Main Drainage. However, the flood from the Rio Grande which is not evaluated in the hydro-dynamic model analysis will be remained. The remaining inundation period is 13 hours at the 5 year frequency flood.

(4) San Juan Area

The area which suffers from the inundation depth of more than 30 cm will be reduced from 70.7 % of the total area to 45.8 % in the 10-year frequency flood. This area has a comparatively small reduction of inundation area because this area includes the lower reach area of Arroyo Yapacanicito where is affected by the increase of discharge from upper reach. The area improved significantly is located the middle and the upstream of Arroyo Yapacanicito and San Juan Main Drainage basin. The remaining inundation period of Arroyo Yapacanicito is 14 hours at the 10 year frequency flood.

(5) Antofagasta Area

The area which suffers from the inundation depth of more than 30 cm will be reduced from 67.6 % of the total area to 9.2 % in the 10-year frequency flood. The reduction of inundation in the area is realized by the improvement of Arroyo Jochi, Arroyo Tacuaral and the Antofagasta Main Drainage. The inundation condition of the swamp area in the down stream of those rivers will be remained and the effect of retarding basin is expected. The remaining inundation period of Arroyo Tacuaral is 1.2 days at the 10 year frequency flood. And the period of Antofagasta Main Drainage is 2 hours at the 5 year frequency flood.

7. Operation and Maintenance

7.1 Present Condition of O/M of River and Drainage Facilities

Due to the decentralization of the administrative institutes in Bolivia, the municipal governments have responsibilities to develop and maintain public infrastructure such as the secondary roads, the basic sanitation and the basic drainage systems like canals, cross drains and small bridges. However, the operation and maintenance are not yet included in the scope of river works of the concerned agencies at present. The maintenance works of the rivers have been carried out locally by the private sectors, but those for the bridges across the rivers have been done by SNC.

Most of the existing drainage facilities observed in the Study Area are developed and maintained by the private individual or groups and the municipal governments concentrate their effort upon the drainage facilities related to the road facilities like small bridges and cross drains in fact.

Except for the small or minor drainage facilities developed by individual farmers, only Okinawa Drainage and San Juan Area have their major drainage facilities. In those areas, the main drainage canal systems have been developed and maintained by the associations of Japan – Bolivia, which is the colonial farmers' organization. Those associations possess the construction equipment and the work shops for their maintenance, and carry out the construction and maintenance works for roads, cross drains and drainage canals by their own budget. Their major equipment is listed and shown below:

Organization	Possessing equipment	Facilities to be maintained
Association of Japan – Bolivia of Okinawa	Bulldozer – 2, Motor grader – 2, Back hoe – 2, Dump Truck – 4, Tractor Shovel – 1, Others	Road : 280km length in total Main canal : 40 km length in total
Association of Japan – Bolivia of San Juan de Yapacani	Bulldozer – 3, Motor grader – 1, Back hoe – 2, Dump Truck – 2, Tractor Shovel – 1, Others	Road : 200km length in total Main canal : 35 km length in total

There are 5 municipalities concerning the Study Area as shown below. The Okinawa Municipality has been established by dividing from the Warnes Municipality since April 1998. The actual activities and budget of the municipality are still now under the Warnes Municipality, but it is planned to separate in the year 2001.

Basin	Concerned municipalities	Basin	Concerned municipalities
Chane Area	Mineros, Saavedra	San Juan Area	San Carlos
Pailon Area	Warnes, (Okinawa)	Antofagasta Area	San Carlos
Okinawa Drainage Area	Warnes, (Okinawa)		

Each municipality government has a technical department that is responsible for the development and maintenance of the infrastructures and possesses the construction equipment by themselves. In general, the budget, equipment and staff of the municipality's technical department are insufficient to cope with all the infrastructures. The major effort is concentrated upon the road and related structures at present. To make up their construction capacity, the municipalities request the National Road Service (SNC) to provide the construction equipment and dispatch the operators under the agreement that the municipality government bears the cost for fuel, materials, spare parts and food. The equipment possessed by the municipalities and the budget expenditure in the infrastructure development/maintenance sector are listed as below:

Municipality	Major Equipment	Budget for Infrastructure (1998)
Mineros Municipality	Motor grader : 1 Back hoe : 1 Dump truck (5ton) : 1	Bs. 2,546,762
Saavedra Municipality	none	Bs. 912,264
Warnes Municipality	Motor grader : 1 (in repair) Back hoe and truck loader : 2 Dump truck (5ton) : 2	Bs. 1,326,593
San Carlos Municipality	Motor grader : 1 Back hoe : 1	Bs. 3,301,749

The operation and maintenance of the drainage facilities are to be conducted by the local government or farmer groups such as the association or the cooperative because of the facility scale. In the Okinawa Drainage Area and the San Juan Area, the association is proposed to operate and maintain the drainage facilities continuously in their communities, and municipality governments are proposed to do in the remaining areas. For the effective operation and maintenance of the facilities and their function, the enhancement of the municipal authorities' budget, organization and capability is necessary.

7.2 Proposed O/M Activity for River and Drainage Facilities

The operation and maintenance works for the river and drainage improvement consist of inspection, regular maintenance, periodic maintenance and rehabilitation works. They are defined as a systematic activity in order to preserve and maintain the river and drainage systems under an acceptable condition. The work plan for the operation and maintenance work is shown below:

Items	Activities	Recommended Frequency
Inspection	To identify the channel condition of rivers/drainage.	Around once a month
Regular Maintenance	Mowing and partial repair of channel side slopes to keep the flow capacity of the channel in the minimum requirement.	Before and after the flood season yearly
Periodic Maintenance	Repairing collapsed channel slopes and dredging channel bed to recover the flow capacity nearly t o the initial condition.	Depends on the damage (around once a few years)
Rehabilitation	Large scale repair and rehabilitation of channels.	Depends on the damage

The operation and management works for river and drainage are classified into 2 categories due to the scale of target system, i.e., river and drainage systems. The river management should be conducted under the initiative of the Departmental Government because river basins cover more than one Municipality and the operation and maintenance works for rivers are large scale in general. On the other hands, an individual local government (municipality level) due to the basin and work scale can conduct the drainage management. The division of operation and maintenance activities is proposed as below:

Items	River Management	Drainage Management	
		Main Drainage	Secondary Drainage
Responsible Organization	Departmental Government	Municipality	Inhabitants group
Inspection	Municipality under the control of Departmental Government	Municipality with inhabitants participation	Inhabitants group
Regular Maintenance	Municipality with inhabitants participation under the control of Departmental Government	Municipality with inhabitants participation	Inhabitants group
Periodic Maintenance	Departmental Government	Municipality	Inhabitants group
Rehabilitation	Departmental Government	Municipality	Inhabitants group

TABLES

TABLE C.2.1 (1) BRIDGES AND CULVERTS IN STUDY AREA (CHANE - PAILON AREA)

No.	River System	Structural Type	Bridge Dimension			Culvert Dimension	Remarks	Location		Condition
			L (m)	W (m)	H (m)			Lat	Lon	
P1	Pailon	RC Bridge	25	6	5		3 Span	17°18'30,7"	62°53'52,5"	New
P2	Okinawa Pailon	RC Bridge	92	9	7		3 Span	17°13'52,8"	62°56'28,3"	New
P3	Rancho Chico	RC Bridge	25	9	5		1 Span	17°13'58,0"	62°56'45,0"	New
P4	El Chaco	RC Bridge	51	9	4		2 Span	17°14'06,9"	62°57'45,6"	New
P5	El Empalme II	RC Bridge	25	9	4		1 Span	17°14'31,8"	62°58'57,4"	New
P6	Pailon	Wood Soil Bridge	20.0	5.0	-			17°06'25.3"	63°02'30.0"	Temporary Bridge
CH1	Chane	Wood RC-Bridge	22.0	5.0	10.0		1 Span	17°04'42.3"	63°04'38.4"	Regular
CH2	Chane	Metal Gabion Bridge	16.0	5.5	7.0		1 Span	17°03'09.0"	63°07'06.0"	Falling Down
CH3	Chane	Wood Bridge	28.0	5.0	5.0		5 Span	17°00'16.9"	63°10'16.5"	Regular
CH4	Chane	RC-Bridge	15.0	5.0	4.0			16°59'22.5"	63°12'46.8"	Not finished building
CH5	Chane	RC-Bridge	80.0	9.0	7.0		3 Span	16°58'04.3"	63°13'16.8"	Good
OD1	Okinawa Drainage	RC-Pipe Culvert	12	7	3	D-1.5m X 3 pipe	2 Span	17°11'00.3"	62°54'37.3"	Regular
OD2	Okinawa Drainage	RC-Box Culvert	36	7	2	W-2.4m X H-2.0 m X 6 boxes		17°10'10,8"	62°54'48,9"	Regular
OD3	Okinawa Drainage	Brick Concrete Bridge	7.0	8.0	2.2	D-3.5m X 1 Half pipe		17°02'55.9"	63°03'14.8"	Falling Down
OD4	Okinawa Drainage	Brick RC-Pipe Culvert	2.0	6.5	2.5	D-1.5m X 1 pipe		17°10'06.4"	62°53'39.6"	Regular
OD4a	Okinawa Drainage	RC Bridge	6.5	6.5	1.5		3 Span	17°10'15.0"	62°53'38.4"	Regular
OD4b	Okinawa Drainage	Brick RC-Pipe Culvert	2.0	6.5	2.5	D-1.5m X 1 pipe		17°10'25.5"	62°53'37.5"	Regular
OD4c	Okinawa Drainage	Brick RC-Pipe Culvert	2.0	6.5	2.5	D-1.5m X 1 pipe		17°10'51.0"	62°53'30.0"	Regular
OD5	Okinawa Drainage	RC-Box Culvert	2.4	7	1.2			17°09'08,1"	62°52'45,6"	Regular
CC1	Chacras	Wood Bridge	17.0	6.0	4.0		3 Span	17°00'17.1"	63°11'12.9"	Regular

TABLE C.2.1 (2) BRIDGES AND CULVERTS IN STUDY AREA (SAN JUNAN - ANTOFAGASTA AREA)

No.	River System	Structural Type	Bridge Dimension			Culvert Dimension	Remarks	Location		Condition
			L (m)	W (m)	H (m)			Lat	Lon	
T1	Tejeria	RC-Bridge	4.0	7.0	2.0		1 Span	17°21'19.3"	63°50'27.6"	Regular
D1	San Juan Drainage	Brick RC-Bridge	5.0	7.0	2.5	D-1.5m X 2 pipes		17°19'39.7"	63°50'30.1"	Regular
D2	San Juan Drainage	RC-Bridge	4.0	7.2	2.0		1 Span	17°18'03.6"	63°50'31.0"	Regular
D3a	San Juan Drainage	Brick Concrete Bridge	6.0	8.0	2.0	D-1.5m X 3 pipes		17°16'59.1"	63°51'05.4"	Upstream falling down
D3b	San Juan Drainage	RC-Bridge	3.0	9.0	2.0		1 Span	17°16'59.4"	63°53'10.5"	Regular
D4a	San Juan Drainage	Rock Concrete Bridge	3.5	9.0	2.5	D-1.0m X 2 pipes		17°15'53.4"	63°51'07.8"	Regular
D4b	San Juan Drainage	RC-Bridge	5.0	9.0	2.5	D-3.0m X 1 pipe		17°15'53.4"	63°53'18.9"	Regular
D5a	San Juan Drainage	Brick Concrete Bridge	3.5	12.0	2.2	D-1.5m X 2 pipes		17°14'48.6"	63°51'42.1"	Regular
D5b	San Juan Drainage	RC-Bridge	3.0	5.5	3.0		1 Span	17°14'49.5"	63°53'53.4"	Regular
D6	San Juan Drainage	Rock Concrete Bridge	5.0	11.0	4.0	D-3.0m X 1 pipe		17°11'04.5"	63°54'42.7"	Regular
D7	San Juan Drainage	Rock Concrete Bridge	5.0	10.0	1.0	D-1.0m X 1, 2.0m X 1 pipes		17°08'56.1"	63°55'15.9"	Regular
Y1	Yapacanicito	RC-Bridge	9.0	6.4	4.0		2 Span	17°12'05.2"	63°52'21.9"	Regular
Y2	Yapacanicito	Rock Concrete Bridge	17.0	6.0	4.0	D-8.0 m X 2 Half pipes		17°09'55.6"	63°52'30.9"	Regular
Y3	Yapacanicito	Wood RC-Bridge	24.0	4.0	4.0		1 Span	17°03'20.7"	63°53'35.7"	Regular
A1	Antofagasta Drainage	Wood Bridge	9.0	5.0	2.5		2 Span	17°09'56.1"	63°46'25.9"	Old Wood-Rotten
A1a	Antofagasta Drainage	Wood Bridge	4.5	4.5	2.0		1 Span	17°09'47.7"	63°47'13.8"	Regular
A2	Antofagasta Drainage	Wood-RC Bridge	3.5	3.5	4.0		1 Span	17°08'42.4"	63°46'25.3"	Regular
A3	Antofagasta Drainage	Wood Bridge	15.0	-	4.0		1 Span	17°07'36.0"	63°45'48.0"	Destroyed
A4	Antofagasta Drainage	Wood Bridge	5.0	4.0	2.0		1 Span	17°05'55.8"	63°47'09.6"	Falling Down
TC1	Tacuaral	Wood Bridge	7.5	4.0	4.5		1 Span	17°09'34.2"	63°48'04.5"	Regular
TC2	Tacuaral	RC Bridge	14.0	5.0	4.5		1 Span	17°08'14.1"	63°48'04.8"	Regular
J1	Jochi	Rock Concrete Bridge	17.0	6.0	3.0	D-8.0 m X 2 Half pipes		17°11'01.2"	63°51'00.4"	Regular
J2	Jochi	Wood RC-Bridge	11.0	5.0	5.0		2 Span	17°07'53.1"	63°49'36.9"	Falling Down

TABLE C.4.1 RIVER IMPROVEMENT WORKS

Project Item	Length (km)	Channel Width (m)	Bed Width (m)	Channel Depth (m)	Slope	Flow Area (m^2)	Design Discharge (m^3/s)
1. Chane-Pailon							
(1) Rio Chane	**26.350**						
Jct. Rio Pirai - Jct. Qda. Chacras	5.100	100.0	76.0	6.0	1/2	528.0	1,500
Jct. Qda. Chacras - Jct. Rio Pailon	21.250	75.0	51.0	6.0	1/2	378.0	1,212
(2) Rio Pailon	**31.410**						
1) Rio Pailon (downstream)	**23.360**						
Jct. Rio Chane - National Road No.9	23.360	70.0	50.0	5.0	1/2	300.0	908
2) Rio Pailon (upstream)	**8.050**						
National Road No.9 - Jct. Arroyo Los Sauces	8.050	65.0	45.0	5.0	1/2	275.0	995
2. San Juan-Antofagasta							
(1) San Juan							
1) Arroyo Yapacanicito	**17.360**						
Downstream - Midstream	3.560	35.0	23.0	3.0	1/2	87.0	213
Midstream - Up stream	13.810	30.0	18.0	3.0	1/2	72.0	165
(2) Antofagasta							
1) Arroyo Jochi	**11.800**						
Downstream - Midstream	8.460	30.0	16.0	3.5	1/2	80.5	194
Midstream - Up stream	3.340	22.0	8.0	3.5	1/2	52.5	174
2) Arroyo Tacuaral	**5.800**						
Downstream - Midstream	5.800	26.0	10.0	4.0	1/2	72.0	194

TABLE C.4.2 (1) PROPOSED RIVER IMPROVEMENT PLAN OF RIO CHANE AND RIO PAILON

River	Section	Accumulate Distance (m)	Existing Riverbed EL. (m)	Left Bank EL. (m)	Right Bank EL. (m)	Proposed Riverbed EL. (m)	High Water Level (m)	Channel Width (m)	Longitudinal Slope
Rio Chane	1	0	221.794	227.463	226.155	221.000	227.760	100.0	1/2,800
	2	1,149	221.955	227.185	228.151	221.410	228.790		
	3	2,089	221.616	227.788	228.670	221.746	229.170		
	4	3,002	222.236	228.598	229.708	222.072	229.440		
	5	4,124	222.832	226.451	230.171	222.473	229.790		
	6	5,103	223.542	226.672	231.683	222.822	229.980		
	7	6,044	223.990	230.591	231.812	223.345	230.010	75.0	1/1,800
	8	7,351	225.922	234.050	230.278	224.072	231.180		
	9	8,275	224.770	231.822	232.776	224.585	231.890		
	10	9,292	224.950	232.315	227.820	225.150	232.590		
	11	10,192	226.328	233.608	230.865	225.650	232.900		
	12	11,349	225.706	233.970	233.855	226.293	233.470		
	13	12,030	226.330	234.073	234.948	226.671	234.260		
	14	12,773	226.925	232.479	234.664	227.084	234.890		
	15	13,844	227.436	231.806	234.238	227.679	235.240		
	16	14,821	226.602	235.601	236.064	228.222	235.390		
	17	15,936	227.598	235.677	235.409	228.841	236.170		
	18	16,951	228.623	233.925	234.151	229.405	236.520		
	19	17,966	228.911	235.251	236.790	229.969	236.670		
	20	18,876	228.568	235.705	235.248	230.474	237.330		
	21	19,745	229.245	237.127	236.859	230.957	237.800		
	22	20,812	231.065	237.726	238.267	231.550	238.520		
	23	21,817	230.725	239.143	239.548	232.108	239.170		
	24	22,748	231.799	238.378	237.782	232.625	239.510		
	25	23,229	231.949	239.578	238.830	232.893	239.600		
	26	24,646	232.972	239.532	238.979	233.680	240.260		
	27	25,441	233.709	240.088	240.125	234.121	240.830		
	28	26,354	238.242	244.286	244.437	234.629	241.250		
Rio Pailon	1	26,354	238.242	244.286	244.437	235.629	241.370	70.0	1/1,500
	2	27,331	238.311	244.681	244.702	236.280	241.840		
	3	28,011	239.042	241.190	244.246	236.733	242.410		
	4	28,754	239.598	244.455	244.571	237.229	242.780		
	5	29,673	240.767	245.932	247.553	237.842	243.260		
	6	30,668	241.226	245.989	245.764	238.505	244.010		
	7	31,742	242.102	246.207	245.707	239.221	244.760		
	8	32,447	243.073	244.603	245.333	239.691	245.210		
	9	33,505	243.985	247.235	247.355	240.396	245.610		
	10	33,883	244.481	247.204	246.672	240.651	246.120		
	11	35,150	246.367	247.719	247.785	241.493	246.830		
	12	36,414	247.532	248.898	248.887	242.335	247.600		
	13	37,958	247.392	249.836	250.002	243.365	248.240		
	14	38,936	245.241	249.271	249.481	244.016	249.470		
	15	39,675	246.781	251.131	251.346	244.509	250.230		
	16	40,697	248.296	251.226	250.996	245.191	250.970		
	17	41,632	248.427	251.052	251.142	245.814	251.600		
	18	42,781	247.857	252.445	251.474	246.580	252.270		
	19	43,217	248.613	251.905	252.968	246.871	252.810		
	20	44,756	248.077	252.351	252.105	247.897	253.460		
	21	45,942	249.798	253.351	253.450	248.687	254.020		
	22	46,768	250.632	253.463	253.448	249.238	254.540		
	23	47,686	251.413	254.669	254.645	249.850	254.610		
	24	48,688	251.433	255.343	254.903	250.518	254.970		
	25	49,986	252.421	255.548	255.221	251.383	255.420	65.0	1/6,000
	26	51,006	251.887	257.104	256.231	251.553	256.430		
	27	52,167	252.195	255.418	255.575	251.747	256.820		
	28	53,048	251.573	256.163	256.621	251.894	257.050		
	29	54,048	251.902	256.273	256.255	252.060	257.510		
	30	55,181	251.823	256.591	256.982	252.249	258.020		
	31	56,630	252.805	257.532	257.603	252.491	258.210		
	32	57,429	252.300	258.332	258.387	252.624	258.370		
	33	58,032	253.692	256.647	258.817	252.724	258.960		

TABLE C.4.2 (2) PROPOSED RIVER IMPROVEMENT PLAN OF SAN JUAN - ANTOFAGASTA

River	Section	Accumulate Distance (m)	Existing Riverbed EL. (m)	Left Bank EL. (m)	Right Bank EL. (m)	Proposed Riverbed EL. (m)	High Water Level (m)	Channel Width (m)	Longitudinal Slope
Arroyo Yapacamicito	1	0	250.642	251.562	253.979	249.476	252.257	35.0	1/1,280
	2	522	250.486	253.046	254.331	249.944	253.090		
	3	1,595	251.364	254.604	252.379	250.726	253.091		
	4	2,576	251.652	255.177	253.172	251.507	253.848		
	5	3,556	252.306	255.876	253.636	252.288	254.043	30.0	
	6	4,675	252.041	253.701	255.561	252.288	254.902		
	7	5,463	252.911	253.976	256.311	252.913	254.826		
	8	6,411	253.386	254.491	256.746	253.616	255.540		
	9	7,567	253.556	257.343	255.065	254.554	255.655		
	10	8,540	254.237	255.547	257.947	254.227	255.610		
	11	9,428	254.879	257.799	256.354	254.873	255.940		
	12	10,456	252.781	254.708	256.598	252.788	256.191		
	13	11,680	255.324	257.771	259.680	255.315	257.870		
	14	12,707	255.997	259.722	259.852	255.997	259.840		
	15	13,575	260.390	262.850	264.411	256.800	261.171		
	16	14,564	261.686	265.076	266.596	260.023	262.650		
	17	15,311	261.939	265.109	266.739	260.569	264.337		
	18	16,260	262.210	268.220	268.258	261.351	265.367		
	19	17,363	262.210	268.218	268.258	262.210	267.503		
Arroyo Jochi	1	0	248.890	253.614	253.624	250.313	252.662	30.0	1/900
	2	772	250.378	254.185	254.325	251.091	253.279		
	3	1,953	252.225	255.998	255.927	252.424	255.250		
	4	2,924	253.734	258.428	259.088	254.036	256.888		
	5	3,749	253.655	258.953	259.343	254.924	257.864		
	6	4,687	255.129	260.063	260.803	256.036	258.775		
	7	5,600	256.801	260.784	260.604	257.036	259.559		
	8	6,592	257.755	261.548	261.038	258.147	259.575		
	9	7,344	258.656	262.624	262.344	258.924	260.462		
	10	8,463	260.076	262.923	263.444	260.147	261.916		
	11	9,608	261.035	264.072	264.832	261.780	263.874	22.0	
	12	10,608	262.110	265.080	265.080	262.891	264.928		
	13	11,800	264.827	266.618	266.318	264.224	266.508		
Arroyo Tacuaral	1	0	249.030	254.359	254.369	249.795	251.943	26.0	1/900
	2	493	252.426	254.576	254.496	250.350	253.981		
	3	1,377	252.984	256.124	255.864	251.350	256.178		
	4	2,554	254.281	257.281	257.331	252.683	257.327		
	5	3,450	253.616	258.306	258.116	253.683	258.193		
	6	4,110	255.127	258.997	259.062	254.350	258.722		
	7	4,988	256.322	259.882	260.042	255.350	259.829		
	8	5,799	255.881	260.351	260.491	256.239	260.409		

TABLE C.4.3 BRIDGE CONSTRUCTION OF RIVER IMPROVEMENT WORKS

Project Item	Location	Proposed Bridge Dimension					Elevation of Bridge (m)	Elevation of Riverbed (m)	Water Level of Flood (m)	
		L (m)	W (m)	H (m)	Type	Span No.			10-year	50-year
1. Chane-Pailon										
(1) Rio Chane										
Bridge Reconstrcution- 1	km 2.490	115.0	5.5	10.5	B	4	232.25	221.75	229.17	229.56
Bridge Reconstrcution- 2	km 7.550	83.5	5.5	10.0	B	3	234.07	224.07	231.18	231.73
Bridge Reconstrcution- 3	km 15.910	82.0	5.5	11.0	B	3	240.40	229.40	236.52	237.00
Bridge Reconstrcution- 4	km 21.730	86.5	8.0	11.0	A	3	243.63	232.63	239.51	239.91
(2) Rio Pailon										
1) Rio Pailon (downstream)										
Bridge Reconstrcution- 1	km 28.660	75.0	5.5	8.0	B	3	245.84	237.84	242.78	243.06
2) Rio Pailon (upstream)										
2. San Juan-Antofagasta										
(1) San Juan										
1) Arroyo Yapacanicito										
Bridge Reconstrcution- 1	km 12.710	34.0	5.5	6.0	B	1	261.71	255.71	258.89	259.01
(2) Antofagasta										
1) Arroyo Jochi										
Bridge Reconstrcution- 1	km 2.920	36.0	5.5	7.0	B	1	260.31	253.31	257.58	257.92
Bridge Reconstrcution- 2	km 9.610	24.5	5.5	6.5	B	1	267.39	260.89	264.53	264.59
2) Arroyo Tacuaral										
Bridge Reconstrcution- 1	km 3.050	30.0	5.5	8.0	B	1	262.77	254.77	259.01	259.09

TABLE C.4.4 BILL OF QUANTITY OF RIVER IMPROVEMENT AND ROAD-CUM-EMBANKMENT

Work Item	Clearing & Grubbing (m^2)	Soil Excavation (m^3)	Soil Transportation (m^3)	Sruplus Soil Filling (m^3)	Slope Forming (m^2)	Operation Road (m^2)	Bridge Construction (pcs / m)	
RIVER IMPROVEMENT								
1. Chane - Pailon Area	1,740,960	14,834,785	14,834,785	14,834,785	0	406,224	5	442.0
(1) Rio Chane	790,620	5,638,360	5,638,360	5,638,360	0	184,478	4	367.0
(2) Rio Pailon	950,340	9,196,425	9,196,425	9,196,425	0	221,746	1	75.0
1) Down stream	708,960	7,776,983	7,776,983	7,776,983	0	165,424	1	75.0
2) Upstream	241,380	1,419,442	1,419,442	1,419,442	0	56,322	-	-
2. San -Juan - Antofagasta Area	1,108,860	1,291,257	1,291,257	1,291,257	0	258,734	4	124.5
(1) San Juan Area	520,890	651,546	651,546	651,546	0	121,541	1	34.0
1) Arroyo Yapacanicito	520,890	651,546	651,546	651,546	0	121,541	1	34.0
(2) Antofagasta Area	587,970	639,711	639,711	639,711	0	137,193	3	90.5
1) Arryo Jochi	414,000	337,844	337,844	337,844	0	96,600	2	60.5
2) Arroyo Tacuaral	173,970	301,867	301,867	301,867	0	40,593	1	30.0
Grand Total	2,849,820	16,126,042	16,126,042	16,126,042	0	664,958	9	566.5

Work Item	Clearing & Grubbing (m^2)	Slope Forming (m^2)	Soil Filling (m^3)	Base Course (m^2)
ROAD-CUM-EMBANKMENT				
Road-cum-embankemnt	73,710	58,963	36,528	34,398

TABLE C.5.1 DRAINAGE IMPROVEMENT WORKS

Project Item	Length (km)	Channel Width (m)	Bed Width (m)	Channel Depth (m)	Slope	Flow Area (m^2)	Design Discharge (m^3/s)	Remarks
1. Chane-Pailon								
(1) Rio Chane								
(2) Rio Pailon								
1) Rancha Chico	**3.600**							
Jct. Rio Pailon (down) - Jct. Rio Pailon (up)	3.600	42.0	26.0	4.0	1/2	136.0	109.0	
2) El Chaco	**1.470**							
Jct. El Empalme II - National Road No. 9	1.470	30.0	16.0	3.0	1/2	69.0	137.7	
3) El Enpalme II	**5.290**							
Jct. Rio Pailon - Jct. El Chaco	0.690	35.0	19.0	4.0	1/2	108.0	193.0	
Jct. El Chaco - National Road No. 9	4.610	18.0	6.0	3.0	1/2	36.0	50.9	
(3) Okinawa Drainage	**21.650**							
Downstream - Midstream	19.840	28.0	12.0	4.0	1/2	80.0	249.0	
Midstream - Upstream	1.810	25.0	13.0	3.0	1/2	57.0	116.0	
2. San Juan-Antofagasta								
(1) San Juan								
1) San Juan Main Drainage	**34.950**							
km 11	2.410		As is				33.2	Canal Rehabilitation
km 13	3.660	13.0	4.0	3.0	1/1.5	25.5	55.7	
km 15	8.930		As is				49.7	Canal Rehabilitation
km 17	3.840	12.0	4.5	2.5	1/1.5	20.6	41.9	
km 24	5.560		As is				18.2	Canal Rehabilitation
km 28	10.550		As is				63.9	Canal Rehabilitation
2) Arroyo Tejeria	**8.160**							
Jct. Rio Yapacani - Upstream	4.480	22.0	6.0	3.0	1/2	42.0	88.6	
Midstream - Upstream	3.680	20.0	4.0	3.0	1/2	36.0	31.5	
(2) Antofagasta								
Antofagasta Main Drainage	**8.800**							
Downstream - Midstream	5.310	28.0	12.0	3.0	1/2	60.0	222.9	
Midstream - Upstream	3.490	25.0	9.0	3.0	1/2	51.0	222.3	

TABLE C.5.2 (1) PROFILE OF DRAINAGE IMPROVEMENT (CHANE-PAILON AREA)

Drainage	Section	Accumulate Distance (m)	Existing Riverbed EL. (m)	Left Bank EL. (m)	Right Bank EL. (m)	Proposed Riverbed EL. (m)	High Water Level (m)	Channel Width (m)	Longitudinal Slope
Okinawa Main Drainage	1	0	242.944	244.414	244.704	241.500	245.400	28.0	1/3,300
	2	302	243.077	244.929	244.869	241.591	245.430		
	3	1,280	244.917	245.097	245.077	241.887	245.576		
	4	2,728	243.930	245.250	245.430	242.325	245.870		
	5	3,222	244.069	245.379	245.559	242.474	245.970		
	6	4,433	245.247	246.567	246.807	242.841	246.580		
	7	5,415	244.667	246.597	246.797	243.138	247.180		
	8	6,267	245.201	247.001	247.289	243.395	247.500		
	9	7,714	245.758	248.008	248.198	243.833	248.040		
	10	8,540	245.999	248.719	248.789	244.083	248.330		
	11	10,229	246.661	248.858	249.228	244.594	248.860		
	12	10,968	247.081	248.711	248.916	244.817	249.080		
	13	11,538	247.015	249.030	249.485	244.989	249.230		
	14	12,846	248.219	249.609	250.149	245.385	249.490		
	15	13,639	248.524	249.579	250.679	245.625	249.710		
	16	14,807	248.463	250.425	251.281	245.978	250.000		
	17	15,740	248.775	250.595	251.155	246.260	250.210		
	18	16,711	249.762	250.348	250.468	246.554	250.440		
	19	17,570	249.214	250.744	250.744	246.814	250.610		
	20	18,429	249.171	252.316	252.041	247.074	250.810		
	21	19,839	249.472	250.972	251.072	247.500	251.300		
	21	19,839	249.472	250.972	251.072	248.500	251.300	25.0	1/3,600
	22	20,550	249.410	251.475	252.063	248.606	251.620		
	23	21,652	247.540	251.590	251.555	249.000	251.850		
Rancha Chico	0	0	253.343	254.873	255.233	252.000	254.380	42.0	1/3,600
	1	1,150	253.662	255.192	255.552	252.319	255.100		
	2	1,200	253.569	254.609	254.429	252.333	255.250		
	3	2,100	254.898	255.258	255.508	252.583	255.760		
	4	3,600	255.315	255.675	255.925	253.000	256.910		
El Chaco	1	0	252.092	254.162	253.602	251.000	254.381	30.0	1/1,500
	2	447	253.592	254.052	253.982	251.304	254.685		
	3	1,472	252.999	254.359	254.669	252.000	255.381		
El Empalme II	0	-176	252.074	253.887	253.840	249.589	253.896	35.0	1/1,800
	1	0	252.143	253.881	253.826	249.800	254.107		
		511	252.344	253.864	253.784	250.412	254.719		
	2	1,586	252.767	253.827	253.697	251.698	254.993	18.0	1/1,800
	3	3,185	253.880	255.670	255.805	252.604	255.899		
	4	4,576	255.265	256.505	256.755	253.392	256.687		
	5	5,119	253.752	257.182	256.492	253.700	256.995		

TABLE C.5.2 (2) PROFILE OF DRAINAGE IMPROVEMENT (SAN JUAN-ANTOFAGASTA AREA)

Drainage	Section	Accumulate Distance (m)	Existing Riverbed EL. (m)	Left Bank EL. (m)	Right Bank EL. (m)	Proposed Riverbed EL. (m)	High Water Level (m)	Channel Width (m)	Longitudinal Slope
San Juan Main Drainage km 15	1	0	271.670	273.900	272.240				
	2	151	274.402	278.962	279.722	272.900	276.002	13.0	1/900
	3	977	275.151	278.931	279.821	273.900	277.002		
	4	2,073	275.560	277.935	279.440	275.223	278.325		
	5	2,715	275.976	278.596	278.956	276.000	279.102		
	6	3,816	277.519	280.839	280.259	277.520	280.622		
San Juan Main Drainage km 17	1	0	266.757	268.767	268.337				
	2	431	270.636	274.896	275.076	269.000	271.963	12.0	1/1,500
	3	1,445	270.721	275.346	273.006	269.677	272.640		
	4	2,475	271.098	274.318	272.896	270.365	273.328		
	5	3,515	271.062	274.617	272.717	271.060	274.023		
	6	4,288	271.761	275.676	273.719	271.761	274.724		
Arroyo Tejeria	1	0	276.665	279.483	285.221	275.727	279.700	22.0	1/900
	2	581	276.336	280.874	281.474	276.372	280.750		
	3	1,281	277.150	281.178	287.324	277.150	281.070		
	4	2,454	278.161	283.049	283.449	278.161	281.558		
	5	3,300	280.129	283.377	284.243	280.129	282.570		
	6	4,463	281.854	284.791	285.622	281.854	284.225		
	7	5,185	283.893	290.276	290.944	283.893	286.260	20.0	
	8	5,935	286.053	290.601	290.871	286.554	288.186		
	9	7,150	288.886	293.333	292.462	287.904	290.622		
	10	8,160	289.026	290.932	290.902	289.026	290.250		
Antofagasta Main Drainage	1	0	249.649	253.000	252.800	248.900	252.760	28.0	1/970
	2	544	251.159	255.000	255.000	249.463	253.560		
	3	1,156	250.304	253.600	253.800	250.096	254.190		
	4	2,237	250.336	255.500	255.700	251.214	254.980		
	5	3,554	253.074	258.300	258.000	252.576	256.640		
	6	4,493	254.815	258.800	258.300	253.548	257.740		
	7	5,305	254.963	257.400	259.400	254.388	258.480	25.0	
	8	6,247	257.000	259.400	259.900	255.362	259.370		
	9	6,881	258.014	261.000	261.200	256.018	260.410		
	10	7,755	260.492	260.400	262.200	256.922	261.430		
	11	8,797	260.897	262.300	263.000	258.000	262.410		

TABLE C.5.3 RUNOFF ANALYSIS FOR DRAINAGE BASIN BY RATIONAL FORMULA

Frequency	San Juan Main Dranage		Drainage for Bridges of Nationa Road No 9		
	km17.00	km13.00	El Chaco	Empalme II (upstream)	Empalme II (downstream)
$T_L = \left(119 \times \frac{H_L^3}{h}\right)^{0.385}$ (hrs H_L : miles h : feet)					
H_L : (km)	4.50	4.00	4.20	3.00	5.50
h : (m)	3.00	2.67	3.00	3.00	8.00
T_L : (hrs)	3.50	3.00	3.50	2.00	3.00
2-year Frequency Flood					
$I = \frac{a}{T_L + b}$ (mm/hr T_L : minutes)					
a :	8,557	8,557	6,292	6,292	6,292
b :	89.00	89.00	89.00	89.00	89.00
I : (mm/hr)	28.62	31.81	21.04	30.11	23.39
$Q_P = \frac{1}{3.6} \times f_C \times I \times A$ (m^3/s I : mm/hr A : km^2)					
f_C :	0.50	0.50	0.50	0.50	0.50
A : (km^2)	8.00	9.50	35.30	8.90	44.20
Q_P : (m^3/s)	31.80	41.97	103.15	37.22	143.59
5-year Frequency Flood					
$I = \frac{a}{T_L + b}$ (mm/hr T_L : minutes)					
a :	10,656	10,656	7,939	7,939	7,939
b :	72.63	72.63	72.63	72.63	72.63
I : (mm/hr)	37.70	42.18	28.09	41.21	31.43
$Q_P = \frac{1}{3.6} \times f_C \times I \times A$ (m^3/s I : mm/hr A : km^2)					
f_C :	0.50	0.50	0.50	0.50	0.50
A : (km^2)	8.00	9.50	35.30	8.90	44.20
Q_P : (m^3/s)	41.89	55.65	137.72	50.94	192.95
10-year Frequency Flood					
$I = \frac{a}{T_L + b}$ (mm/hr T_L : minutes)					
a :	12,044	12,044	8,967	8,967	8,967
b :	66.56	66.56	66.56	66.56	66.56
I : (mm/hr)	43.55	48.85	32.42	48.06	36.37
$Q_P = \frac{1}{3.6} \times f_C \times I \times A$ (m^3/s I : mm/hr A : km^2)					
f_C :	0.50	0.50	0.50	0.50	0.50
A : (km^2)	8.00	9.50	35.30	8.90	44.20
Q_P : (m^3/s)	48.39	64.45	158.95	59.41	223.27
20-year Frequency Flood					
$I = \frac{a}{T_L + b}$ (mm/hr T_L : minutes)					
a :	13,396	13,396	10,071	10,071	10,071
b :	62.48	62.48	62.48	62.48	62.48
I : (mm/hr)	49.16	55.25	36.96	55.19	41.53
$Q_P = \frac{1}{3.6} \times f_C \times I \times A$ (m^3/s I : mm/hr A : km^2)					
f_C :	0.50	0.50	0.50	0.50	0.50
A : (km^2)	8.00	9.50	35.30	8.90	44.20
Q_P : (m^3/s)	54.62	72.90	181.21	68.22	254.95
50-year Frequency Flood					
$I = \frac{a}{T_L + b}$ (mm/hr T_C : minutes)					
a :	15,155	15,155	11,394	11,394	11,394
b :	58.67	58.67	58.67	58.67	58.67
I : (mm/hr)	56.41	63.50	42.41	63.77	47.74
$Q_P = \frac{1}{3.6} \times f_C \times I \times A$ (m^3/s I : mm/hr A : km^2)					
f_C :	0.50	0.50	0.50	0.50	0.50
A : (km^2)	8.00	9.50	35.30	8.90	44.20
Q_P : (m^3/s)	62.68	83.78	207.93	78.83	293.07

TABLE C.5.4 HYDRAULIC CONDITION OF DRAINAGE IMPROVEMENT

Ferquency / Drainage	Q_{design} (m^3/s)	Proposed Canal Dimension					Bed Elv (m)	Bank Elv (m)	Water Level (m)	Water Depth (m)	Overflow to the lower reach		
		Channel Width (m)	Bed Width (m)	Canal Depth (m)	Side Slope	Long. Slope					Overflow Width (m)	$Q_{overflow}$ (m^3/s)	Q_{canal} (m^3/s)
2-year Frequency Flood													
San Juna Drainage km 13	41.970	13.000	4.000	3.000	1/1.5	1/900	273.340	276.340	276.342	3.002	15.000	1.194	40.776
San Juan Drainage km 17	31.800	12.000	4.500	2.500	1/1.5	1/1,500	270.200	272.700	272.774	2.574	15.000	6.546	25.254
El Empalme II (upstream)	37.220	18.000	6.000	3.000	1/2.0	1/1,800	249.800	252.800	252.604	2.804			
El Empalme II (downstream)	143.590	35.000	19.000	4.000	1/2.0	1/1,800	251.700	255.700	255.305	3.605			
El Chaco	103.150	30.000	18.000	3.000	1/2.0	1/1,500	251.000	254.000	253.929	2.929			
5-year Frequency Flood													
San Juna Drainage km 13	55.650	13.000	4.000	3.000	1/1.5	1/900	273.340	276.340	276.495	3.155	15.000	9.454	46.196
San Juan Drainage km 17	41.890	12.000	4.500	2.500	1/1.5	1/1,500	270.200	272.700	272.958	2.758	15.000	12.186	29.704
El Empalme II (upstream)	50.940	18.000	6.000	3.000	1/2.0	1/1,800	249.800	252.800	253.024	3.224			
El Empalme II (downstream)	192.950	35.000	19.000	4.000	1/2.0	1/1,800	251.700	255.700	255.901	4.201			
El Chaco	137.720	30.000	18.000	3.000	1/2.0	1/1,500	251.000	254.000	254.381	3.381			
10-year Frequency Flood													
San Juna Drainage km 13	64.450	13.000	4.000	3.000	1/1.5	1/900	273.340	276.340	276.635	3.295	15.000	13.043	51.407
San Juan Drainage km 17	48.390	12.000	4.500	2.500	1/1.5	1/1,500	270.200	272.700	273.097	2.897	15.000	15.121	33.269
El Empalme II (upstream)	59.410	18.000	6.000	3.000	1/2.0	1/1,800	249.800	252.800	253.239	3.439			
El Empalme II (downstream)	223.270	35.000	19.000	4.000	1/2.0	1/1,800	251.700	255.700	256.202	4.502			
El Chaco	158.950	30.000	18.000	3.000	1/2.0	1/1,500	251.000	254.000	254.631	3.631			
20-year Frequency Flood													
San Juna Drainage km 13	72.900	13.000	4.000	3.000	1/1.5	1/900	273.340	276.340	276.779	3.439	15.000	15.909	56.991
San Juan Drainage km 17	54.620	12.000	4.500	2.500	1/1.5	1/1,500	270.200	272.700	273.237	3.037	15.000	17.592	37.028
El Empalme II (upstream)	68.220	18.000	6.000	3.000	1/2.0	1/1,800	249.800	252.800	253.450	3.650			
El Empalme II (downstream)	254.950	35.000	19.000	4.000	1/2.0	1/1,800	251.700	255.700	256.500	4.800			
El Chaco	181.210	30.000	18.000	3.000	1/2.0	1/1,500	251.000	254.000	254.879	3.879			
50-year Frequency Flood													
San Juna Drainage km 13	83.870	13.000	4.000	3.000	1/1.5	1/900	273.340	276.340	276.972	3.632	15.000	19.074	64.796
San Juan Drainage km 17	62.680	12.000	4.500	2.500	1/1.5	1/1,500	270.200	272.700	273.424	3.224	15.000	20.416	42.264
El Empalme II (upstream)	78.830	18.000	6.000	3.000	1/2.0	1/1,800	249.800	252.800	253.690	3.890			
El Empalme II (downstream)	293.070	35.000	19.000	4.000	1/2.0	1/1,800	251.700	255.700	256.838	5.138			
El Chaco	207.930	30.000	18.000	3.000	1/2.0	1/1,500	251.000	254.000	255.161	4.161			

TABLE C.5.5 SUMMARY OF SECONDARY DRAINAGE IMPROVEMENT

Area	Cross Section			Number of Canals	Total Length (km)	Box Culvert	
	Surface Widht (m)	Channel Depth (m)	Slope				
1. Chane - Pailon Area							
1.1 Rio Pailon Basin	12.0	3.0	1/1.5	9	18.50	9	3.5 x 3.0 x 2battery
1.2 Okinawa Drainage Basin	12.0	3.0	1/1.5	14	35.50	17	3.5 x 3.0 x 2battery
2. San Juan - Antofagasta Area							
2.1 San Juan Area	14.0	3.0	1/1.5	18	40.50	18	3.0 x 3.0 x 3battery
2.2 Antofasta Area	14.0	3.0	1/1.5	21	35.00	21	3.0 x 3.0 x 3battery

TABLE C.5.6 BRIDGE CONSTRUCTION OF DRAINAGE IMPROVEMENT WORKS

Project Item	Location	Proposed Bridge Dimension					Elevation of Bridge (m)	Elevation of Channelbed (m)	Water Level of Flood (m)	
		L (m)	W (m)	H (m)	Type	Span No			5-year	50-year
1. Chane-Pailon										
(1) Rio Pailon										
1) El Empalme II										
Bridge Reconstrcution- 1	km 3.190	24.0	5.5	6.0	B	1	258.60	252.60	256.81	257.74
(2) Okinawa Drainage										
Bridge Reconstrcution- 1	km 0.300	38.7	5.5	7.0	B	2	248.59	241.59	245.43	246.02
2. San Juan-Antofagasta										
(1) San Juan										
1) San Juan Main Drainage										
Bridge Reconstrcution- 1	km 13 Drainage	18.5	8.0	6.5	A	1	279.40	272.90	276.06	276.53
Bridge Reconstrcution- 2	km 17 Drainage	16.5	8.0	6.5	A	1	275.50	269.00	272.16	272.63
2) Arroyo Tejeria										
Bridge Reconstrcution- 1	km 7.150	20.0	8.0	7.5	A	1	295.40	287.90	290.62	291.66
(2) Antofagasta										
1) Antofagasta Main Drainage										
Bridge Reconstrcution- 1	km 3.560	35.5	5.5	7.5	B	1	260.08	252.58	256.64	257.23
Bridge Reconstrcution- 2	km 6.250	30.0	5.5	6.7	B	1	262.06	255.36	259.37	259.92

TABLE C.5.7 BILL OF QUANTITY OF DRAINAGE IMPROVEMENT

Work Item	Clearing & Grubbing (m2)	Soil Excavation (m3)	Soil Transportation (m3)	Sruplus Soil Filling (m3)	Slope Forming (m2)	Operation Road (m2)	Bridge Construction (pcs / m)	
1. Chane - Palon Area	311,010	3,451,154	2,236,154	3,451,154	0	0	2	62.7
(1) Rio Pailon Basin	311,010	814,102	397,852	814,102	0	0	1	24.0
1) Rancha Chico	108,000	226,306	226,306	226,306	0	0	0	
2) El Empalme II	158,850	146,715	146,715	146,715	0	0	1	24.0
3) El Chaco	44,160	24,831	24,831	24,831	0	0	0	
4) Secondary Drainage	0	416,250	0	416,250	0	0		
(2) Okinawa Dranage Basin	0	2,637,052	1,838,302	2,637,052	0	0	1	38.7
1) Okinawa Main Drainage	0	1,838,302	1,838,302	1,838,302	0	0	1	38.7
2) Secondary Drainage	0	798,750	0	798,750	0	0		
2. San Juan - Antofagasta Area	1,558,530	2,376,870	624,120	2,376,870	0	0	5	121
(1) San Juan Area	1,294,620	1,232,553	235,053	1,232,553	0	0	3	55.0
1) San Juan Main Drainage (Km 13,17)	225,660	92,560	92,560	92,560	0	0	2	35.0
2) San Juan Main Drainage (Km 11, 15, 24, 28)	824,160	32,699	32,699	32,699	0	0	0	
3) ArroyoTejeria	244,800	109,794	109,794	109,794	0	0	1	20.0
4) Secondary Drainage	0	997,500	0	997,500	0	0		
(2) Antofagasta Area	263,910	1,144,317	389,067	1,144,317	0	0	2	65.5
1) Antofagasta Main Drainage	263,910	389,067	389,067	389,067	0	0	2	65.5
2) Secondary Drainage	0	755,250	0	755,250	0	0		
Grand Total	1,869,540	5,828,024	2,860,274	5,828,024	0	0	7	183.2

TABLE C.6.1 (1) INUNDATION CONDITION OF WITH AND WITHOUT PROJECT : CHANE-PAILON AREA

(unit : km^2 - %)

Flood	Inundation Condition	Rio Chane Basin				Rio Pailon Basin				Okinawa Drainage Basin			
		Without Project		With Project		Without Project		With Project		Without Project		With Project	
2-year Frequency Flood	Whole Area	143.7	100.0%	143.7	100.0%	270.9	100.0%	270.9	100.0%	185.0	100.0%	185.0	100.0%
	d > 0 cm	125.0	87.0%	63.7	44.3%	229.6	84.7%	18.8	6.9%	88.2	47.7%	0.0	0.0%
	d >= 30 cm	102.4	71.3%	63.7	44.3%	171.9	63.5%	18.8	6.9%	58.2	31.4%	0.0	0.0%
	d >= 100 cm	19.3	13.4%	40.6	28.2%	71.7	26.5%	18.8	6.9%	0.0	0.0%	0.0	0.0%
5-year Frequency Flood	Whole Area	143.7	100.0%	143.7	100.0%	270.9	100.0%	270.9	100.0%	185.0	100.0%	185.0	100.0%
	d > 0 cm	125.0	87.0%	120.3	83.7%	237.1	87.5%	59.0	21.8%	96.1	52.0%	8.2	4.5%
	d >= 30 cm	102.4	71.3%	86.7	60.4%	200.5	74.0%	28.0	10.3%	75.4	40.8%	0.0	0.0%
	d >= 100 cm	19.3	13.4%	0.0	0.0%	118.9	43.9%	0.0	0.0%	17.9	9.7%	0.0	0.0%
10-year Frequency Flood	Whole Area	143.7	100.0%	143.7	100.0%	270.9	100.0%	270.9	100.0%	185.0	100.0%	185.0	100.0%
	d > 0 cm	132.0	91.8%	127.5	88.8%	244.8	90.4%	80.3	29.6%	110.6	59.8%	24.7	13.4%
	d >= 30 cm	118.9	82.7%	97.8	68.1%	210.1	77.6%	41.3	15.2%	90.4	48.9%	0.0	0.0%
	d >= 100 cm	75.8	52.7%	51.7	36.0%	122.4	45.2%	4.6	1.7%	43.3	23.4%	0.0	0.0%
20-year Frequency Flood	Whole Area	143.7	100.0%	143.7	100.0%	270.9	100.0%	270.9	100.0%	185.0	100.0%	185.0	100.0%
	d > 0 cm	137.5	95.7%	127.5	88.7%	250.0	92.3%	86.6	32.0%	118.1	63.8%	49.3	26.7%
	d >= 30 cm	131.9	91.8%	109.0	75.9%	221.9	81.9%	40.5	14.9%	104.0	56.2%	3.1	1.7%
	d >= 100 cm	117.8	82.0%	71.2	49.5%	153.6	56.7%	1.1	0.4%	67.9	36.7%	0.0	0.0%
50-year Frequency Flood	Whole Area	143.7	100.0%	143.7	100.0%	270.9	100.0%	270.9	100.0%	185.0	100.0%	185.0	100.0%
	d > 0 cm	139.3	97.0%	134.6	93.7%	256.0	94.5%	142.2	52.5%	124.9	67.5%	57.0	30.8%
	d >= 30 cm	133.0	92.6%	125.7	87.5%	233.3	86.1%	68.9	25.4%	115.2	62.3%	10.1	5.5%
	d >= 100 cm	121.0	84.2%	105.8	73.6%	161.9	59.8%	10.9	4.0%	87.4	47.3%	0.0	0.0%

TABLE C.6.1 (2) INUNDATION CONDITION OF WITH AND WITHOUT PROJECT : SAN JUAN-ANTOFAGASTA AREA

(unit : km^2 - %)

Flood	Inundation Condition	San Juan Area				Antofagasta Area			
		Without Project		With Project		Without Project		With Project	
2-year Frequency Flood	Whole Area	369.3	100.0%	369.3	100.0%	238.0	100.0%	238.0	100.0%
	d > 0 cm	291.2	78.8%	189.2	51.2%	177.9	74.8%	58.8	24.7%
	d >= 30 cm	188.6	51.1%	160.5	43.5%	118.0	49.6%	23.2	9.7%
	d >= 100 cm	75.5	20.4%	71.1	19.3%	17.2	7.2%	9.1	3.8%
5-year Frequency Flood	Whole Area	369.3	100.0%	369.3	100.0%	238.0	100.0%	238.0	100.0%
	d > 0 cm	302.3	81.8%	200.3	54.2%	197.3	82.9%	81.5	34.3%
	d >= 30 cm	218.8	59.2%	166.2	45.0%	140.0	58.8%	16.7	7.0%
	d >= 100 cm	90.8	24.6%	76.1	20.6%	23.0	9.7%	7.8	3.3%
10-year Frequency Flood	Whole Area	369.3	100.0%	369.3	100.0%	238.0	100.0%	238.0	100.0%
	d > 0 cm	337.8	91.5%	215.3	58.3%	231.6	97.3%	108.6	45.6%
	d >= 30 cm	261.2	70.7%	169.1	45.8%	160.8	67.6%	21.9	9.2%
	d >= 100 cm	112.0	30.3%	96.5	26.1%	34.9	14.7%	8.6	3.6%
20-year Frequency Flood	Whole Area	369.3	100.0%	369.3	100.0%	238.0	100.0%	238.0	100.0%
	d > 0 cm	345.8	93.6%	240.6	65.2%	235.1	98.8%	121.6	51.1%
	d >= 30 cm	285.7	77.4%	196.5	53.2%	181.5	76.3%	54.6	22.9%
	d >= 100 cm	134.8	36.5%	116.0	31.4%	44.1	18.5%	13.8	5.8%
50-year Frequency Flood	Whole Area	369.3	100.0%	369.3	100.0%	238.0	100.0%	238.0	100.0%
	d > 0 cm	365.4	98.9%	275.7	74.7%	237.7	99.9%	140.6	59.1%
	d >= 30 cm	298.4	80.8%	220.4	59.7%	202.8	85.2%	68.8	28.9%
	d >= 100 cm	154.3	41.8%	130.4	35.3%	89.7	37.7%	17.2	7.2%

TABLE C.6.2 (I) REMAINING INUNDATION PERIOD WITH PROJECT

1. RIO CHANE - PAILON (10-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
24.000	258.817	258.963	10.3	0.4	0.146			
29.900	258.387	258.368	0.0	0.0	0.000			
30.600	257.603	258.207	32.3	1.3	0.604			
31.300	256.982	258.016	45.3	1.9	1.034			
32.300	256.273	257.506	52.3	2.2	1.233			
33.700	256.621	257.048	21.2	0.9	0.427			
34.600	255.575	256.819	52.5	2.2	1.241			
35.500	257.104	256.422	0.0	0.0	0.000			
36.500	255.548	255.402	0.0	0.0	0.000	23.8	1.0	0.521
37.100	255.343	254.942	0.0	0.0	0.000			
37.800	254.669	254.593	0.0	0.0	0.000			
38.500	253.463	254.524	53.3	2.2	1.061			
39.500	253.450	254.007	32.8	1.4	0.557			
40.500	252.351	253.446	48.7	2.0	1.095			
41.500	252.968	252.800	0.0	0.0	0.000			
42.800	252.445	252.264	0.0	0.0	0.000			
44.200	251.142	251.594	27.3	1.1	0.452			
45.300	251.226	250.962	0.0	0.0	0.000			
46.500	251.346	250.216	0.0	0.0	0.000			
47.800	249.481	249.458	0.0	0.0	0.000			
49.200	250.002	248.227	0.0	0.0	0.000			
50.300	248.898	247.583	0.0	0.0	0.000			
51.400	247.785	246.832	0.0	0.0	0.000			
52.500	247.204	246.125	0.0	0.0	0.000			
53.200	247.355	245.609	0.0	0.0	0.000			
53.900	245.333	245.215	0.0	0.0	0.000			
54.500	246.207	244.767	0.0	0.0	0.000			
55.650	245.989	244.012	0.0	0.0	0.000			
56.800	247.553	243.264	0.0	0.0	0.000			
57.500	244.571	242.784	0.0	0.0	0.000			
58.200	244.246	242.417	0.0	0.0	0.000			
58.900	244.702	241.843	0.0	0.0	0.000			
59.600	244.437	241.367	0.0	0.0	0.000	6.8	0.3	0.132
60.000	244.437	241.250	0.0	0.0	0.000			
60.800	240.125	240.835	16.0	0.7	0.710			
61.600	239.532	240.262	15.0	0.6	0.730			
62.600	239.578	239.603	3.0	0.1	0.025			
63.600	238.378	239.507	22.5	0.9	1.129			
64.500	239.548	239.167	0.0	0.0	0.000			
65.500	238.267	238.524	9.8	0.4	0.257			
66.500	237.127	237.806	16.3	0.7	0.679			
67.500	236.959	237.336	12.0	0.5	0.377			
68.500	236.790	236.674	0.0	0.0	0.000			
69.500	236.234	236.524	10.0	0.4	0.291			
70.500	235.677	236.171	12.5	0.5	0.494			
71.500	236.064	235.396	0.0	0.0	0.000			
72.500	234.238	235.238	20.7	0.9	1.000			
73.400	234.664	234.893	8.3	0.3	0.229			
74.300	234.948	234.258	0.0	0.0	0.000			
75.200	233.970	233.469	0.0	0.0	0.000			
76.500	233.608	232.899	0.0	0.0	0.000			
77.700	232.315	232.594	10.3	0.4	0.279			
78.800	232.776	231.895	0.0	0.0	0.000			
80.000	234.050	231.180	0.0	0.0	0.000			
81.000	231.812	230.011	0.0	0.0	0.000	7.1	0.3	0.282
81.900	231.683	229.982	0.0	0.0	0.000			
82.800	230.171	229.796	0.0	0.0	0.000			
83.800	229.708	229.442	0.0	0.0	0.000			
84.800	228.670	229.170	17.2	0.7	0.500			
86.400	228.151	228.793	21.2	0.9	0.642			
88.000	227.463	227.759	13.2	0.5	0.296	8.6	0.4	0.240

TABLE C.6.2 (2) REMAINING INUNDATION PERIOD WITH PROJECT

2. ARROYO YAPACANICHTO (10-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
14.300	268.238	266.043	0.0	0.0	0.000			
15.400	268.239	263.867	0.0	0.0	0.000			
16.400	265.924	262.837	0.0	0.0	0.000			
17.100	265.836	262.556	0.0	0.0	0.000			
18.100	263.631	258.923	0.0	0.0	0.000			
19.000	259.787	257.856	0.0	0.0	0.000			
20.000	258.726	257.210	0.0	0.0	0.000			
20.400	255.653	257.104	37.8	1.6	1.451			
22.200	257.077	256.571	0.0	0.0	0.000			
23.100	256.747	256.256	0.0	0.0	0.000			
24.100	256.204	255.985	0.0	0.0	0.000			
25.300	255.619	255.763	9.2	0.4	0.145			
26.200	255.144	255.711	27.7	1.2	0.568			
27.000	254.631	255.692	38.7	1.6	1.061			
28.100	254.756	255.674	25.7	1.1	0.918			
29.100	254.175	255.660	38.3	1.6	1.486			
30.100	253.492	255.582	41.8	1.7	2.090			
31.100	253.689	254.076	11.2	0.5	0.388			
31.700	252.771	253.463	15.0	0.6	0.692	13.6	0.6	0.489

3. ARROYO JOCHI (10-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
13.800	266.468	266.008	0.0	0.0	0.000			
15.000	265.080	264.428	0.0	0.0	0.000			
16.000	264.452	263.374	0.0	0.0	0.000			
17.200	263.183	261.416	0.0	0.0	0.000			
18.300	262.484	259.962	0.0	0.0	0.000			
19.000	261.293	259.075	0.0	0.0	0.000			
20.000	260.694	258.059	0.0	0.0	0.000			
20.900	260.433	257.275	0.0	0.0	0.000			
21.900	259.148	256.364	0.0	0.0	0.000			
22.700	258.758	255.388	0.0	0.0	0.000			
23.700	255.963	253.750	0.0	0.0	0.000			
24.900	254.255	251.779	0.0	0.0	0.000			
25.600	253.619	251.662	0.0	0.0	0.000	0.0	0.0	0.000

4. ARROYO TACUARAL (10-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
16.800	260.421	261.798	43.7	1.8	1.377			
17.600	259.962	260.931	39.3	1.6	0.969			
18.500	259.030	259.881	38.2	1.6	0.851			
19.100	258.211	259.479	38.7	1.6	1.268			
20.000	257.306	258.461	39.2	1.6	1.155			
21.200	255.994	256.678	37.8	1.6	0.684			
22.100	254.536	254.481	0.0	0.0	0.000			
22.600	254.364	252.443	0.0	0.0	0.000	29.6	1.2	0.788

TABLE C.6.2 (3) REMAINING INUNDATION PERIOD WITH PROJECT

5. OKINAWA MAIN DRAINAGE (5-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
0.000	252.000	252.215	115.3	4.8	0.215			
5.200	251.573	251.849	15.7	0.7	0.276			
6.300	251.769	251.616	0.0	0.0	0.000			
7.000	251.022	251.296	18.5	0.8	0.274			
8.400	252.179	250.807	0.0	0.0	0.000			
9.300	250.744	250.610	0.0	0.0	0.000			
10.100	250.408	250.439	4.5	0.2	0.031			
11.100	250.875	250.208	0.0	0.0	0.000			
12.000	250.853	249.996	0.0	0.0	0.000			
13.200	250.129	249.710	0.0	0.0	0.000			
14.000	249.879	249.491	0.0	0.0	0.000			
15.300	249.258	249.226	0.0	0.0	0.000			
15.900	248.814	249.075	12.3	0.5	0.261			
16.600	249.043	248.863	0.0	0.0	0.000			
18.300	248.754	248.326	0.0	0.0	0.000			
19.100	248.103	248.042	0.0	0.0	0.000			
20.600	247.145	247.496	16.8	0.7	0.351			
21.400	246.697	247.178	19.5	0.8	0.481			
22.400	246.687	246.580	0.0	0.0	0.000			
23.600	245.469	245.975	57.8	2.4	0.506	13.0	0.5	0.120

6. ANTOFAGASTA MAIN DRAINAGE (5-YEAR FREQUENCY)

Chainage	Bank Height	Peak W.L. (m)	Duration (hrs)	Duration (days)	Inundaton Depth (m)	Average Duration (hrs)	Average Duration (days)	Average Inundaton Depth (m)
0.000	262.650	262.414	0.0	0.0	0.000			
1.040	261.300	261.430	6.7	0.3	0.130			
1.920	261.100	260.413	0.0	0.0	0.000			
2.550	259.650	259.375	0.0	0.0	0.000			
3.490	258.400	258.479	5.3	0.2	0.079			
4.300	258.550	257.741	0.0	0.0	0.000			
5.240	258.150	256.644	0.0	0.0	0.000			
6.560	255.600	254.979	0.0	0.0	0.000			
7.640	253.700	254.187	10.7	0.4	0.487			
8.250	255.000	253.563	0.0	0.0	0.000			
8.800	252.900	252.758	0.0	0.0	0.000	2.1	0.1	0.063

FIGURES

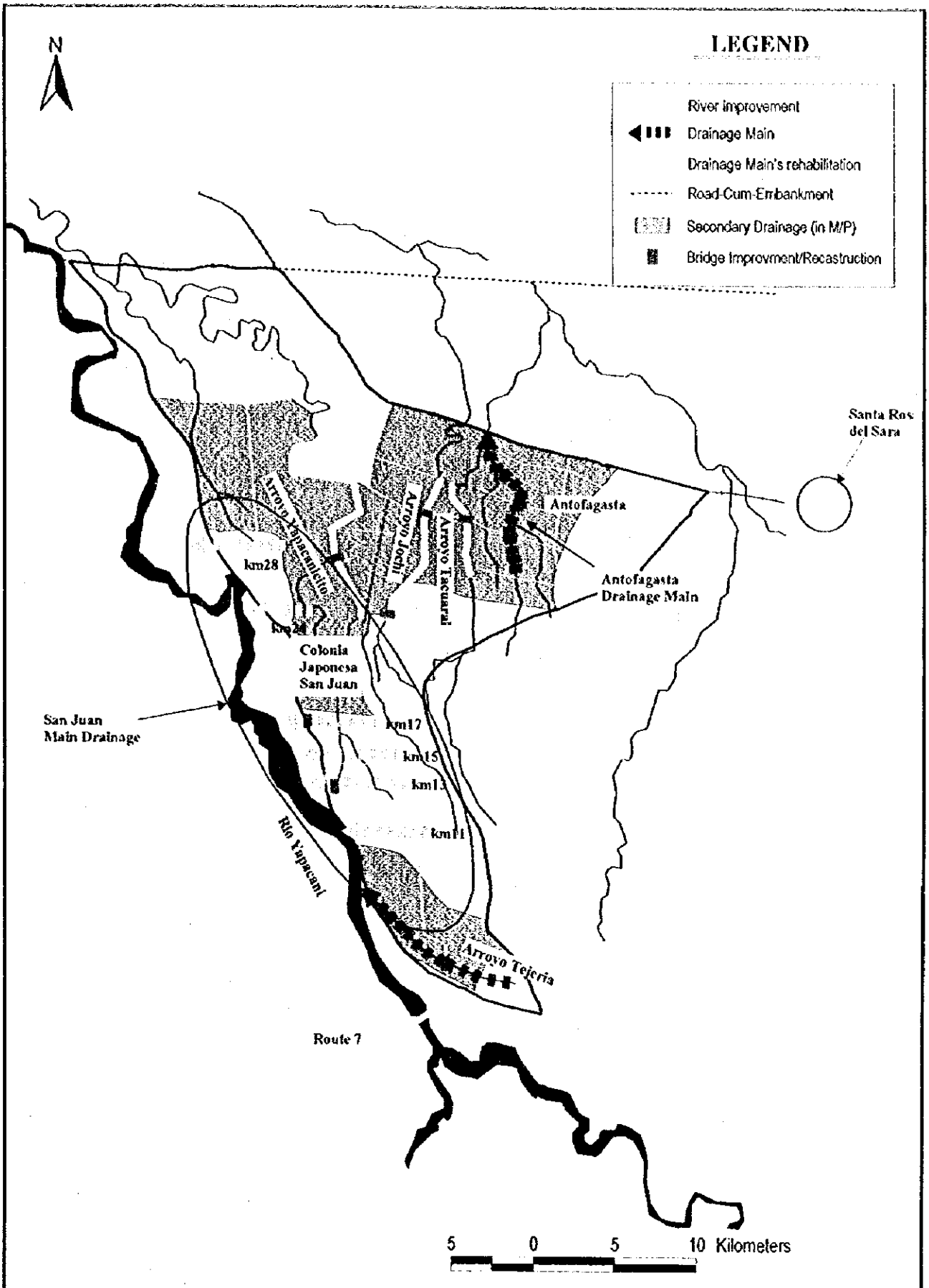


FIG.C.1.1(1) PROPOSED STRUCTURAL MESURES (SAN JUAN-ANTOFAGASTA AREA)

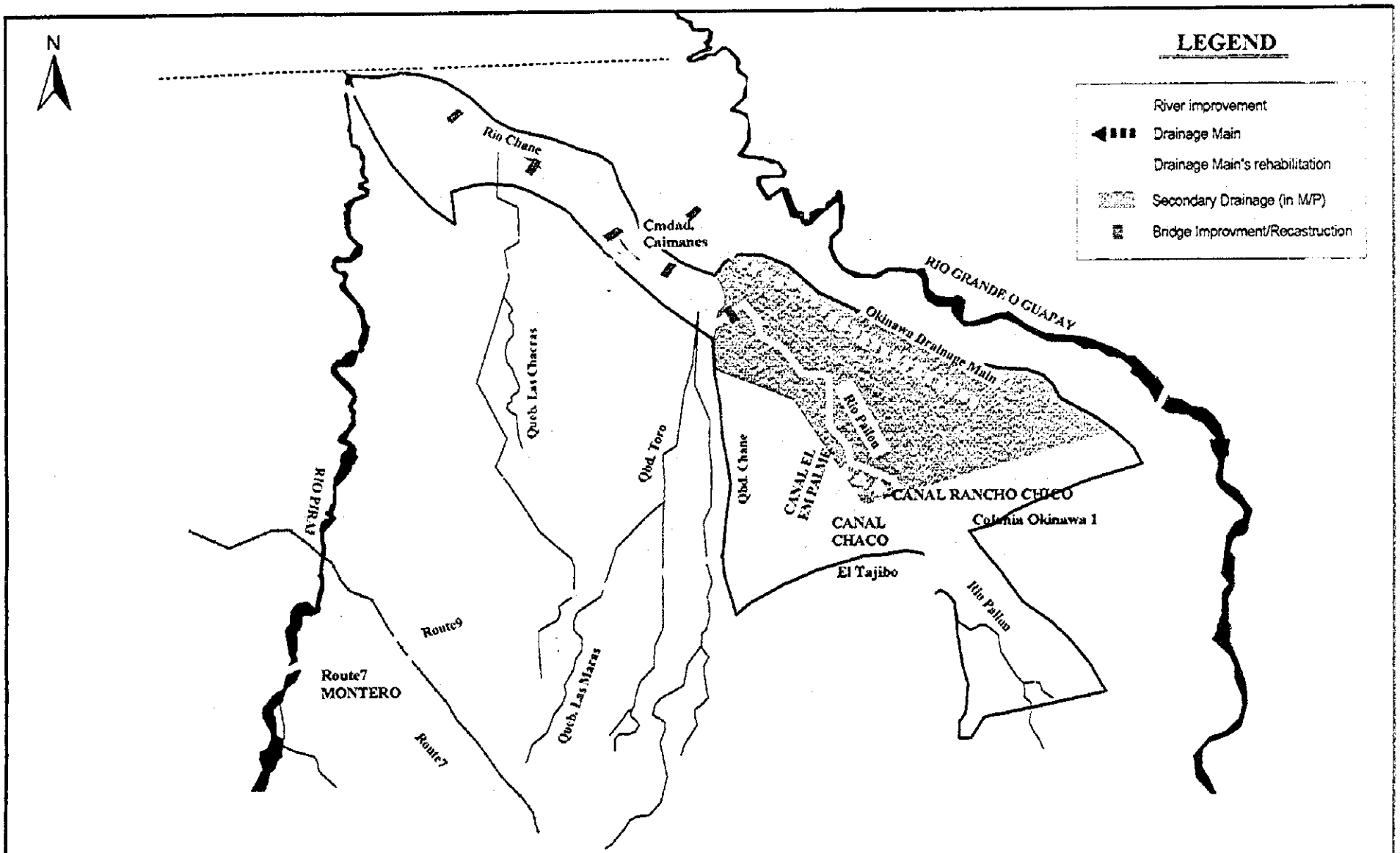
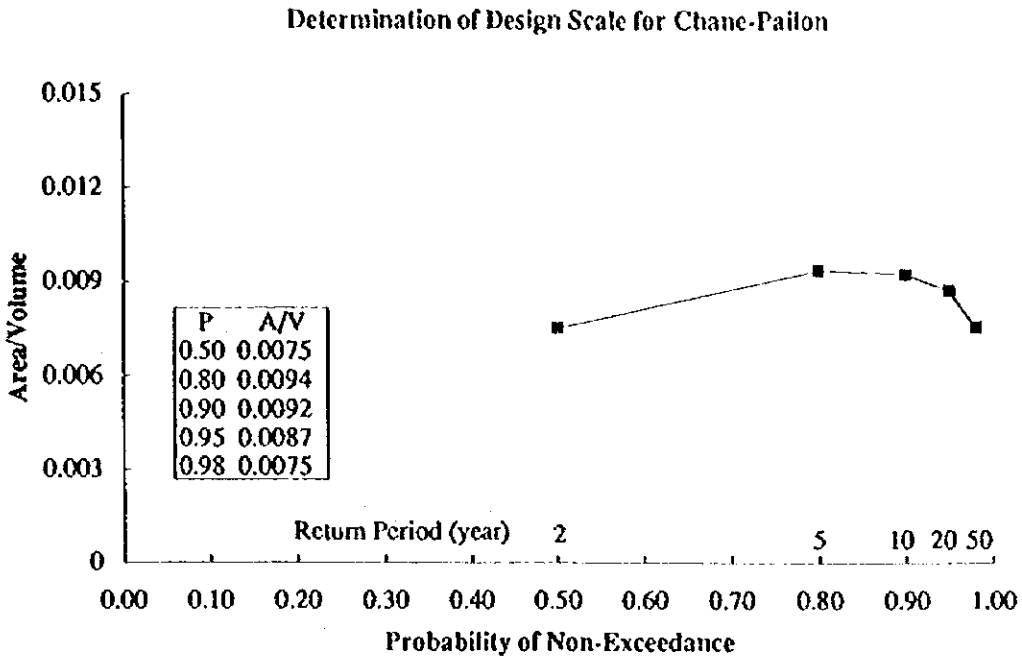
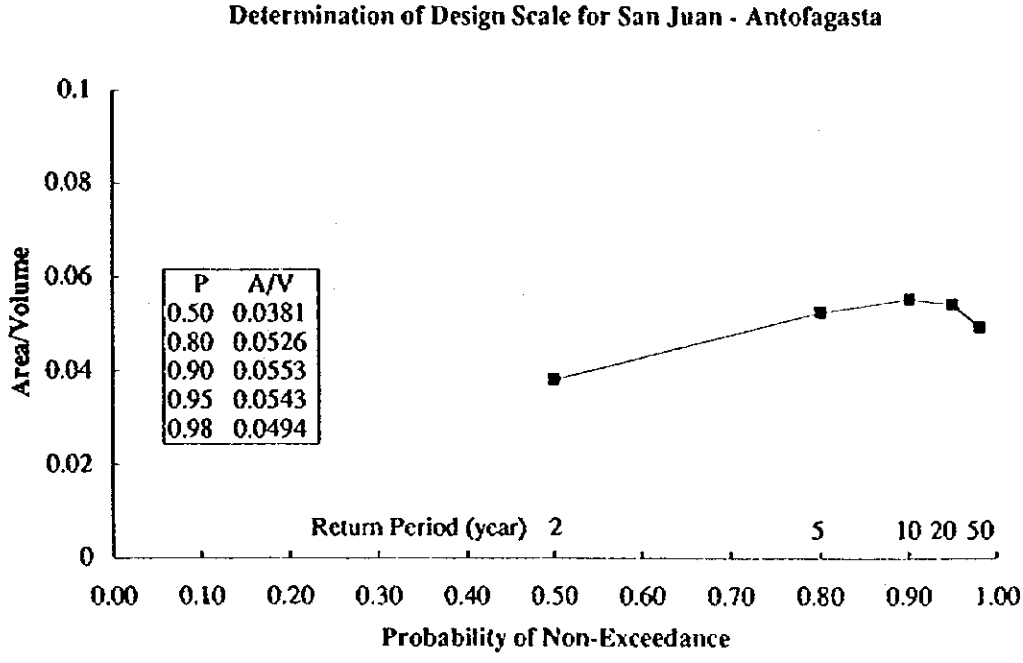


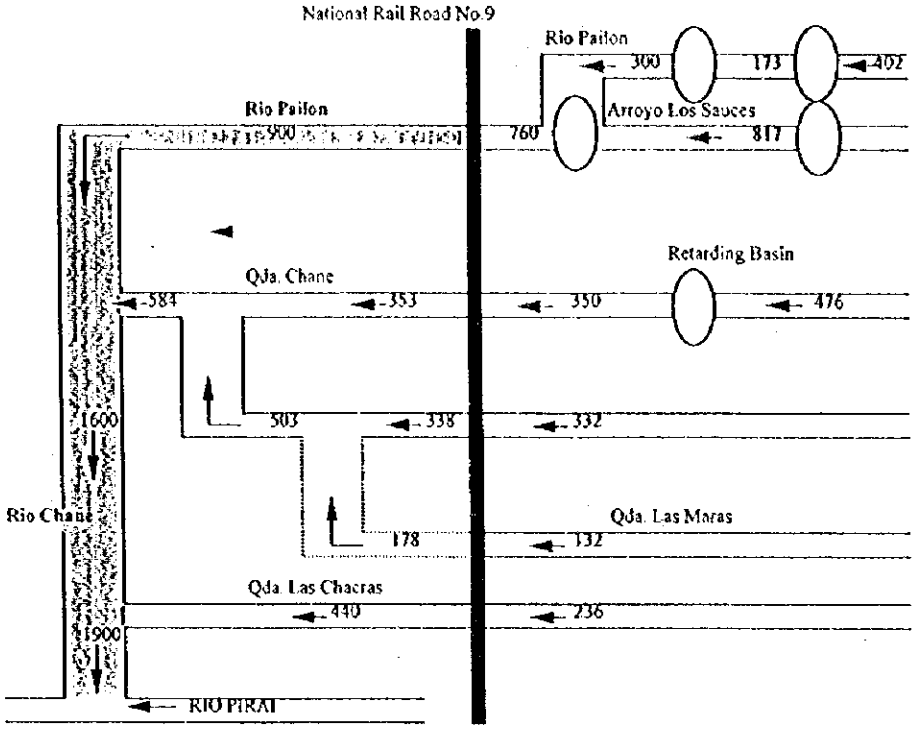
FIG.C.1.1(2) PROPOSED STRUCTURAL MESURES
(CHANE-PAILON AREA)



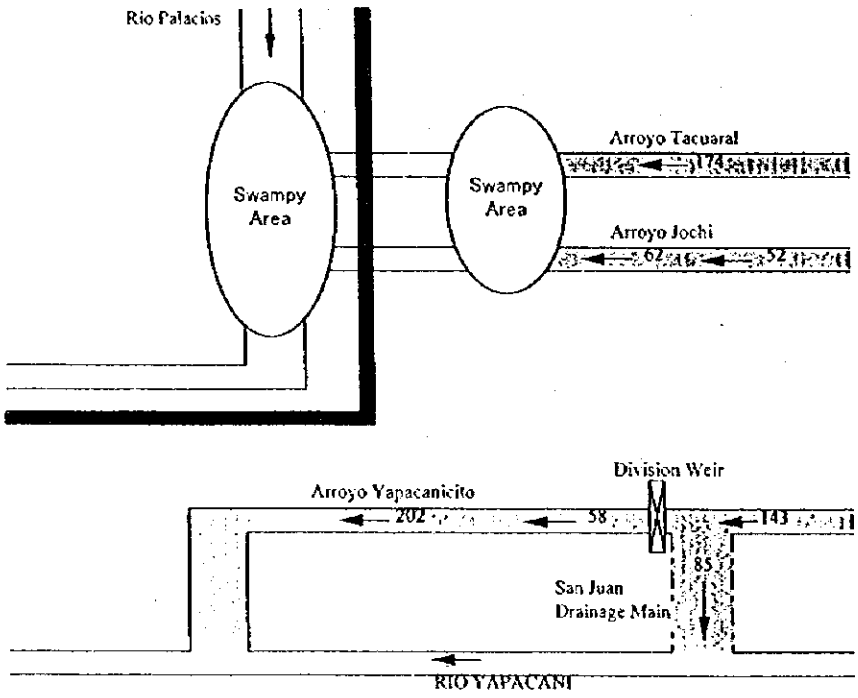


Note: Area - Annual Average Protected Area
Volume - Excavation Volume

FIG. C.3.1 DETERMINATION OF DESIGN SCALE



CHANE-PAILON SCHEME

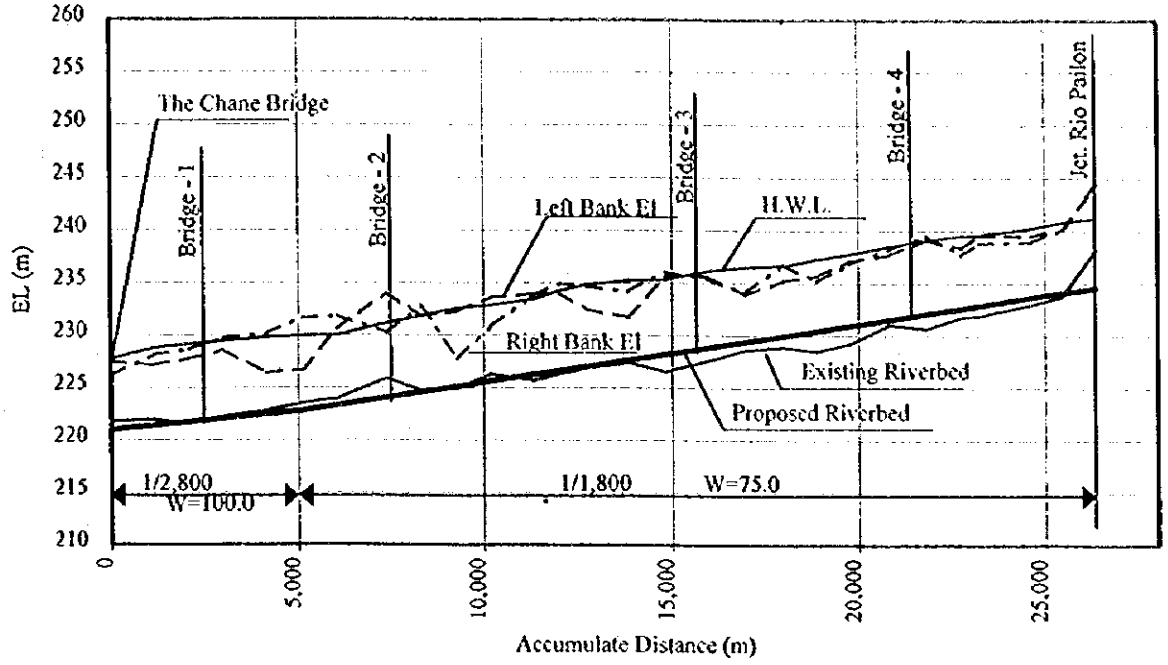


SAN JUAN-ANTOFAFASTA SCHEME

Legen
: Design Discharge (m^3/sec)
: With River Improvement
: Without River Improvement
: Rehabilitation of Drainage
: With Drainage Improvement

FIG. C.4.1 DESIGN DISCHARGE DISTRIBUTION OF 10-YEAR FLOODS

Rio Chane



Rio Pailon

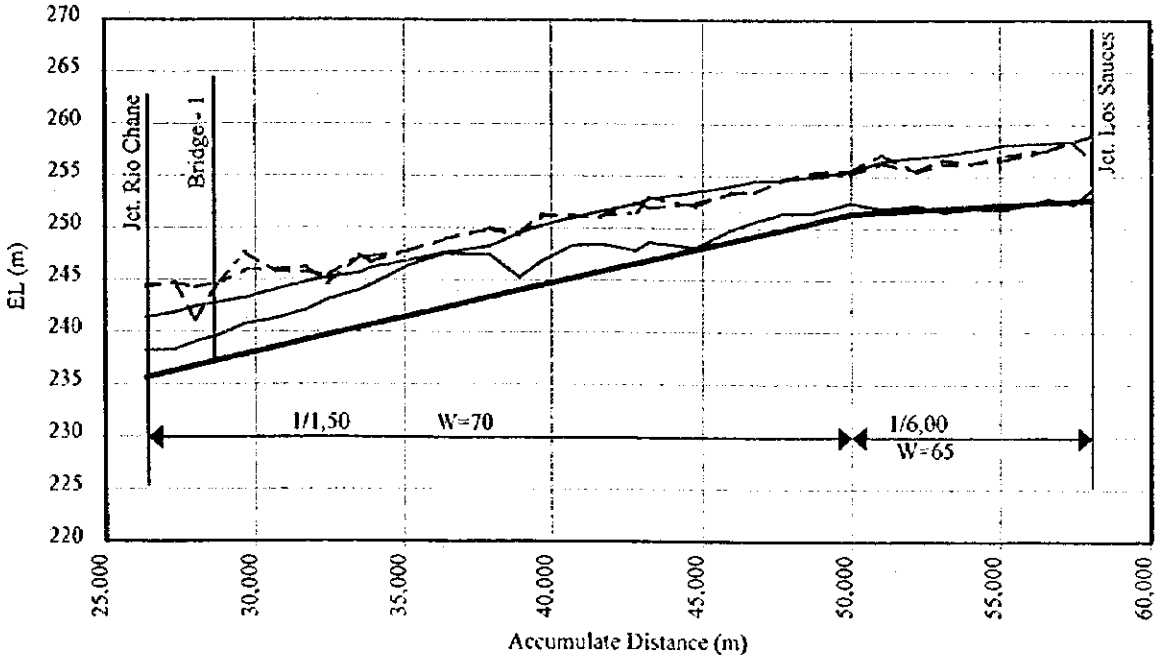
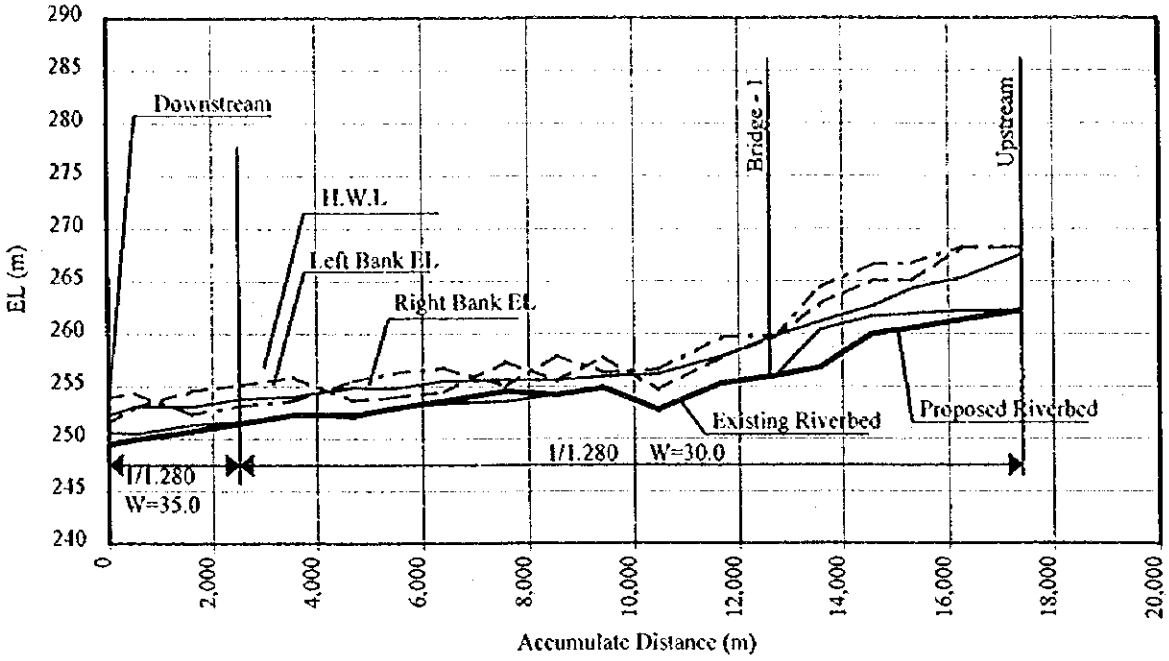


FIG. C.4.2 (1) LONGITUDINAL PROFILE OF RIO CHANE AND RIO PAILON

Arroyo Yapacanicito



Arroyo Jochi

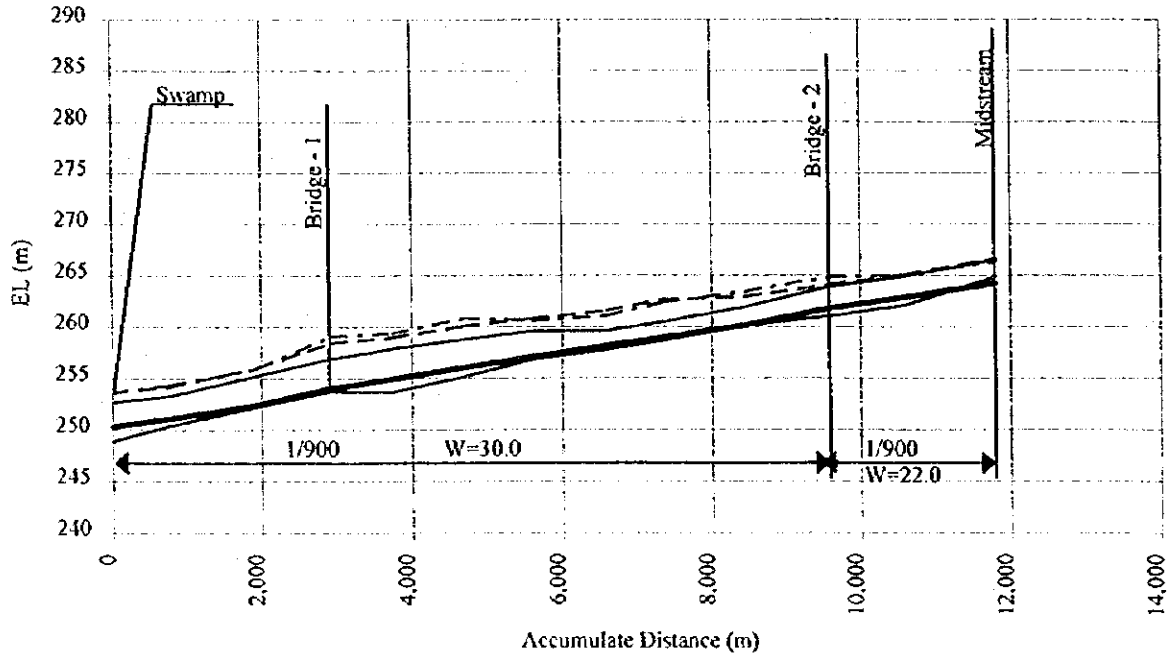


FIG. C.4.2 (2) LONGITUDINAL PROFILE OF ARROYO YAPACANICITO AND JOCHI

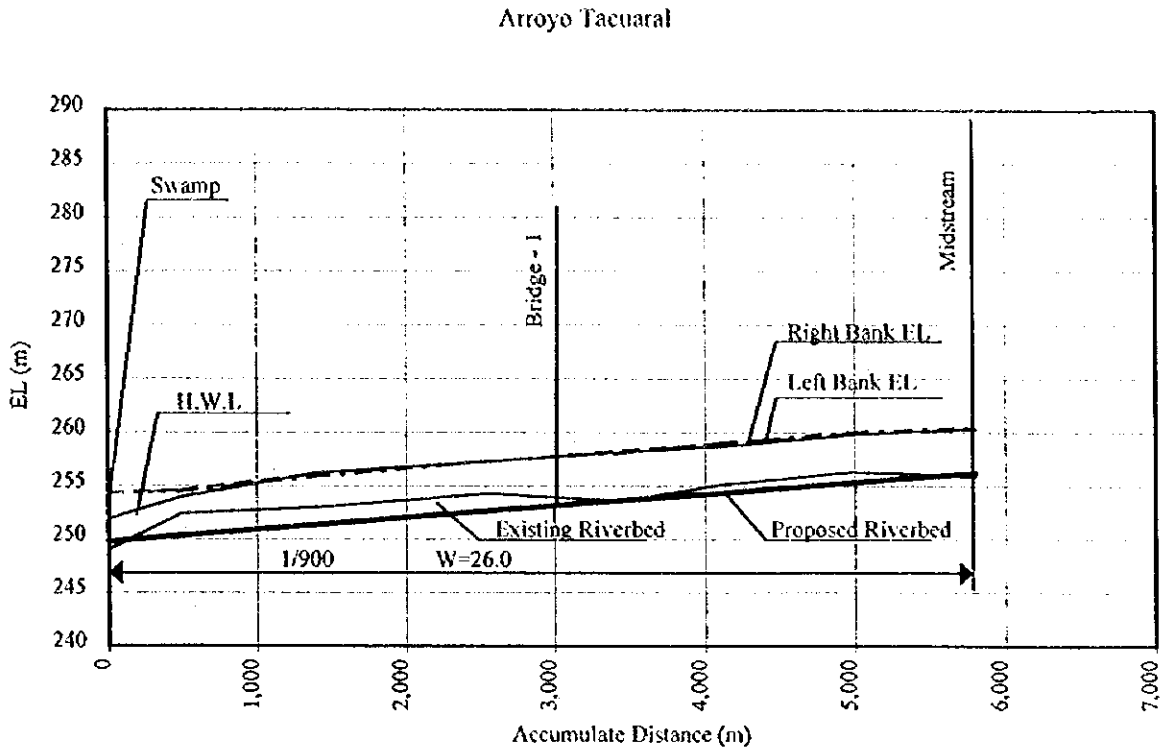
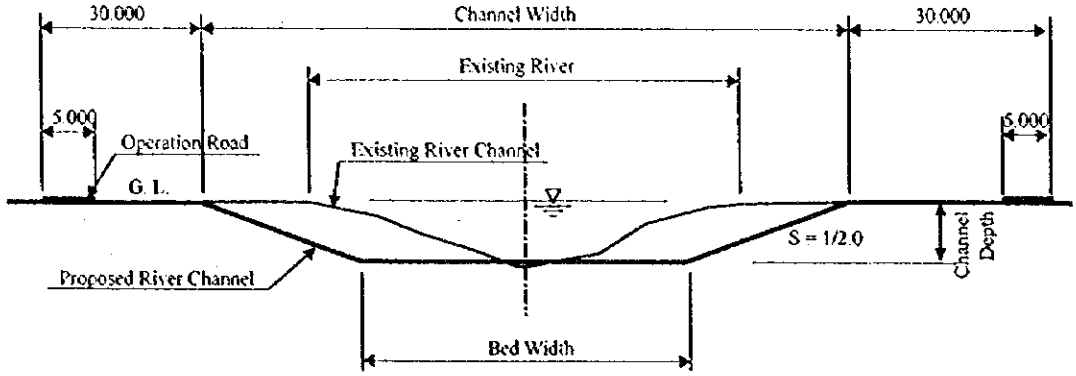


FIG. C.4.2 (3) LONGITUDINAL PROFILE OF ARROYO TACUARAL



River	Length (km)	Channel Width (m)	Bed Width (m)	Channel Depth (m)	Slope
1. Chane-Pailon					
(1) Rio Chane	**26.350**				
Jct. Rio Pirai - Jct. Qda. Chacras	5.100	100.0	76.0	6.0	1/2
Jct. Qda. Chacras - Jct. Rio Pailon	21.250	75.0	51.0	6.0	1/2
(2) Rio Pailon	**31.410**				
1) Rio Pailon (downstream)	**23.360**				
Jct. Rio Chane - National Road No.9	23.360	70.0	50.0	5.0	1/2
2) Rio Pailon (upstream)	**8.050**				
National Road No.9 - Jct. Arroyo Los Sauces	8.050	65.0	45.0	5.0	1/2
2. San Juan-Antofagasta					
(1) San Juan					
1) Arroyo Yapacanicito	**17.360**				
Downstream - Midstream	3.560	35.0	23.0	3.0	1/2
Midstream - Up stream	13.810	30.0	18.0	3.0	1/2
(2) Antofagasta					
1) Arroyo Jochi	**11.800**				
Downstream - Midstream	8.460	30.0	16.0	3.5	1/2
Midstream - Up stream	3.340	22.0	8.0	3.5	1/2
2) Arroyo Tacuaral	5.800				
Downstream - Midstream	5.800	26.0	10.0	4.0	1/2

FIG. C.4.3 STANDARD CROSS SECTION OF RIVER IMPROVEMENT

PROFILE : ROAD-CUM-EMBANKMENT

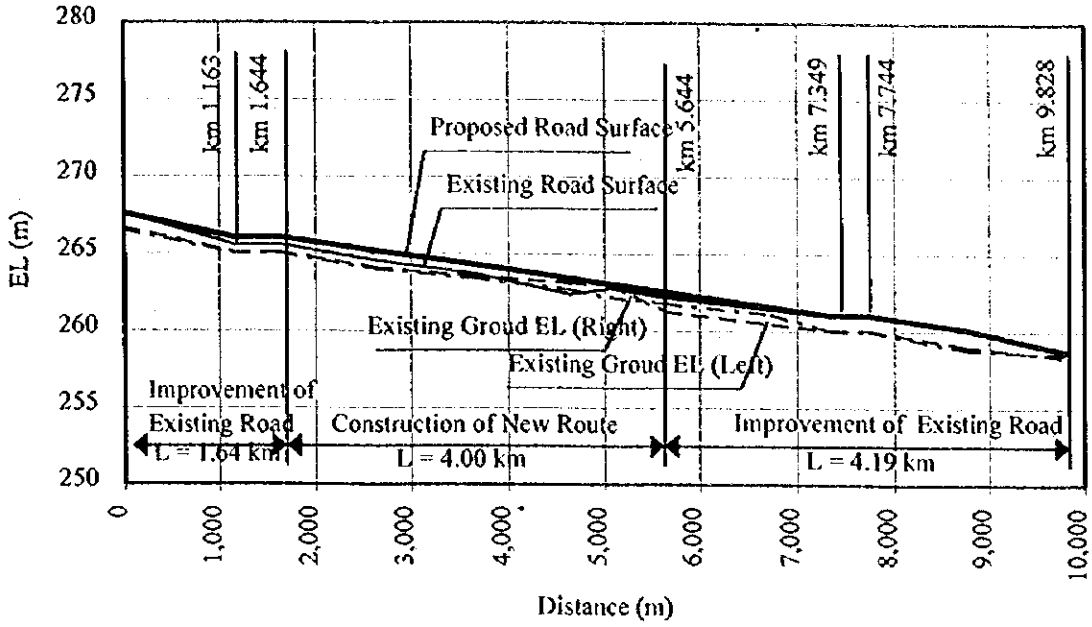
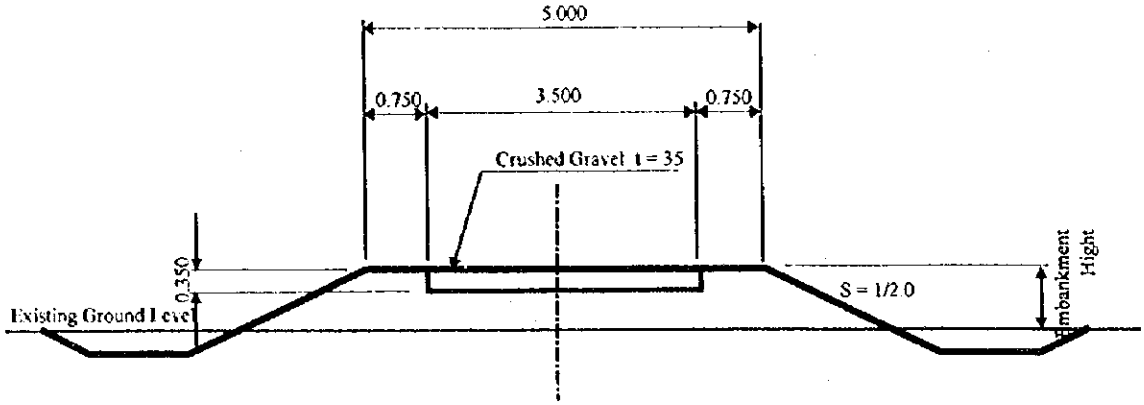


FIG. C.4.4 LONGITUDINAL PROFILE OF ROAD-CUM-EMBANKMENT



Sec. No.	Distance (m)	Existing GL (m)			Proposed Road EL (m)	Hight from Average GL
		Road Surface EL	GL (Left)	GL (Right)		
1	0	267.618	266.698	266.538	267.618	1.00
	1,163	265.607	265.092	265.069	266.080	1.00
2	1,644	265.607	265.092	265.069	266.080	1.00
3	2,644	264.582	264.112	264.032	265.201	1.13
4	3,644	263.740	263.550	263.446	264.321	0.82
5	4,644	262.408	263.138	262.708	263.441	0.52
6	5,063	262.789	263.039	262.209	263.073	0.45
7	5,644	262.208	261.288	261.808	262.562	1.01
8	6,744	261.424	260.474	261.094	261.595	0.81
	7,349	260.973	260.093	260.033	261.063	1.00
9	7,744	260.973	260.093	260.033	261.063	1.00
10	8,744	260.188	259.058	258.848	260.188	1.23
11	9,828	258.708	258.358	258.498	258.708	0.28

FIG. C.4.5 STANDARD CROSS SECTION OF ROAD-CUM-EMBANKMENT