Ministry of Agriculture
Republic of Peru

THE PREPARATORY STUDY
ON
PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU

FINAL REPORT
I-6 SUPPORTING REPORT
ANNEX-3 RIVERBED FLUCTUATION ANALYSIS

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.

PIURA
Chira
LIMA
Canete
Chincha
Pisco
ICA
Yauca
AREQUIPA
Camana/Majes
COLOMBIA
ECUADOR
BRAZIL
BOLIVIA
CHILE
PERU
SOUTH PASIFIC OCEAN
LORETO
AMAZONAS
LAMBAYEQUE
CAJAMARCA
SAN MARTIN
LA LIBERTAD
ANCASH
HUANUCO
PASCO
UCAYALI
JUNIN
MADRE DE DIOS
CUSCO
HUANCAVELICA
AYACUCHO
APURIMAC
PUNO
MOQUEGUA
TACNA
TUMBES
Boundary representation is not necessarily authoritative
Legend
International boundary
Province boundary
Project Area
Taget Rivers
National capital
Department capital
Railroad
Road
200 Km
200 Miles

Study Area

THE PREPARATORY STUDY ON PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU
FEASIBILITY STUDY REPORT
SUPPORTING REPORT

Annex-3
Riverbed Fluctuation Analysis

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CHAPTER 1 OUTLINE OF ANALYSIS

The flood management plan shall be formulated to secure the long-term flood safety with the examination of future riverbed fluctuation.

In order to clarify the aggradation and degradation of riverbed and to identify the issues for the formulation of flood management plan, the numerical simulation was conducted for the future 50-year riverbed fluctuation regarding the targeted five (5) rivers (valley).

1.1 Analysis Flow

The work flow for analysis is shown in ***Figure 1.1***.

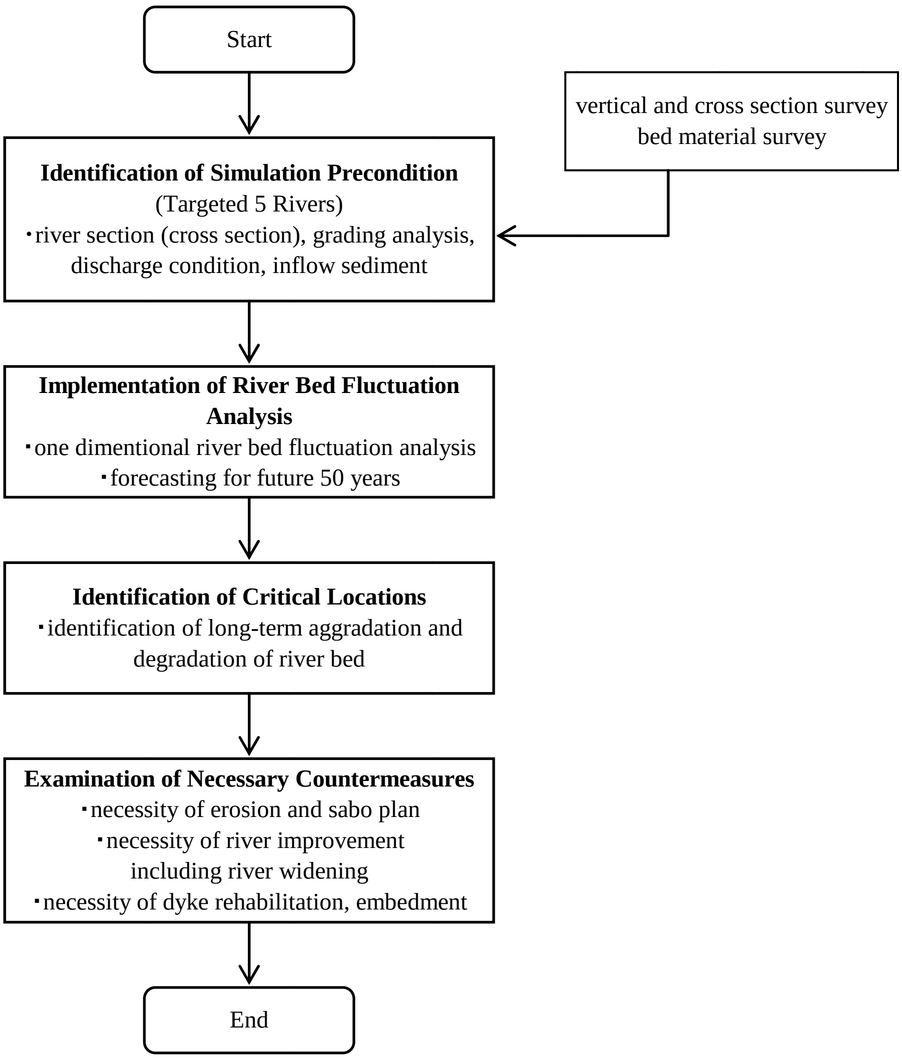


Figure 1.1 **Work Flow for Analysis**

1.2 Outline of Riverbed Fluctuation Analysis

For the implementation of riverbed fluctuation analysis, one-dimensional (1D) model was utilized. The Study aims at the long-term estimation and at grasping the aggradation and degradation of riverbed at narrowed and wide areas and the change of average bed height along with the sediment transport from the upstream. Therefore, for the practical implementation and evaluation of these parameters, the 1D analysis method is the most suitable. ***Table 1.1*** shows the outline of riverbed fluctuation analysis used in the Study.

Table 1.1 **Outline of Riverbed Fluctuation Analysis**

Items	Content
Water Flow	One-dimensional Non-uniform Flow Model
Sediment Transportation	One-dimensional Mixed Grain Size Riverbed Fluctuation Model
Bed Load	Ashida & Michiue's Bed load formula
Suspended Load	Ashida & Michiue's Suspended Load formula considering non-equilibrium of suspended sediment
Calculation Method	MacCormack Method

1.2.1 Basic Equation

Basic equation consists of equation of flowing water and sediment transportation. Regarding the flowing water, a continuous equation of water and dynamic equation are adopted, and for the sediment transport, continuous equation of moving sediment, transport equation for suspended sediment and sediment continuous equation on exchange layer. As shown in ***Figure 1.2***, The basic equation is shown as follows. The analysis area consists of three parts, which are flowing water, movable bed and fixed bed. X-axis means longitudinal direction. Z-axis means vertical direction.

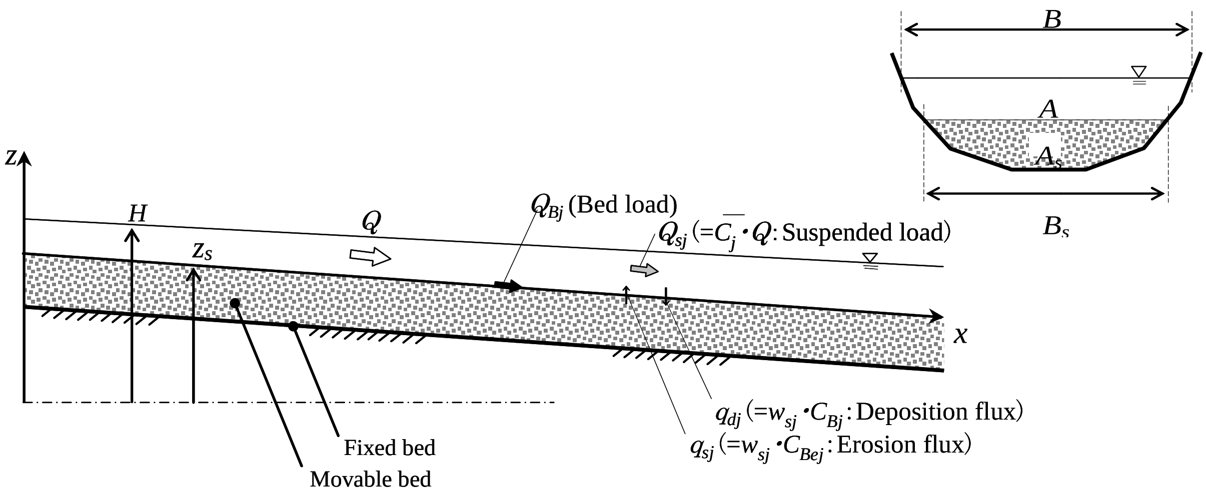


Figure 1.2 **Pattern Diagram of Riverbed Fluctuation Model**

Equation of continuity for water flow

Eq.(1)

Equation of motion for water flow

Eq.(2)

Equation of continuity for sediment flow

Eq.(3)

Equation of transportation for suspended sediment load

Eq.(4)

Equation of continuity for exchange layer

in the case of aggradation

Eq.(5)

in the case of degradation

Eq.(6)

: erosion flux Eq.(7)

Where, A=cross-sectional area of water flow (m2), Q=flow rate (m3/s), t=time (s), x=longitudinal distance (m), z=vertical height from reference level (m), g=gravitational acceleration (m/s2), H=water surface height from reference level (m), As=cross-sectional area of riverbed (m2), λ=porosity of riverbed, Qbj=bed load (m3/s), qsj=erosion flux of suspended load (m/s), qdi=deposition flux of suspended load (m/s), wsj=particle settling velocity (m/s), CBj=concentration of bottom layer (m3/m3), C=cross-sectional average concentration of suspended sediment, R=hydraulic radius (m), CBej=sediment concentration at reference level (m3/m3), Psj=grain size distribution of exchange layer, Asa=cross-sectional area of exchange layer (m2), Asb= cross-sectional area of riverbed except for exchange layer (m2), Ps1j=Psj at previous time (t0) (t0=t-dt), P0j= grain size distribution of sub layer under exchange layer, a= thickness of exchange layer (m), Bsu=cross-sectional width which erosion and deposition can occur (m), n=Manning's roughness coefficient.

1.2.2 Calculation Procedure

The general procedure of riverbed fluctuation calculation is shown in ***Figure 1.3***. At first, resulting in the calculation of flow fields, the water surface profile and longitudinal distribution of flow rate are identified, and the amount of sediment transport (bed load and suspended load) is estimated based on these hydraulic quantity and theoretical formula (ex. Ashida & Michiue's formula). Then, by the riverbed fluctuation calculation with the amount of sediment transport, the riverbed form is realized. Finally, by using the calculated riverbed form and the amount of sediment transport, the particle size distribution of exchange layer is estimated.

In the actual calculation of flow field and the amount of sediment transport, several disparities will be identified, but in principle, the riverbed fluctuation calculation is conducted with the above procedure.

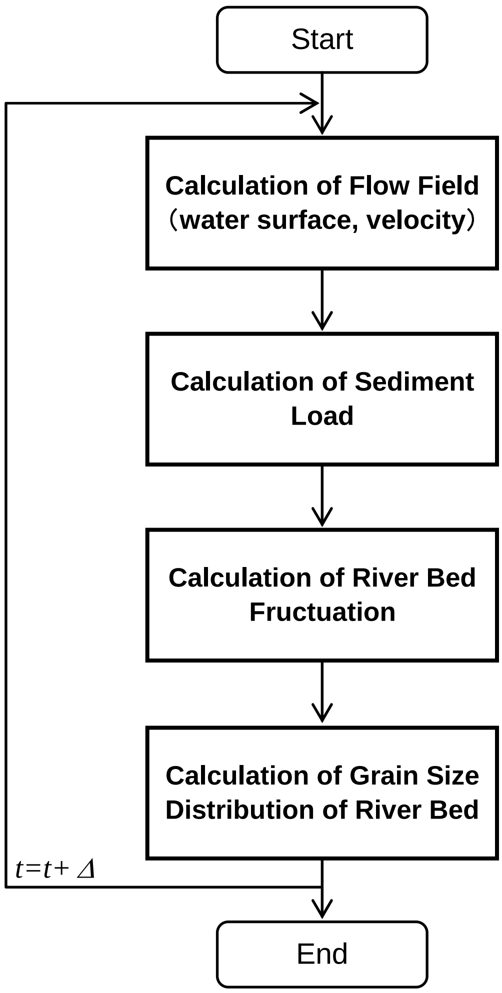


Figure 1.3 **Main Procedure of Riverbed Fluctuation Calculation**

1.3 Main Assumption for Calculation

1.3.1 Topographic Condition

(1) Specification of Topographic Data

As a result of field survey, it was identified that the topographic data in targeted five (5) rivers to be used for the analysis is the only date obtained from the river survey conducted by JICA. Therefore, for the riverbed fluctuation analysis, these survey results were used in principle. The specifications of survey data for each river are shown in ***Table 1.2***.

Table 1.2 **Specifications of Longitudinal and Cross Section Survey**

River	Length of Section	Interval	Implementation Date
Chira	99.5km	500m	December, 2010
Canete	32.5km	500m	November, 2010
Chincha	46.0km	500m	November, 2010
Pisco	45.0km	500m	November, 2010
Yauca	46.0km	500m	November, 2010
Majes-Camana	115.0km	500m	September, 2010

(2) Average Height of Riverbed

Since the average riverbed height is estimated with one-dimensional riverbed fluctuation analysis, as an initial condition of calculation, the average height of current river channel shall be identified. The average height of each targeted river was clarified based on the topographic survey results.

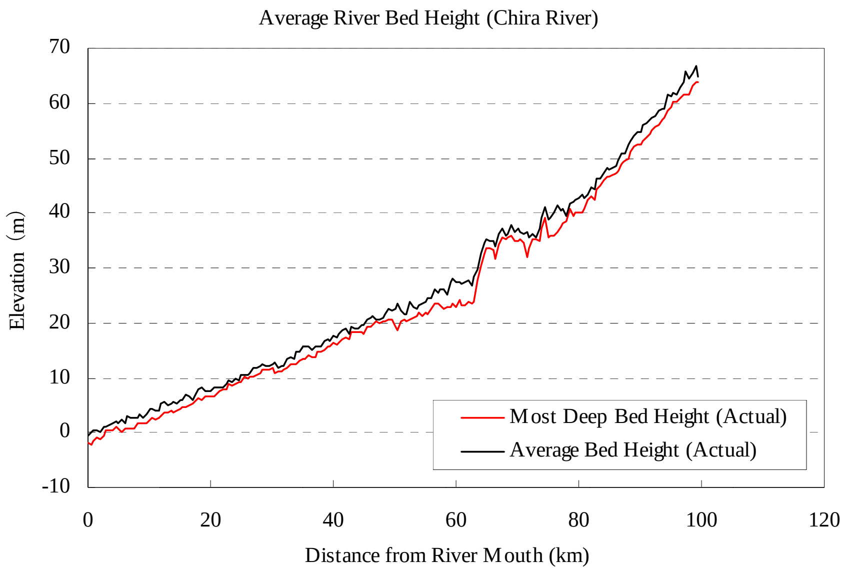


Figure 1.4 **Average Height of Riverbed (Chira River)**

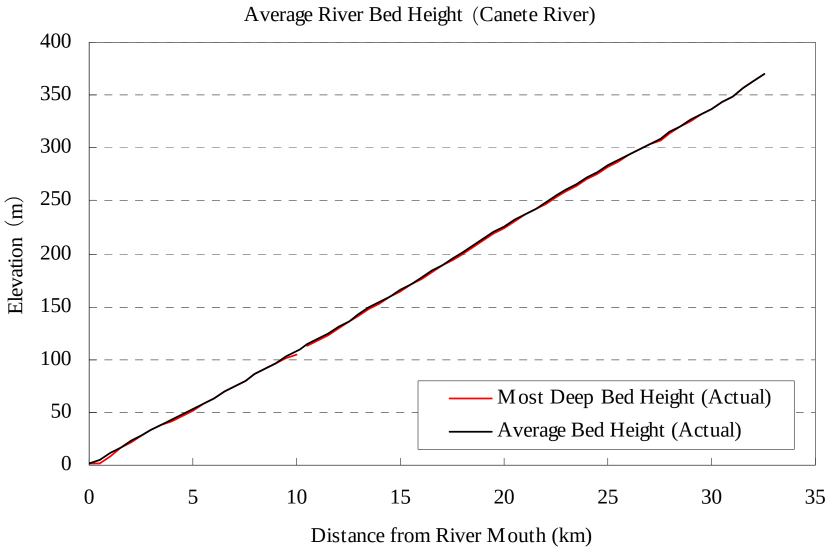


Figure 1.5 **Average Height of Riverbed (Canete River)**

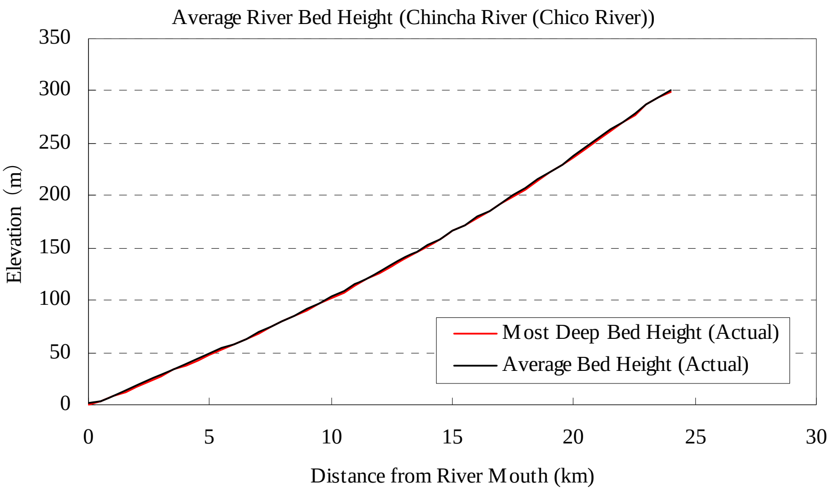


Figure 1.6 **Average Height of Riverbed (Chincha River (Chico River))**

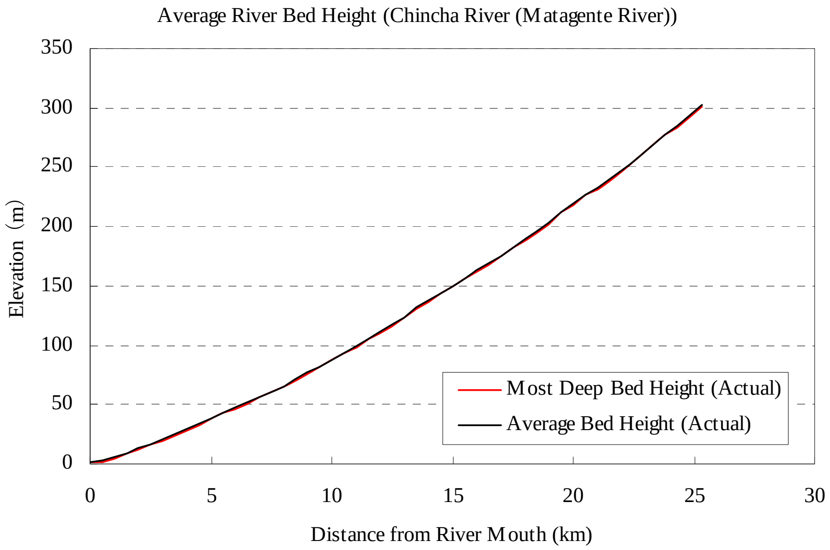


Figure 1.7 **Average Height of Riverbed (Chincha River (Matagente River))**

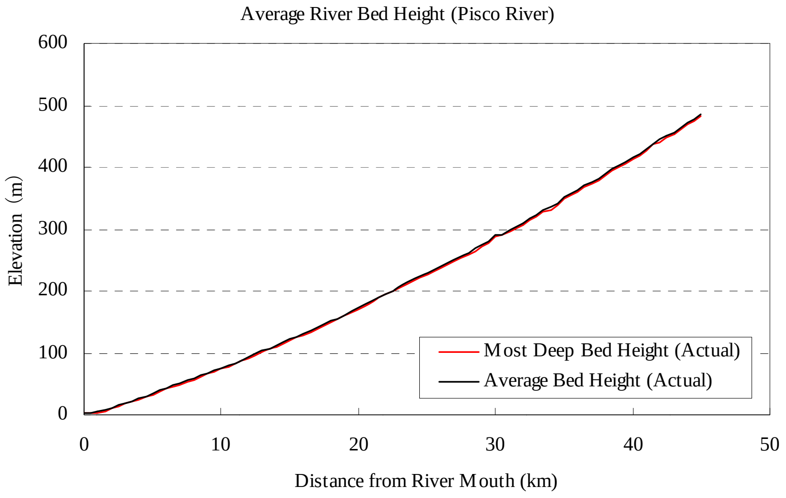


Figure 1.8 **Average Height of Riverbed (Pisco River)**

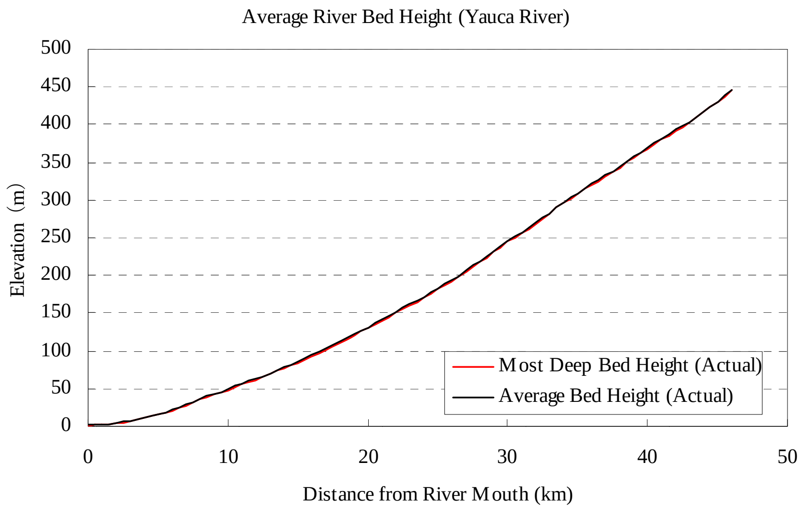


Figure 1.9 **Average Height of Riverbed (Yauca River)**

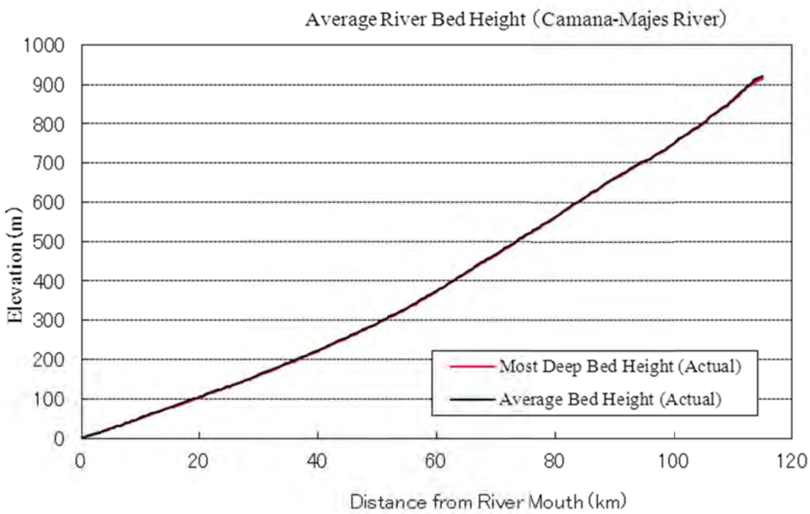


Figure 1.10 **Average Height of Riverbed (Majes-Camana River)**

1.3.2 Grain Size Distribution

Regarding the grain size distribution for bed materials, the condition of grain size distribution was determined by the results of survey in each river. The survey overview and results are shown as follows.

(1) Survey Overview

The overview of bed material survey is shown in ***Table 1.3***. Chincha River is divided into two (2) rivers, the site survey was conducted in both rivers as well.

Table 1.3 **Overview of bed material survey**

River	Number of Survey Location	Survey Location	Implementation Date
Chira	4 locations	4k,42k,60k,93.5k	December, 2010
Canete	4 locations	3k,12.5k,18k,25.5k	November, 2010
Chincha	8 locations (Chico: 5 locations) (Matagente: 3 locations)	Chico: 4k,11k,18k,21.5k,24.5k Matagente: 4k,12k,18k	November, 2010
Pisco	4 locations	5.5k,20k,35k,43k	November, 2010
Yauca	4 locations	5.5k,19k,29k,42k	November, 2010
Majes-Camana	4 locations	7k,30k,55k,80k,100k	September, 2010

(2) Survey Method

The sampling areas with 1m × 1m are set at each site, the riverbed materials were gathered from the 1m depth from the surface. The size and weight of materials with grain size of more than 76.2mm were measured at site, and the grain size distribution of materials with more than 76.2mm was measured by screening test at laboratory. The grain size distribution was completely identified with combination of these results. The site survey is shown in ***Figure 1.11*** to ***Figure 1.16*** and follows.

Figure 1.11 **Riverbed Material Sampling Survey (Chira River No. 3)**

Figure 1.12 **Riverbed Material Sampling Survey (Canete River No. 4)**

Vista panorámica del sector explorado

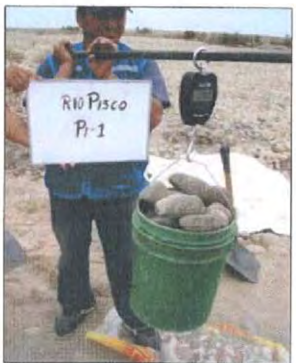
Llenado de agua a la calicata para determinar el volúmen excavado

Materiales extraidos de la excavación de la calicata

Figure 1.13 **Riverbed Material Sampling Survey (Chincha River No. 4)**

Vista panorámica del sector explorado

Materiales extraidos de la excavación de calicata



Determinación del peso por tamaños de los materiales extraídos de la calicata

Llenado de agua a la calicata para determinar el volúmen excavado

Figure 1.14 **Riverbed Material Sampling Survey (Pisco River No. 1)**

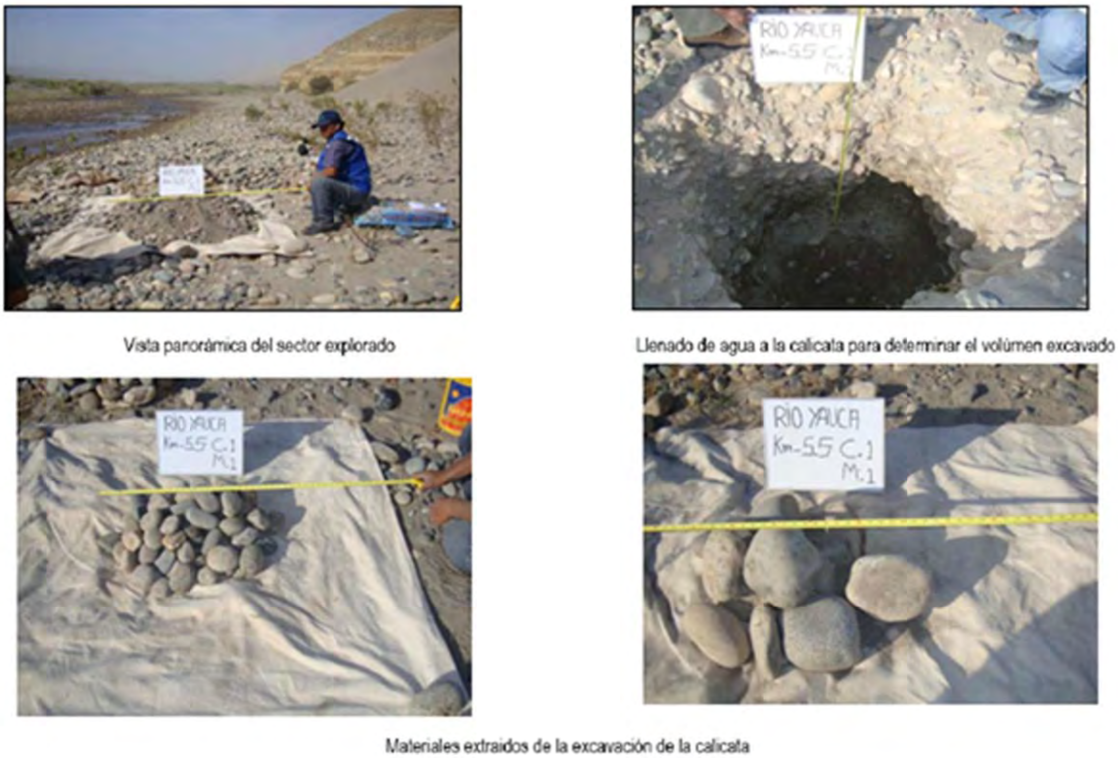


Figure 1.15 **Riverbed Material Sampling Survey (Yauca River No. 1)**

Figure 1.16 **Riverbed Material Sampling Survey (Majes-Camana River No. 2)**

(3) Survey Result

The survey results are shown from ***Figure 1.17*** to ***Figure 1.23*** below.

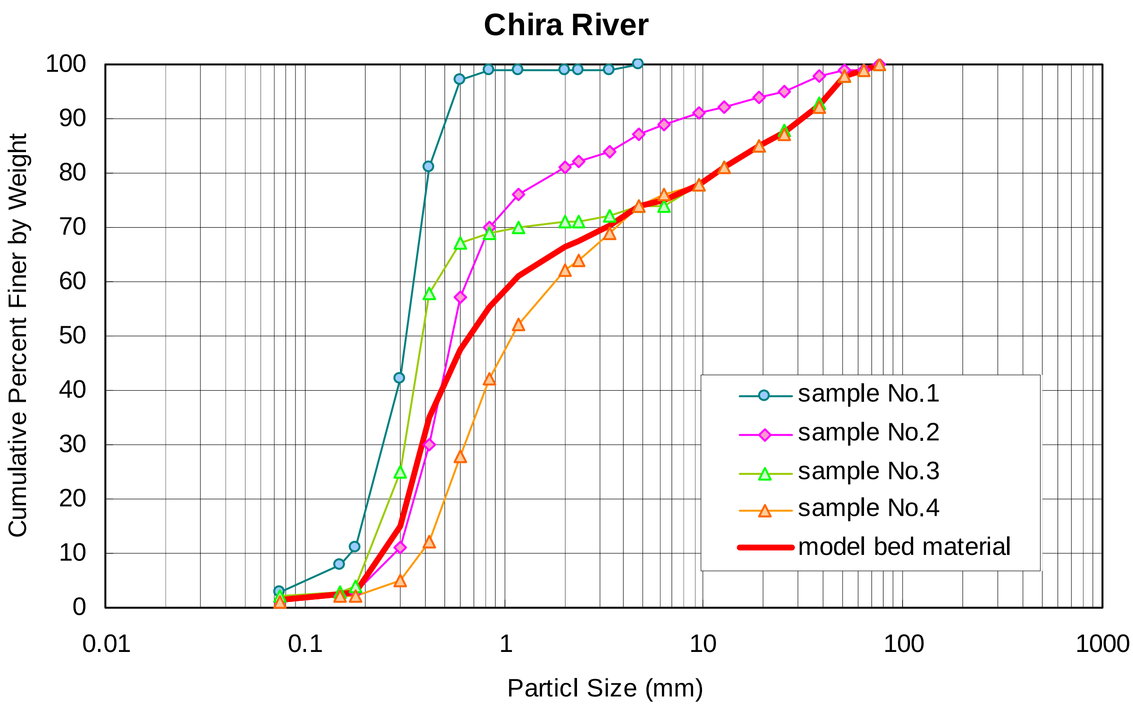


Figure 1.17 **Survey Result of Grain Size Distribution (Chira River)**

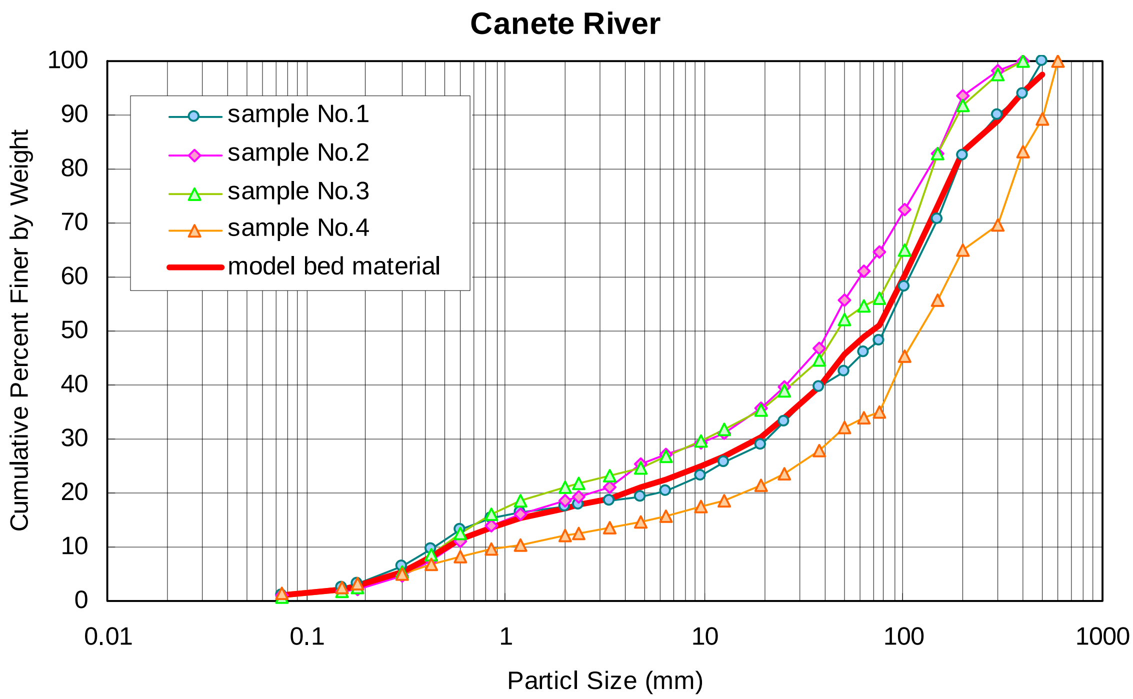


Figure 1.18 **Survey Result of Grain Size Distribution (Canete River)**

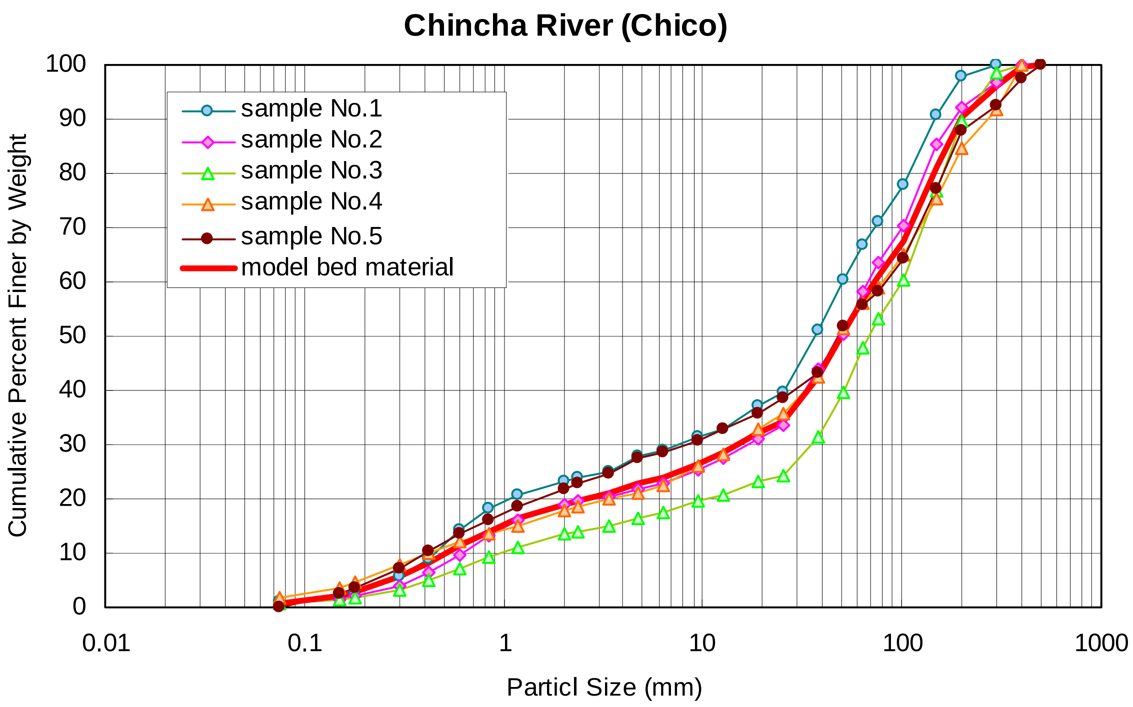


Figure 1.19 ***Survey Result of Grain Size Distribution (Chincha River (Chico River))***

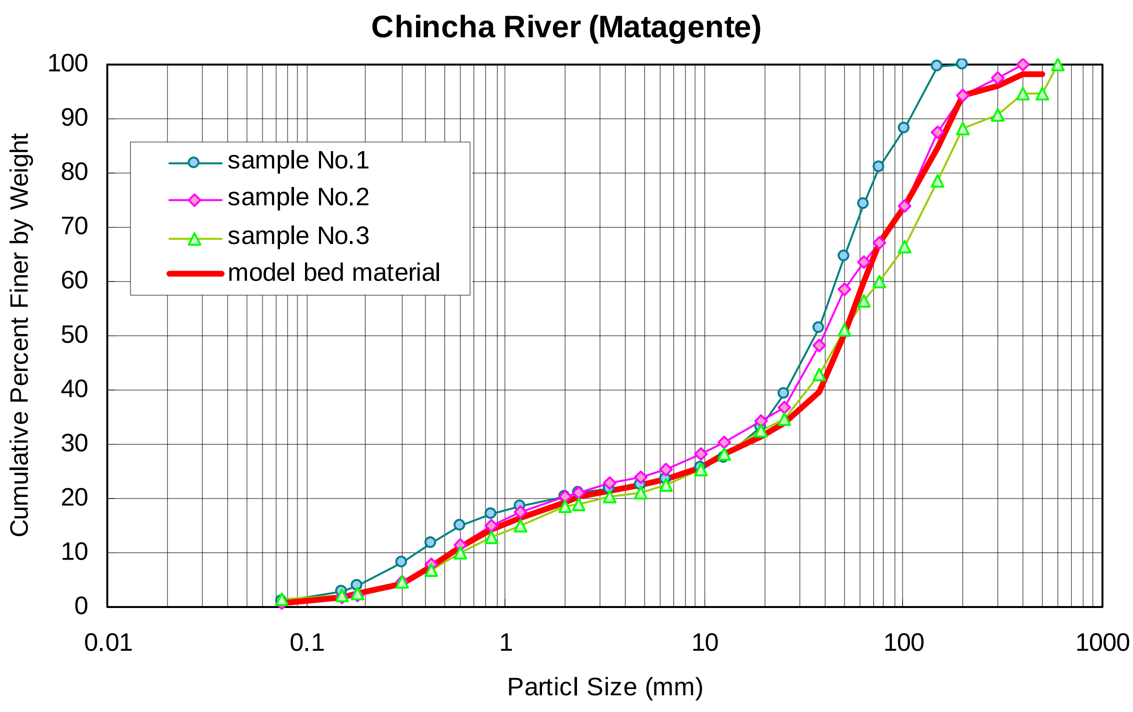


Figure 1.20 **Survey Result of Grain Size Distribution (Chincha River (Matagente River))**

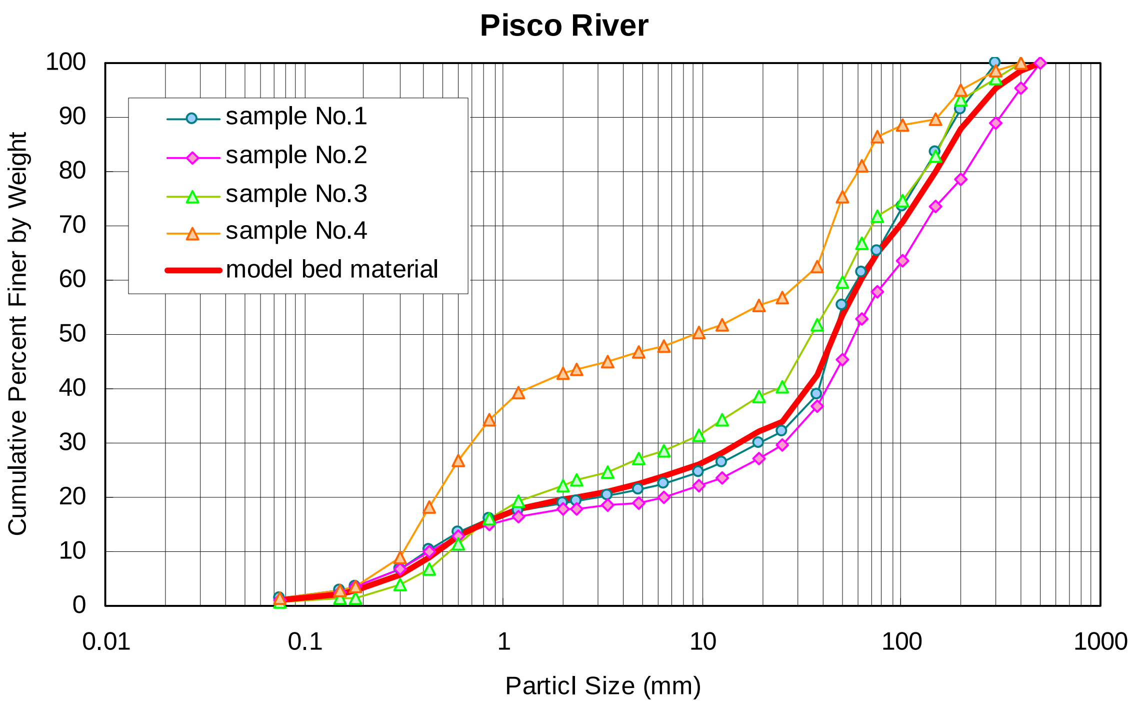


Figure 1.21 **Survey Result of Grain Size Distribution (Pisco River)**

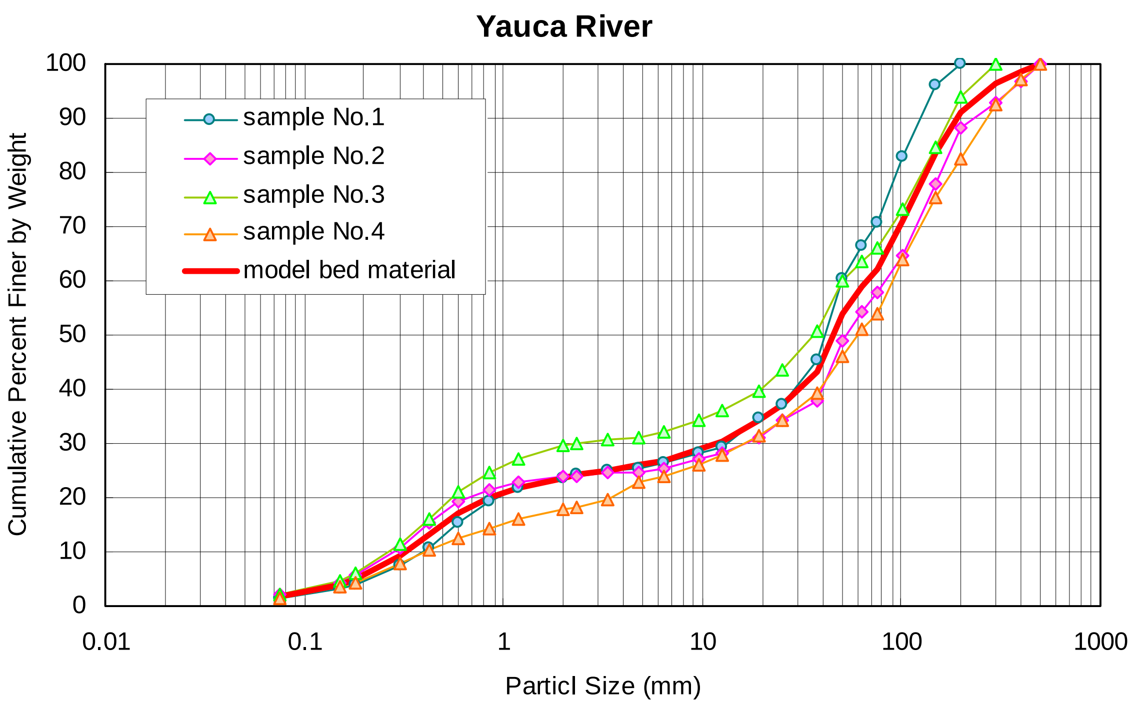


Figure 1.22 **Survey Result of Grain Size Distribution (Yauca River)**

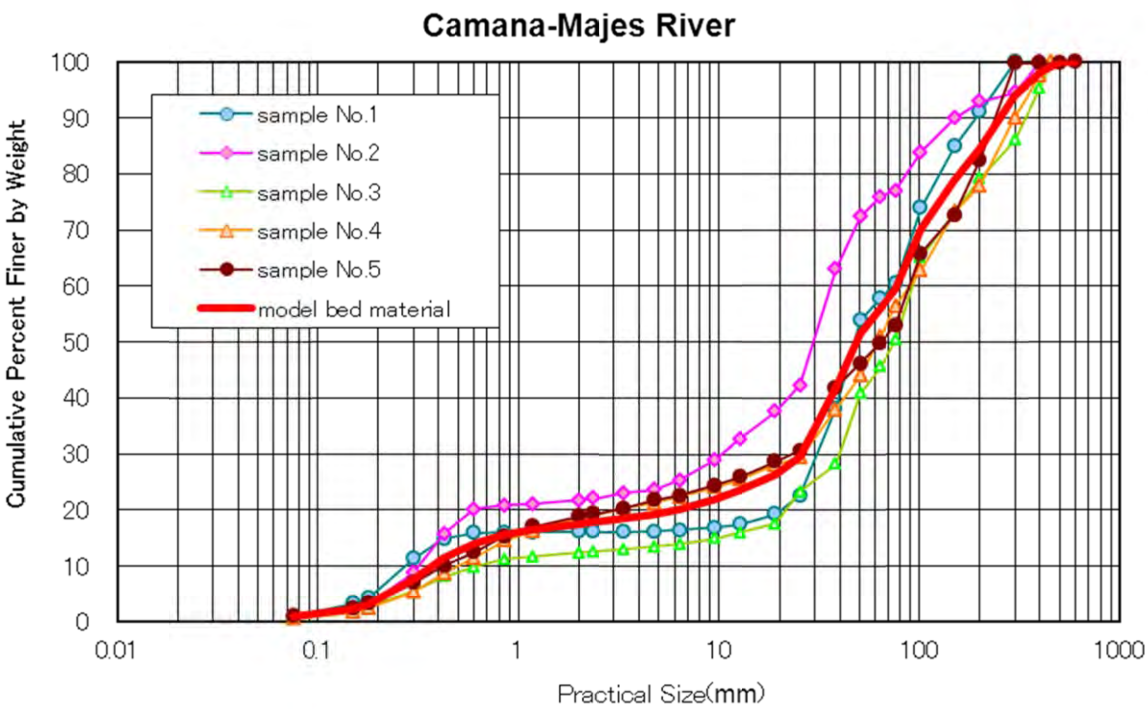


Figure 1.23 **Survey Result of Grain Size Distribution (Majes-Camana River)**

(4) Grain Size Segment used for Calculation

By using the riverbed fluctuation analysis, the movement and deposit of various sizes of grains on actual riverbed will be analyzed. However, for the implementation of analysis, the grain size is categorized into ten (10) classes, and the representative size of each class is determined. In the analysis, based on the results of river bed material sampling survey in targeted five (5) rivers, the size classification was determined as follows. In addition, since the percentage of grain with more than 500mm is high in Canete River, the classification with more than 500mm was additionally set.

Table 1.4 **Size Classification of Grain Size Distribution used for Analysis**

Classification		Size Classification (mm)			Representative Grain Diameter (mm)
Grain Size 1	Boulders	500.0	～	75.0	193.6
Grain Size 2	Cobbles	75.0	～	22.4	41.0
Grain Size 3	Coarse Gravel	22.4	～	6.69	12.2
Grain Size 4	Fine Gravel	6.69	～	2.00	3.66
Grain Size 5	Coarse Sand	2.000	～	0.669	1.16
Grain Size 6	Medium Sand	0.669	～	0.224	0.39
Grain Size 7	Fine Sand	0.224	～	0.075	0.13
Grain Size 8	Silt/Clay	0.075	～		0.075

1.3.3 Assumption on River Flow Volume

In each river, the river flow volume has been periodically observed; especially annual peak flow is recorded for the long term (see in ***Table 1.5***). However, the detailed chronological data is not well organized. Therefore, the results of runoff analysis with probable rainfall in the Study (see in **Annex-1** report) are identified as a representative time-series flood hydrograph. Moreover, the supplementary the hydrograph is used as an assumed river flow volume to match the peak flow of representative hydrograph with annual peak flow. The observed data of annual peak flow used for the analysis is shown from ***Figure 1.24*** to ***Figure 1.30***.

Table 1.5 **Condition of River Flow Observation and Adoption to Analysis**

River	Period of Data Availability	Adoption Period for Analysis	Remarks
Chira	Inflow Volume into Poechos Dam (23 years)	1975-1997 (23 years)×2 times + 1975-1978 (4 years)	Since Poechos dam exists in 99.5km, the outflow discharge of the dam will be used for analysis. In addition, inflow volume of the dam will be used for setting the flow volume of tributaries.
	Outflow Discharge from Poechos Dam (23 years)	Ditto	
Canete	1926-2006 (74 years)	1957-2006 (50 years)	Using latest 50 years
Chincha	1950-2006 (57 years)	1957-2006 (50 years)	
Pisco	1933-2008 (76 years)	1959-2008 (50 years)	
Yauca	1961-2008 (48 years)	1961-2008 (48 years) + 1961-1962 (2 years)	
Majes-Camana	1971-2002 (32 years)	1971-2002 (32 years) + 1971-1988 (18 years)	

* Used data is annual peak flow

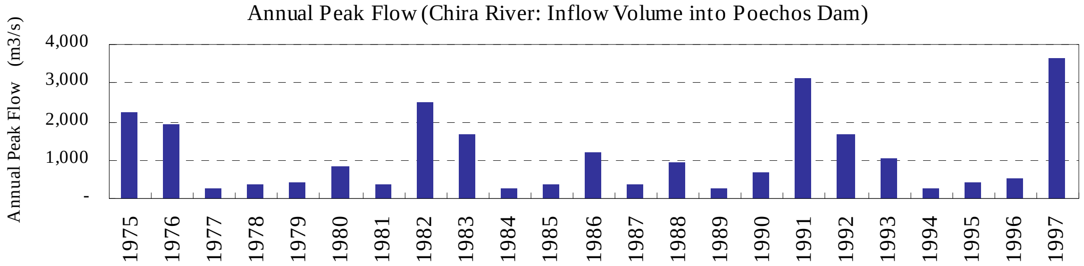


Figure 1.24 **Annual Peak Flow (Observed Data: Chira River: Inflow Volume into Poechos Dam)**

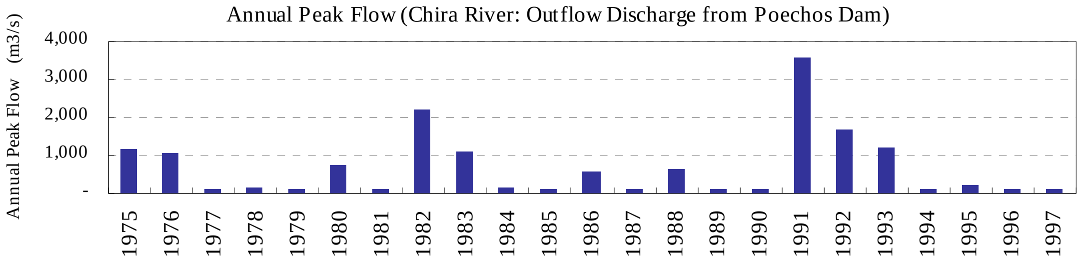


Figure 1.25 **Annual Peak Flow (Observed Data: Chira River: Outflow Discharge from Poechos Dam**

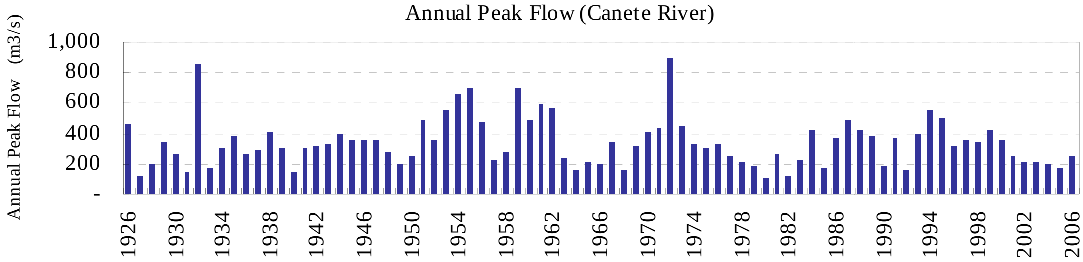


Figure 1.26 **Annual Peak Flow (Observed Data: Canete River)**

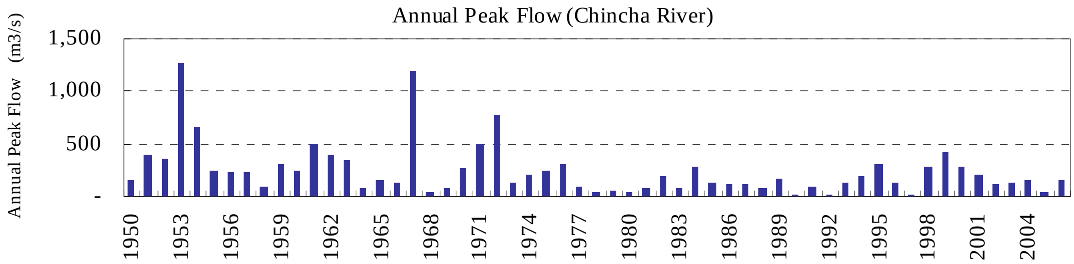


Figure 1.27 **Annual Peak Flow (Observed Data: Chincha River)**

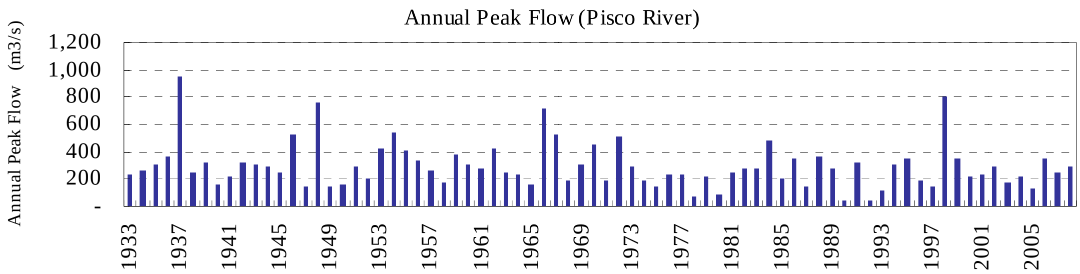


Figure 1.28 **Annual Peak Flow (Observed Data: Pisco River)**

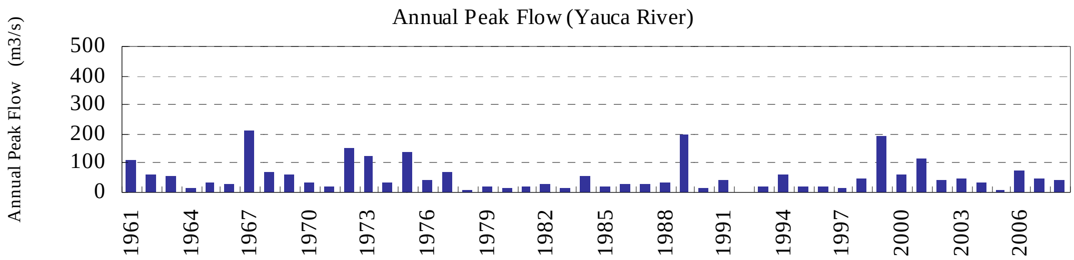


Figure 1.29 **Annual Peak Flow (Observed Data: Yauca River)**

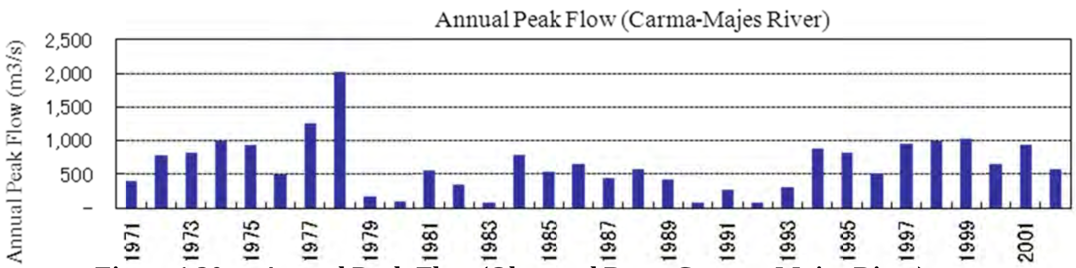


Figure 1.30 **Annual Peak Flow (Observed Data: Camara-Majes River)**

1.3.4 Assumption of Inflow Sediment

(1) Estimation Method

The following describes the set of inflow sediment volume from the upstream, which is important factor for analysis. The method for setup of inflow sediment volume is considered as two (2) alternatives: 1) estimation by existing sediment discharge equation and 2) estimation based on actual sedimentation data in the dam. As for the first method, by substituting the obtained parameters on river course features (shape, bed slope, bed material) into the equation, the inflow sediment volume of each targeted flow will be estimated. On the other hand, the second method using the actual sedimentation data is an analysis method to estimate sedimentation volume inflowing from the upstream based on the annual observed data at Poechos dam which is constructed in Chira River.
In this Study, the riverbed fluctuation analysis was conducted by using both methods, and assumption of inflow sediment was defined with these methods. As a result of analysis, it was realized that the actual river bed condition was reproduced by using the first method. Therefore, the assumption of inflow sediment defined by the first method was adopted for the five (5) targeted rivers.
In addition, since Poechos dam exists at the upstream of Chira River, it was assumed there was no sediment flowing into the river. However, relatively big tributary named Chipillico river flows into the river just downstream of the dam, the sediment inflow volume from the tributary was considered in analysis.

Table 1.6 **Assumption of Sediment Discharge at Upstream**

River	Estimation Method of Sediment Discharge	Remarks
Chira	zero (due to dam existence)	Estimated by equilibrium condition for tributary
Canete	Theoretical formula	Estimated by sensitivity analysis
Chincha	same as above	Equilibrium condition *
Pisco	same as above	same as above
Yauca	same as above	same as above
Majes-Camana	same as above	same as above

* Equilibrium condition: moving maximum sediment volume based on river course feature and flow condition at targeted locations

(2) Set of Inflow Sediment Volume in Canete River

Regarding the Canete River, since the remarkable riverbed fluctuation at upstream was estimated by setting the inflow sediment volume from the upstream as equilibrium sediment volume, the riverbed fluctuation analysis was conducted on the following three (3) cases. The results of the analysis will be described later.

Case	Inflow Sediment Volume	Remarks
Case 1	116,000 m^3/year	equilibrium sediment volume
Case 2	60,000 m^3/year	Half of equilibrium sediment volume
Case 3	30,000 m^3/year	Quarter of equilibrium sediment volume

1.3.5 Other Assumptions

The other assumptions for analysis are summarized in ***Table 1.7***.

Table 1.7 **Other Assumptions for Analysis (Targeted Six Rivers)**

Item	Assumption	Remarks
Time Unit	Δt=2sec	
Spatial Unit	Δx=500m (Chira), 100m (other than Chira)	
Number of Representative Grain Diameter	9 grain diameter (Canete) 8 grain diameter (other than Canete)	
Upstream End Flow	50-year data based on observed discharge volume (annual peak flow) of each river	
Downstream End Water Level	Normal depth	
Tributary Inflow	<u>Chira river:</u> considering the relatively huge tributary (Chipillico river) flowing into the river just downstream of Poechos dam <u>Other than Chira river:</u> without considering any tributaries since there is no big tributary in the targeted area.	
Free Volume	0.4 (constant)	Average size of sand and gravel
Roughness Coefficient	n=0.03 (Chira) n=0.05 (other than Chira river)	Riverbed materials are fine compared with others

CHAPTER 2 RESULTS OF ANALYSIS

The results of riverbed fluctuation analysis on six (6) targeted rivers are described below.

2.1 Results of Analysis (Comparison of Six (6) Rivers)

At first, regarding the analytic results of targeted six (6) rivers for future 50 years, the preliminary comparative study was conducted as shown in ***Table 2.1, Table 2.2, Figure 2.1*** and ***Figure 2.2***. Based on the results, the following characteristics are identified.

- In the five (5) rivers excluding Chira River, the average riverbed height aggrades, indicating these rivers tend to deposit the sediment. The total inflow sediment volume and total riverbed fluctuation level are higher in Majes-Camana, Chincha and Pisco Rivers than those in Canete and Yauca Rivers. In addition, since the dam (Poechos dam) exists upstream of targeted river section and the sedimentation condition has not reached to the design maximum level, almost all the sediment produced at the upstream is caught by the dam. Therefore, the riverbed just downstream of the dam tends to decrease.
- Among six (6) rivers, Majes-Camana, Chincha and Pisco Rivers have a strong trend to accelerate the deposition of sediments flowed in from upstream. This trend can be viscerally understood through the interviews in the survey areas and comparison of riverbed conditions (See in Photo 2.1-1). Inflow sedimentation of Yauca River is smaller than that of others. Because flow volume of the river, which is external force to make the sediment move, is comparatively smaller than others.
- It was realized that the inflow sediment volume in Canete River was small even though the catchment area of the river was large. This is the comprehensive evaluation based on the site survey and riverbed fluctuation analysis. The details are described later.
- The scale of inflow sedimentation of Majes-Camana River is bigger than that of others, because the river basin area is larger and scale of flood is rather bigger than other rivers, and the large amount of sediments can be flowed to downstream. In addition, although the amount of riverbed fluctuation (sediment volume) is large, the average riverbed fluctuation height (range) is about 0.2m for 50 years. The fluctuation height (range) is smaller than Chincha River.

Table 2.1 **Result of Riverbed Fluctuation Analysis**

River	Total Inflow Sediment Volume (10^3m^3)	Annual Inflow Sediment Volume (10^3m^3)	Total Bed Fluctuation (10^3m^3)	Average Bed Fluctuation (m)	Remarks
Carete	3,000	60	673	0.2	
Chincha	5,759	115	2610	0.5	Total inflow to Chico and Matagente Rivers
Pisco	8,658	173	2571	0.2	
Yauca	1,192	23.84	685	0.2	
Chira	5,000	100	- 1,648	- 0.01	Inflow sediment to main river was assumed to be zero due to dam existence.
Majes-Camana	20,956	419	5,316	0.2	

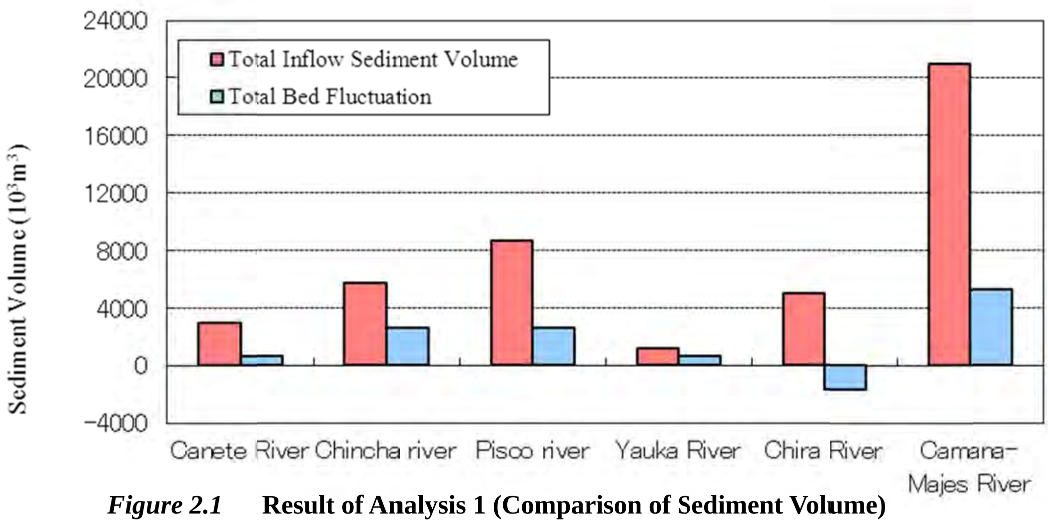


Figure 2.1 **Result of Analysis 1 (Comparison of Sediment Volume)**

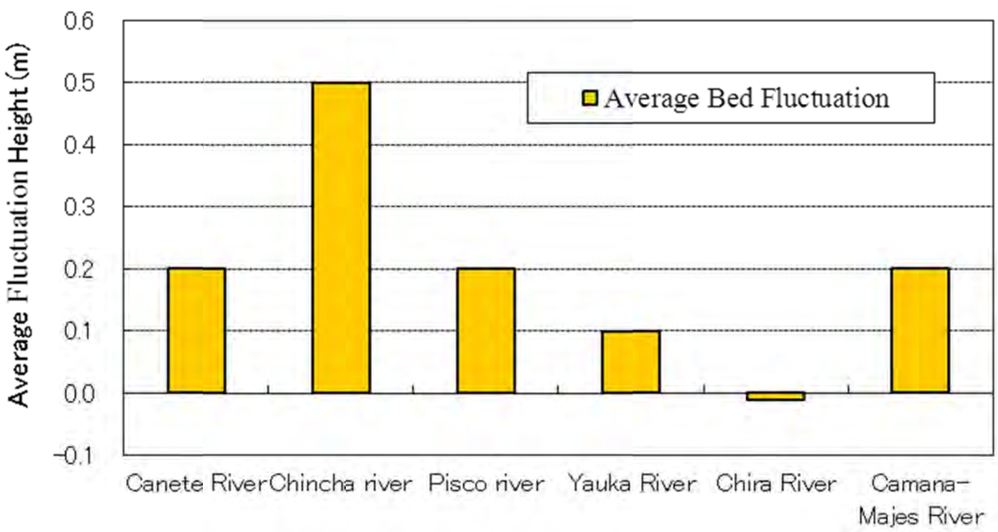
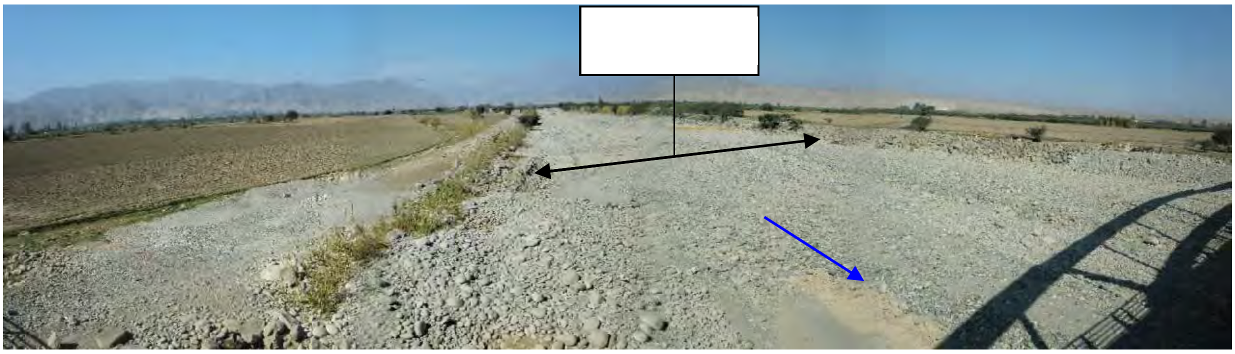


Figure 2.2 **Result of Analysis 2 (Comparison of Riverbed Fluctuation Height)**

Chancha River（Matagente 16km）River channel buried by Sediment



Pisco River (14.5km) Sedimentation of upstream of narrow channel

Majes-Camana River (60km）Sedimentation in wide channel

Figure 2.3 **Situation of Remarkable Riverbed Aggradation**

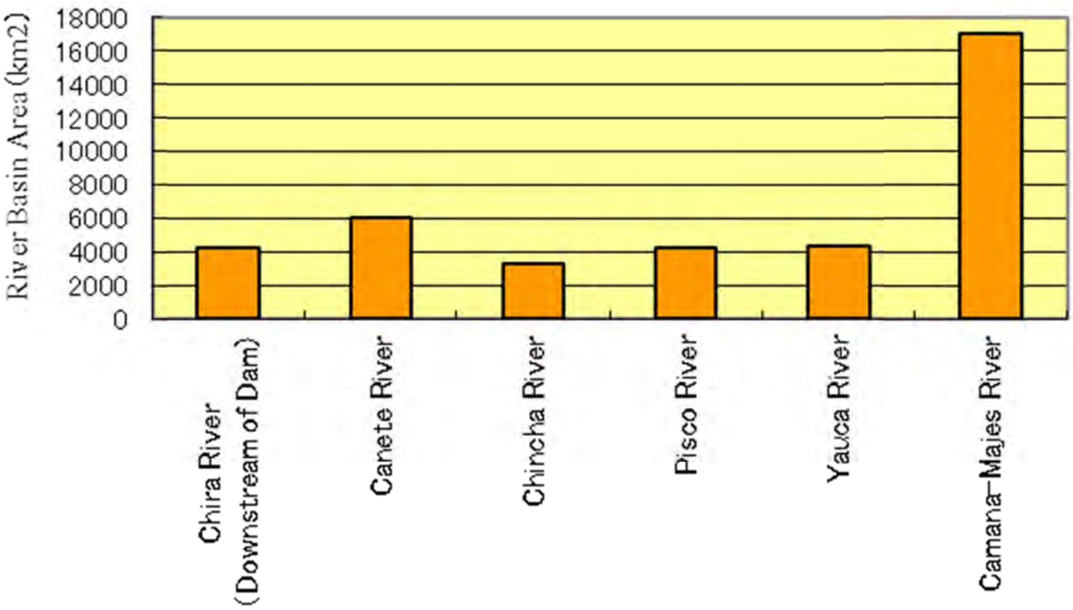


Figure 2.4 **Comparison of River Basin Area**

2.2 Future Trend of Riverbed Fluctuation in Each River

The results of riverbed fluctuation analysis in each river are shown from ***Figure 2.6*** to ***Figure 2.16***.

2.2.1 Chira River

Based on the results of analysis in Chira River, the followings are indicated.

- Since the sediment inflow is blocked by the Poechos Dam, the remarkable riverbed degradation can be identified just downstream of the dam.
- On the other hand, the sediment transport from the upstream and tributaries is deposited at the Sullana Weir located at the middle stream, the riverbed aggradation can be identified. From the short-term point of view, problems led by the sedimentation is not serious, however, there is possibility that the flow capacity will be insufficient in the future without the riverbed excavation.
- In the downstream river section, the extraordinary riverbed fluctuation will be not occurred. However, in case of big flood occurrence, the riverbed degradation will be happened at the several sections. These results correspond with the information obtained from the interview in the survey, and effectiveness of the riverbed fluctuation model was verified.

2.2.2 Canete River

By comparing to the results of analysis, it was identified that riverbed aggradation with maximum in 3.5m was estimated at the location of 27km to 31km in case 1. This results from that the river width at the location is remarkably narrow and inflow sediment from the upstream is not transported well. However, based on the local hearing and site survey results, it is said that the probability of riverbed aggradation is low due to the sediment inflow at the upstream section of Canete River. Moreover, the dam is constructed at the upstream. Therefore, as a result of two cases for analysis with decrease of inflow sediment volume, the case 2 analysis relatively represents the actual situation. In addition, the Plantanal Dam for hydro-power was constructed in upstream of the Canete River in recent years. Influence for future riverbed fluctuation affected by dam is described as follows.

Table 2.2 **Result of Riverbed Fluctuation Simulation in Canete River**

Case	Total Inflow Sediment Volume	Maximum Riverbed Fluctuation Height at Upstream	Evaluation	
Case 1	5,820,000 m3 116,000m3/yr	3.5m (50 yrs later) 1.7m (10 yrs later)	Riverbed aggradation with 0.6m can be observed at overall river channel	×
Case 2	3,000,000 m3 60,000m3/yr	2.1m (50 yrs later) 1.2m (10 yrs later)	Riverbed aggradation is smaller than that of case 1. 0.2m of riverbed rises in overall river section.	○
Case 3	1,500,000 m3 30,000 m3/yr	1.5m (50 yrs later) 0.9m (10 yrs later)	Riverbed aggradation at upstream is mitigated compared with case 1 and 2. On the other hand, riverbed degradation can be identified at 19km to 25km section.	△

(3) Influence on the downstream riverbed fluctuation by the Plantanal Dam

The Plantanal Dam is constructed for hydro-power generation. It has been operated since September, 2009. It is a small scale dam with dam height of 35.7m, storage capacity of 0.8-0.9 million m3 (See in ***Figure 2.5***).

The dam is located in the upper stream about 60km from the mouth of the river. It is in slightly upper stream out of the target study area. The sediment runoff is predicted to be almost same as the examined volume in the study area. Since the annual sediment discharge of Canete River is estimated about 60,000m3, there is high possibility that the dam will be filled up by sediment for about ten years from now on, and then sediment will be discharged again to downstream. Therefore, sediment supply will be intercepted for about ten years, and riverbed will degrade temporarily. However, it seems that the influence of sediment due to the dam to the downstream section is temporary.

In addition, after full sedimentation, dam will have a regulating function for sediment yield as a sediment-control dam. When large-scale sediment discharge occurs in upper stream in the future, the sediment yield is controlled by the dam. For this reason, although the riverbed aggrade at a rate of simulation results in the long perspectives, rapid riverbed aggradation is not predicted within the short period.

Table 2.3 **Dimension of Plantanal Dam**

Purpose	Power Generation
Dam height	35.7m
Storage Capacity	0.8～0.9×10^6m^3
Operation Start	September, 2009
Catchment Area	3,280km^2

Dam Facility	Reservoir (Upstream side)
	

Figure 2.5 **Overview of Plantanal Dam**

2.2.3 Chincha River

In Chincha River, caused by no operation of the diversion weir damaged by floods, the diversion rate for sediment inflow in Chico River and Matagente River is not identified. Therefore, for the future prediction, two (2) cases were analyzed: 1) case that all volumes of the inflow sediment flow into the rivers, and 2) case that half volumes of the inflow sediment flow into each river (with 1:1 ratio) (case 1) means the diversion facility does not function, and case 2) means the diversion facility functions).

The results of analysis indicate the following findings.

- In case that sediment and river flow can be divided with 1:1 ratio by rehabilitating the existing diversion weir in the future, it is estimated that the riverbed aggradation with 20cm to 30cm will be occurred fifty (50) years later. On the other hand, without rehabilitation of the existing diversion weir, if the sediment and river flow intensively flow into either river, the riverbed aggradation will be reached to 40cm to 60cm, which means the double of the above case. Therefore, the preventive function of the diversion weir for the riverbed aggradation can be identified.
- Regarding the relations between the hydraulic critical points and riverbed fluctuation, the sediment is deposited at C-1 and C-2 points in Chico River, leading the high risk of inundation at upstream of these critical points . On the other hand, deposit can be found at the M-3 and M-4 in Matagente River, also leading the possibility of the inundation. As for the countermeasure against the sedimentation, the periodical maintenance works in the river shall be required.

2.2.4 Pisco River

The analysis in Pisco River leads the following results.

- For the future fifty (50) years, the riverbed aggradation with 20cm in average was estimated. In terms of the average rate, it is not serious volume of sedimentation. However, the maximum 1m of riverbed aggradation is found in narrowed areas, so the inundation risk is high. Therefore, the periodical maintenance works such as riverbed excavation shall be required in these narrowed areas.
- The riverbed degradation can be found around the 30km distance mark, but it is in the small. Moreover, in consideration with the predictive accuracy by one-dimensional riverbed fluctuation calculation, it cannot be defined as a trouble spot without the verifiable observed data.

2.2.5 Yauca River

According to the analysis results on Yauca River, the following findings were identified.

- It was estimated that the average 10cm of riverbed aggradation will be occurred for the next fifty (50) years. Even though the partial riverbed fluctuation is identified at river mouth and upstream, the riverbed tends to be stable. The main reason for the stability of riverbed is caused by the small volume of river flow for transporting the sediment.

- In the most downstream section, the sediment deposit can be identified. However, since there is no trouble spot in the downstream, the serious problems will not be happened even though the sedimentation will be accelerated.

2.2.6 Majes-Camana River

From the output of analysis of the Majes-Camana River, the followings are identified.

- It is predicted that the riverbed in the Majes-Camana River will aggrades by an average of about 20cm in 50 years in the future. There is low possibility that a big problem will arise from the view point of flood protection. However, in the vicinities of 13km distance mark and 101km distance mark, the riverbed aggradation with about 0.8m and 1m is predicted respectively.
- The riverbed aggradation in the narrow section near 13km distance mark is caused by extension of sediment accumulation in the wide section just downstream section of narrow section. Since water intake located in 12.8km distance mark, and trouble may arise in the intake due to aggradation, maintenance works such as excavation shall be required. Moreover, the vicinity of 101km distance mark is also wide channel section just downstream of narrow section. Since this section also overflowed in the past, it will be needed for maintenance.
- In the other sections without the above-mentioned, the riverbed aggradation seems to be small in general, it is thought that the necessity for maintenance by excavation is low.
- As mentioned above, in the Majes-Camana River, the part of 13km distance mark and 101km distance mark are the sections which need maintenance from the viewpoint of flood protection and water use.

Calculated River Bed Variations

Total amount inflow volume=	5,100,000	(m3)
Annual average inflow volume=	102,000	(m3)
Total amount of bed volume variation=	-1,648,000	(m3)
Average bed height variation=	-0.0	(m)
Maximum bed height variation (aggradation)=	1.6	(m)
Maximum bed height variation (degradation)=	-1.3	(m)

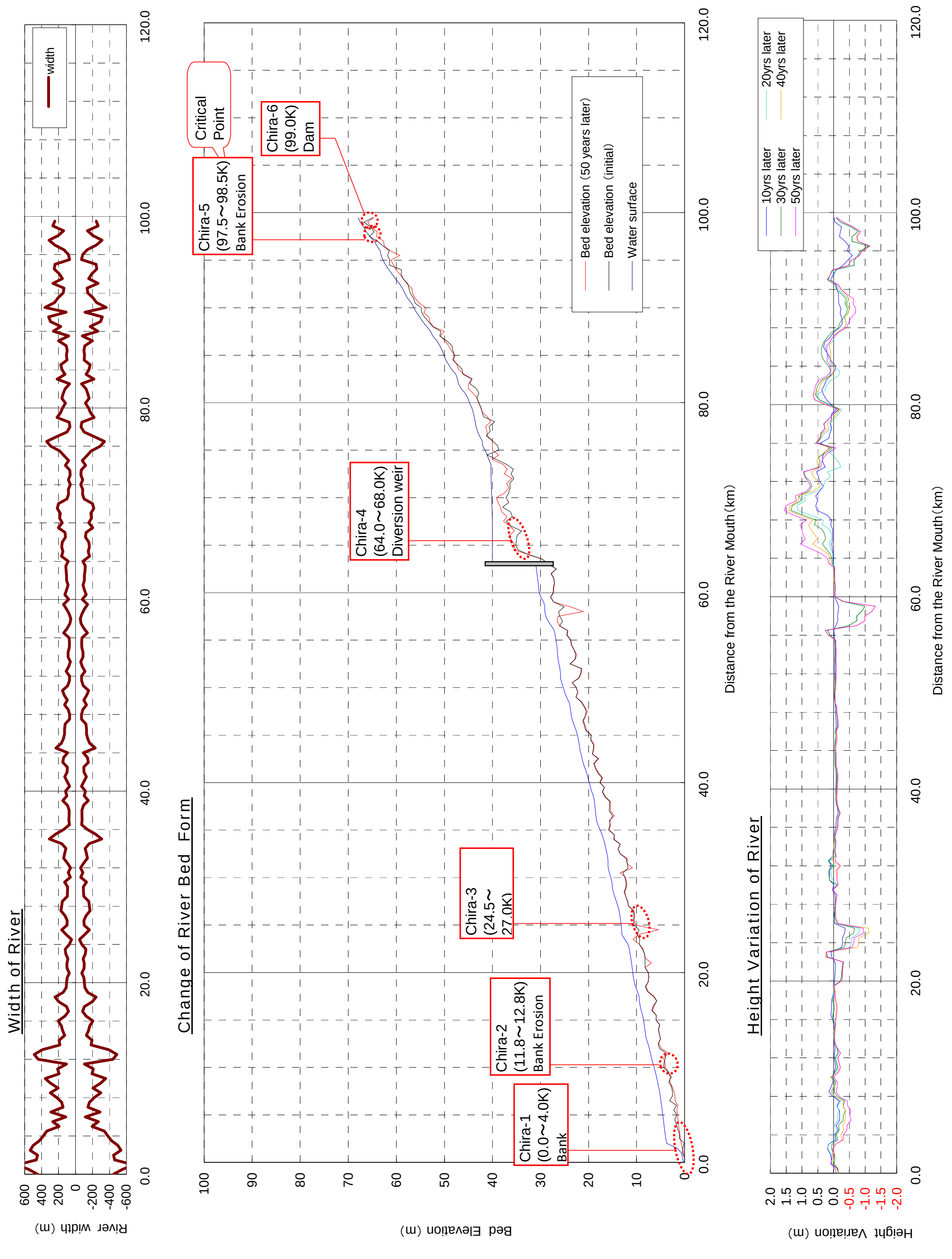


Figure 2.6 **Result of Analysis (Chira River)**

Calculated River Bed Variations

Total amount inflow volume=	5,820,000	(m3)
Annual average inflow volume=	116,000	(m3)
Total amount of bed volume variation=	2,166,000	(m3)
Average bed height variation=	0.6	(m)
Maximum bed height variation (aggradation)=	3.7	(m)
Maximum bed height variation (degradation)=	-0.5	(m)

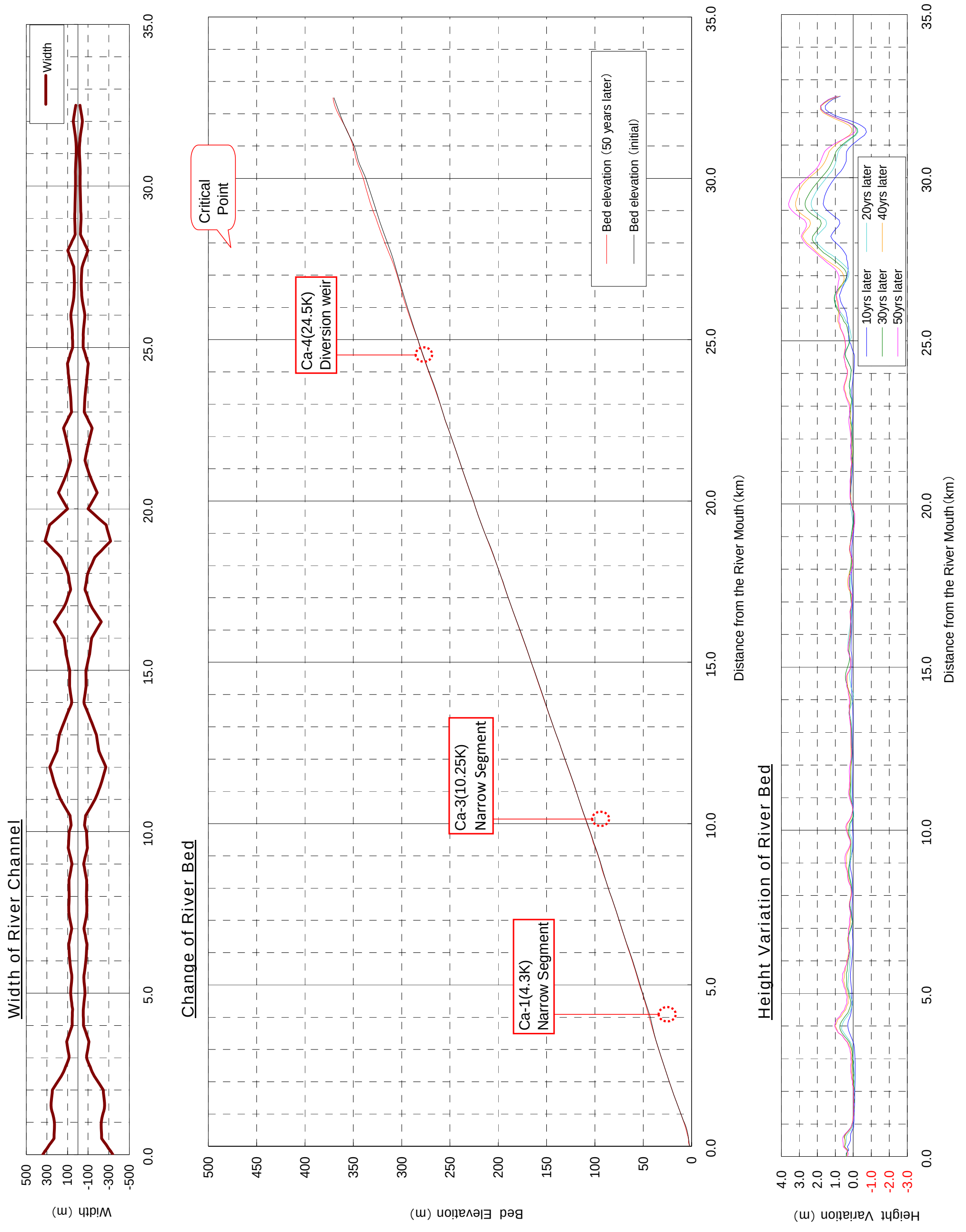
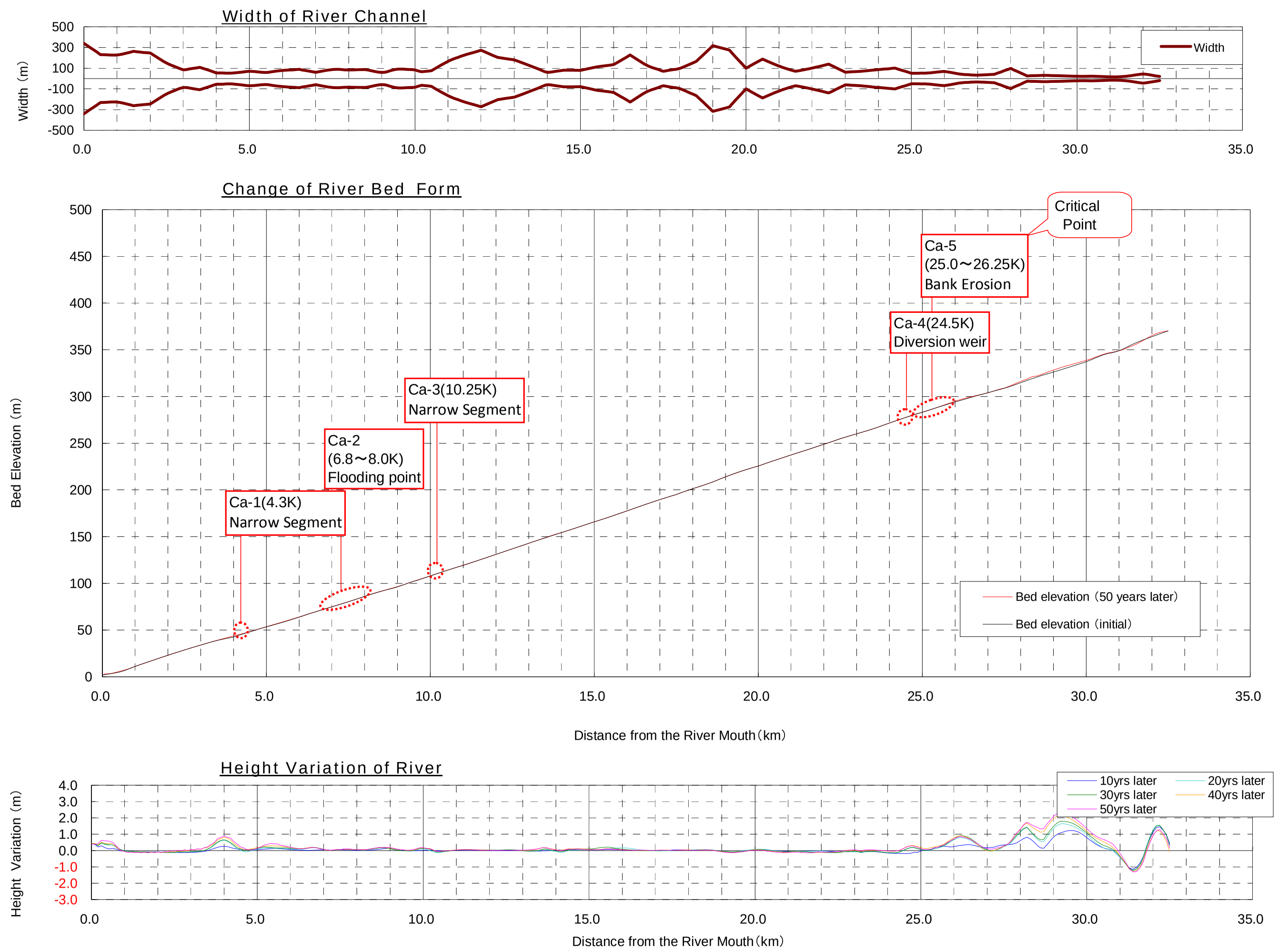


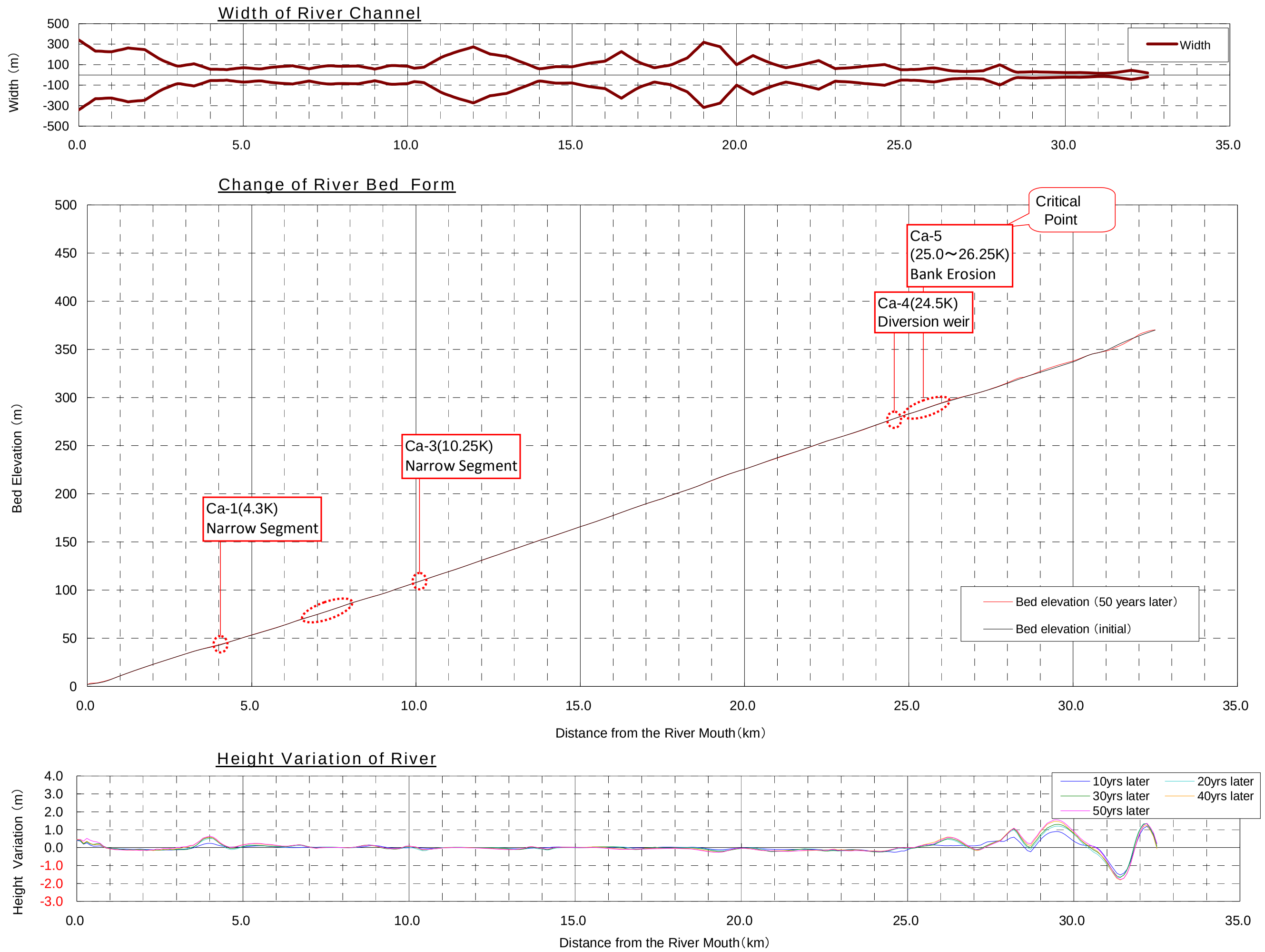
Figure 2.7 **Result of Analysis (Canete River in Case of All Volumes of Sediment Inflow)**



Calculated River Bed Variations

Total amount inflow volume=	2,968,000	(m3)
Annual average inflow volume=	59,000	(m3)
Total amount of bed volume variation=	673,000	(m3)
Average bed height variation=	0.2	(m)
Maximum bed height variation (aggradation)=	2.4	(m)
Maximum bed height variation (degradation)=	-1.7	(m)

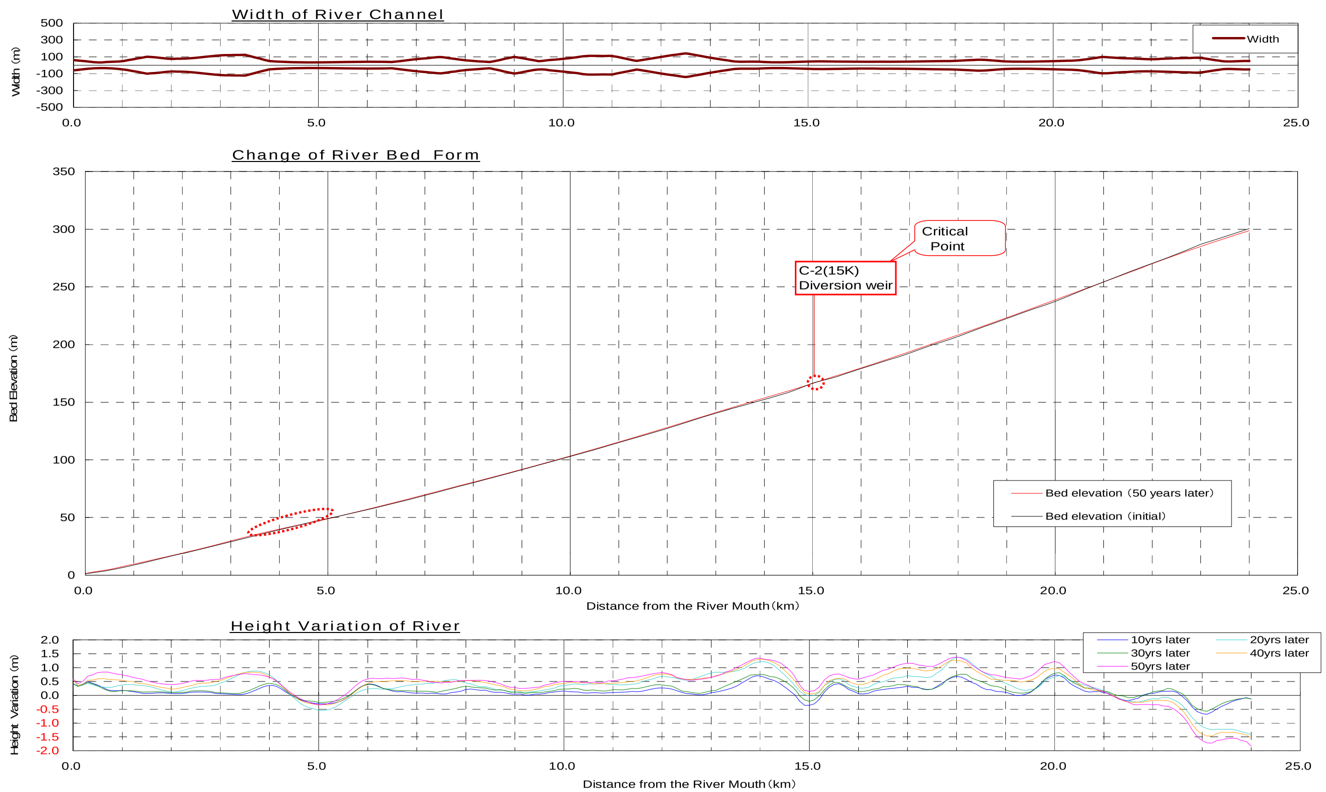
Figure 2.8 **Result of Analysis (Canete River in Case of Half Volumes of Sediment Inflow)**



Calculated River Bed Variations

Total amount inflow volume=	1,513,000	(m3)
Annual average inflow volume=	30,000	(m3)
Total amount of bed volume variation=	-79,000	(m3)
Average bed height variation=	0.1	(m)
Maximum bed height variation (aggradation)=	1.7	(m)
Maximum bed height variation (degradation)=	-2.1	(m)

Figure 2.9 **Result of Analysis (Canete River in Case of Quarter Volumes of Sediment Inflow)**

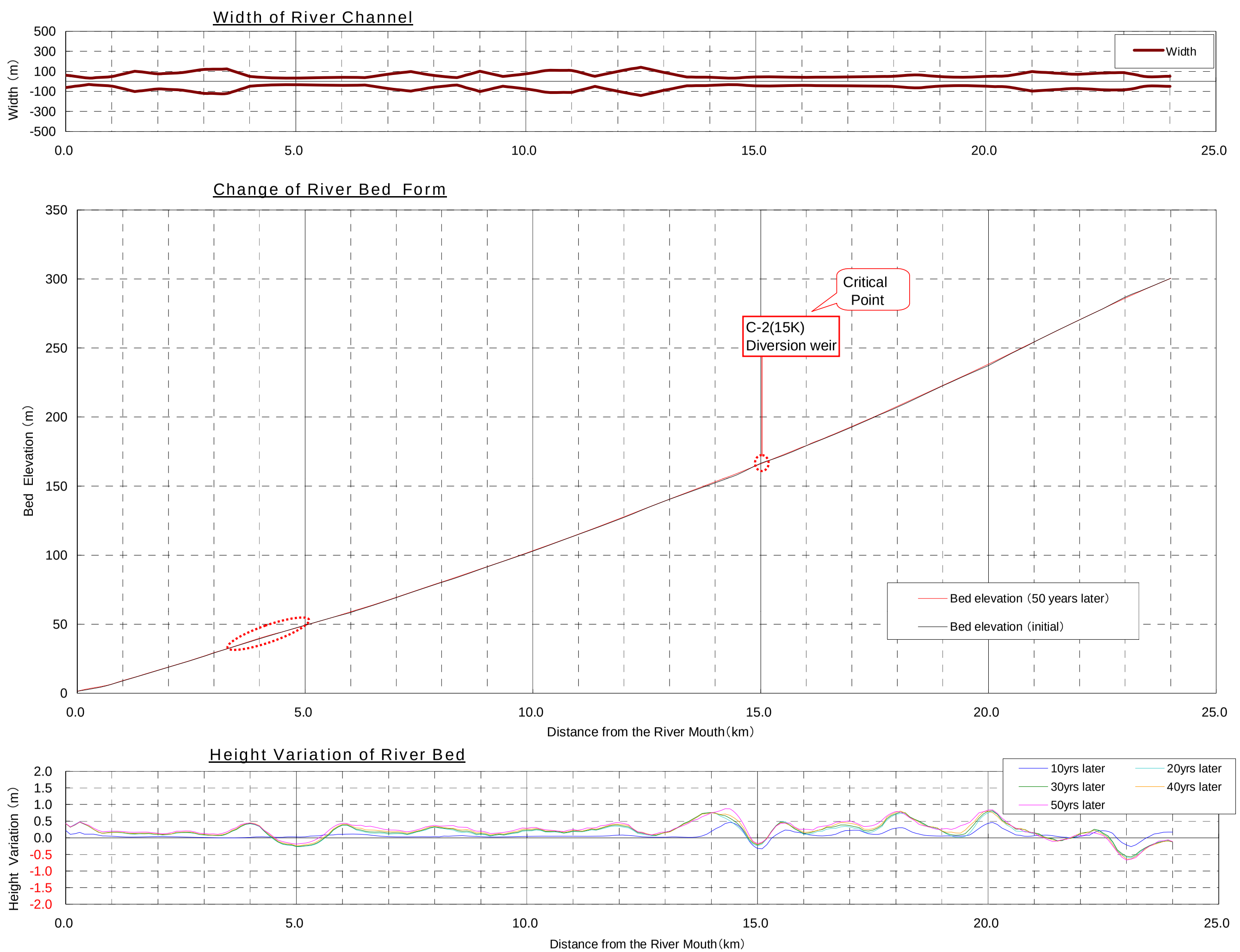


Assuming the condition existing diversion weir

Calculated River Bed Variations

Total amount inflow volume=	5,759,000	(m3)
Annual average inflow volume=	115,000	(m3)
Total amount of bed volume variation=	1,131,000	(m3)
Average bed height variation=	0.4	(m)
Maximum bed height variation (aggradation)=	1.4	(m)
Maximum bed height variation (degradation)=	-1.8	(m)

Figure 2.10 **Result of Analysis (Chincha River (Chico River) in Case of All Volumes of Sediment Inflow)**

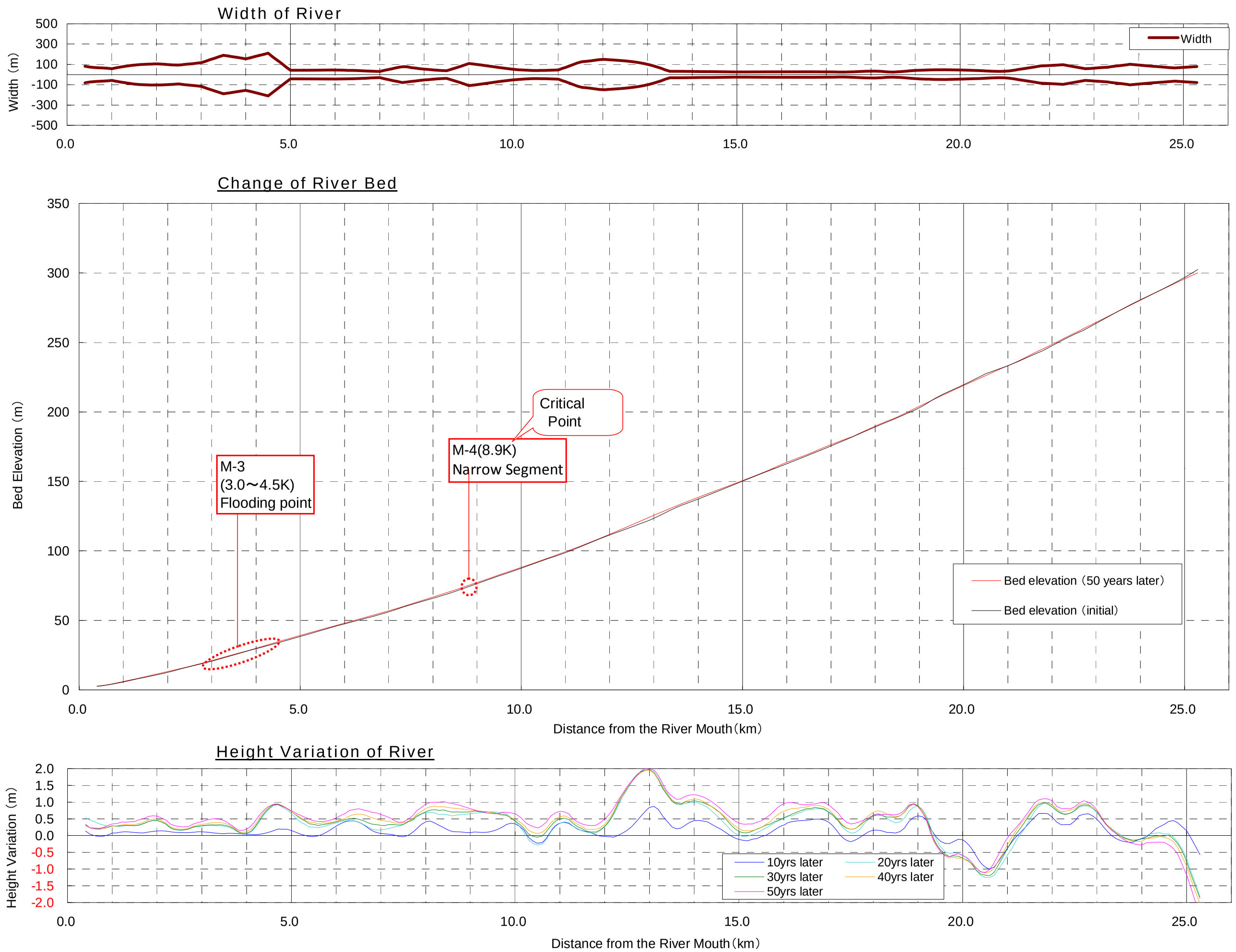


Assuming the condition existing diversion weir

Calculated River Bed Variations

Total amount inflow volume=	2,879,000	(m3)
Annual average inflow volume=	58,000	(m3)
Total amount of bed volume variation=	822,000	(m3)
Average bed height variation=	0.2	(m)
Maximum bed height variation (aggradati	1.1	(m)
Maximum bed height variation (degradati	-0.8	(m)

Figure 2.11 **Result of Analysis (Chincha River (Chico River) in Case of Half Volumes of Sediment Inflow)**

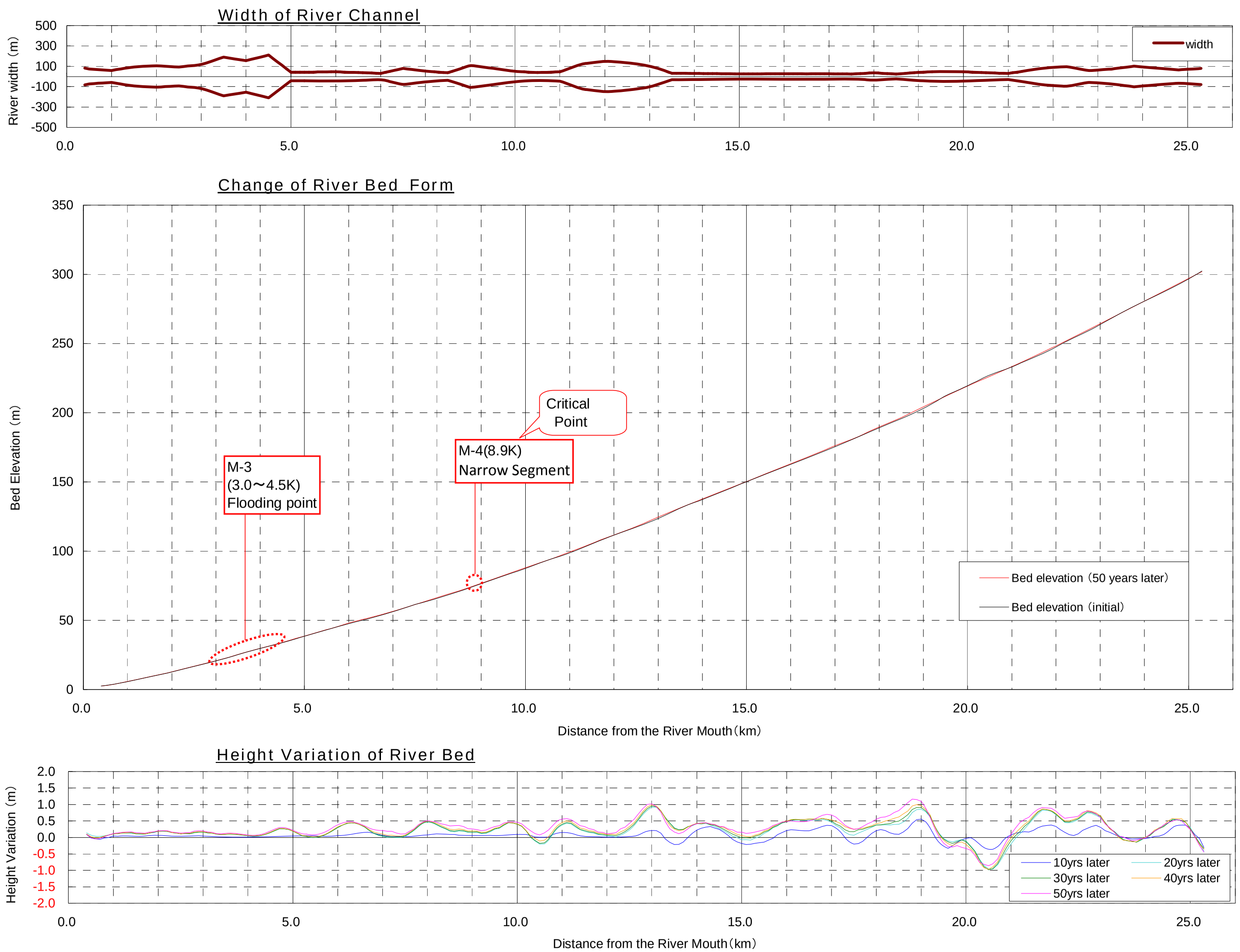


Assuming the condition existing diversion weir

Calculated River Bed Variations

Total amount inflow volume=	5,759,000	(m3)
Annual average inflow volume=	115,000	(m3)
Total amount of bed volume variation=	1,479,000	(m3)
Average bed height variation=	0.5	(m)
Maximum bed height variation (aggradation)=	2.0	(m)
Maximum bed height variation (degradation)=	-1.1	(m)

Figure 2.12 **Result of Analysis (Chincha River (Matagente River) in Case of All Volumes of Sediment Inflow)**



Assuming the existing condition diversion weir

Calculated River Bed Variations

Total amount inflow volume=	2,879,000	(m3)
Annual average inflow volume=	58,000	(m3)
Total amount of bed volume variation=	892,000	(m3)
Average bed height variation=	0.3	(m)
Maximum bed height variation (aggradation)=	1.4	(m)
Maximum bed height variation (degradation)=	-1.2	(m)

Figure 2.13 **Result of Analysis (Chincha River (Matagente River) in Case of Half Volumes of Sediment Inflow)**

Calculated River Bed Variations

Total amount inflow volume=	8,658,000	(m3)
Annual average inflow volume=	173,000	(m3)
Total amount of bed volume variation=	2,571,000	(m3)
Average bed height variation=	0.2	(m)
Maximum bed height variation (aggradation)=	1.8	(m)
Maximum bed height variation (degradation)=	-1.9	(m)

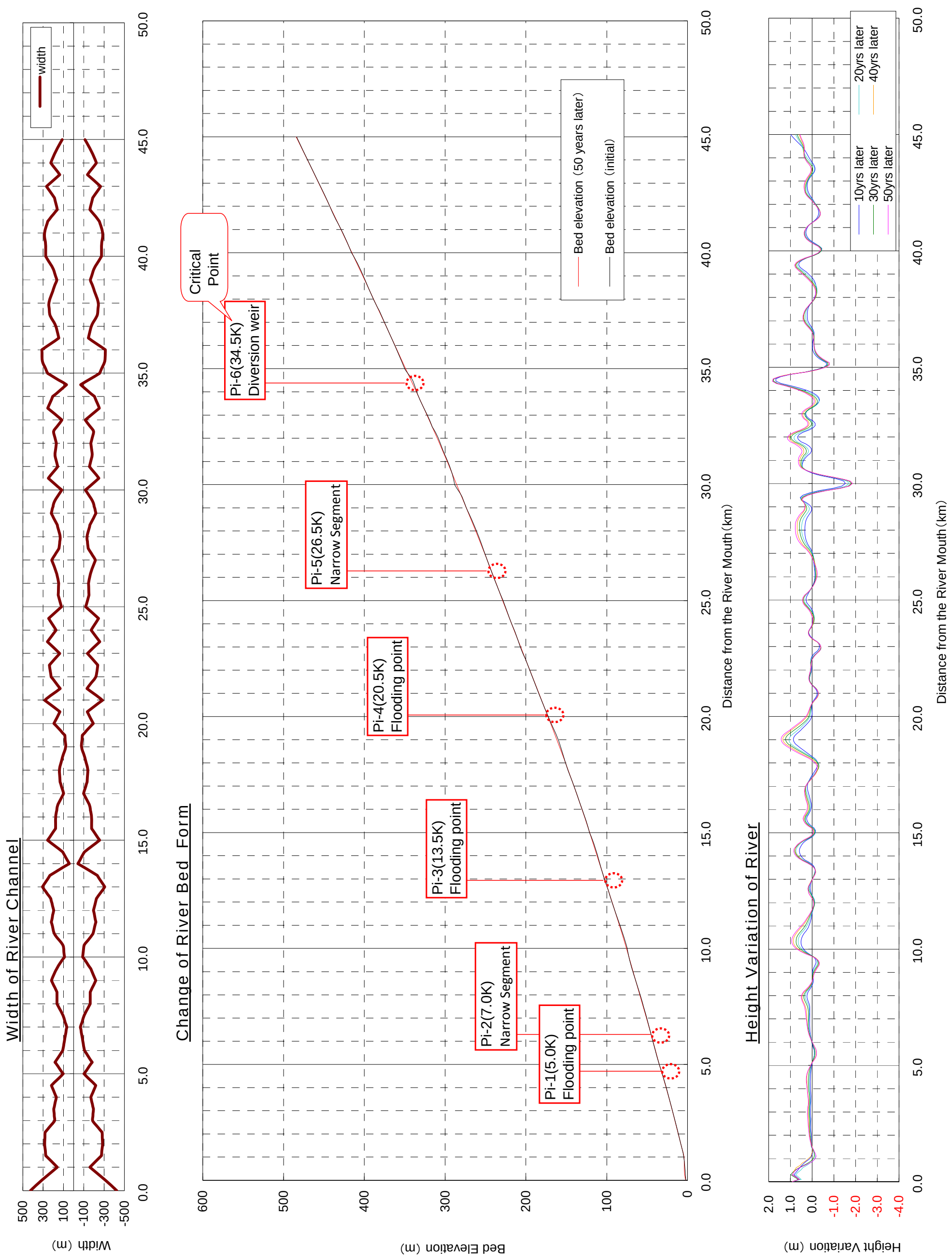
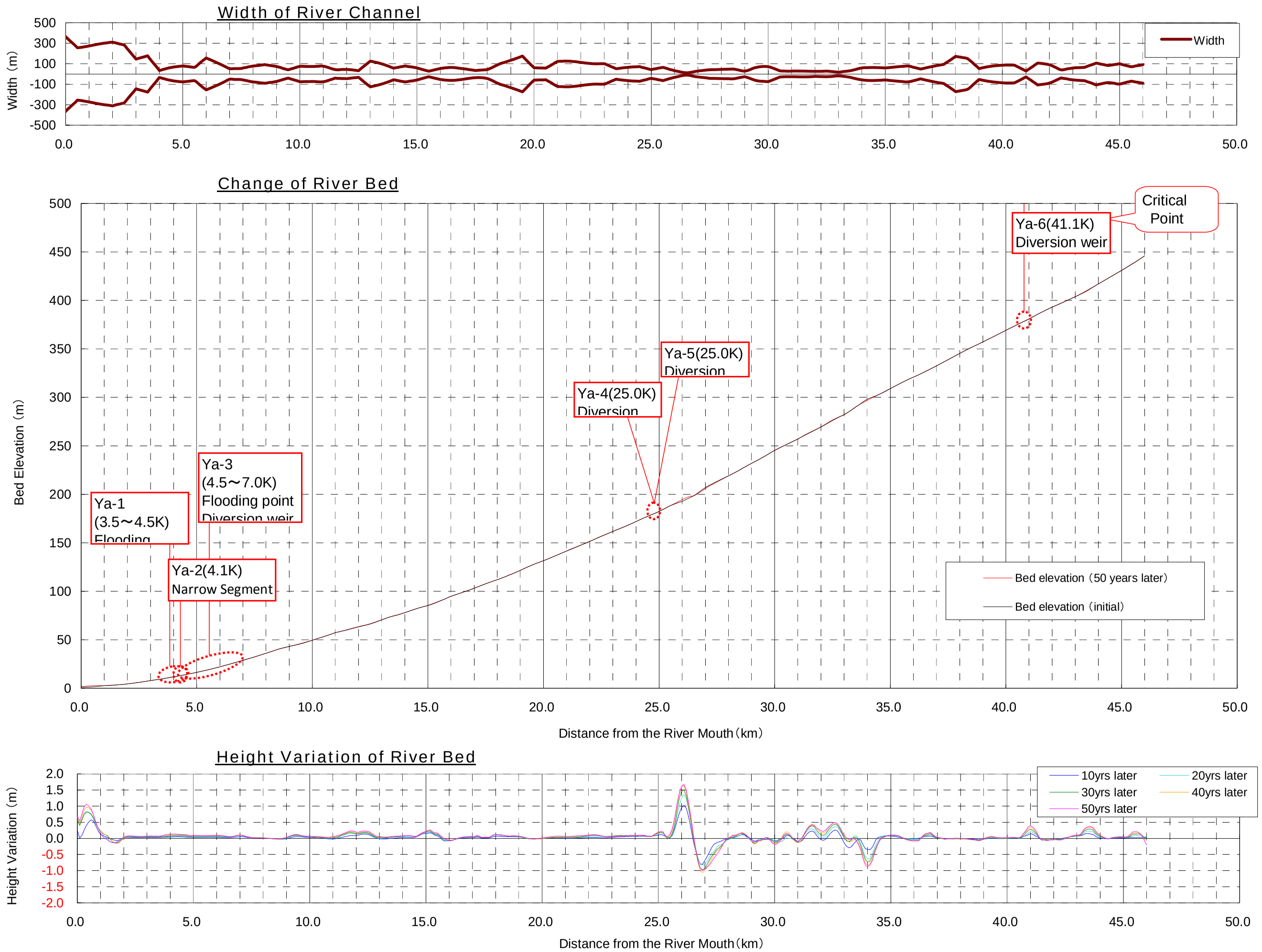


Figure 2.14 **Result of Analysis (Pisco River)**



Calculated River Bed Variations

Total amount inflow volume=	1,192,000	(m3)
Annual average inflow volume=	23,840	(m3)
Total amount of bed volume variation=	685,000	(m3)
Average bed height variation=	0.1	(m)
Maximum bed height variation (aggradation)=	1.7	(m)
Maximum bed height variation (degradation)=	-1.0	(m)

Figure 2.15 **Result of Analysis (Yauca River)**

Calculated River Bed Valiations

Total amount inflow volume=	20,956,000	(m3)
Annual average inflow volume=	419,000	(m3)
Total amount of bed volume=	5,316,000	(m3)
Average bed height variation=	0.2	(m)
Maximum bed height variation (aggradation)=	1.0	(m)
Maximum bed height variation (deggradation)=	-0.4	(m)

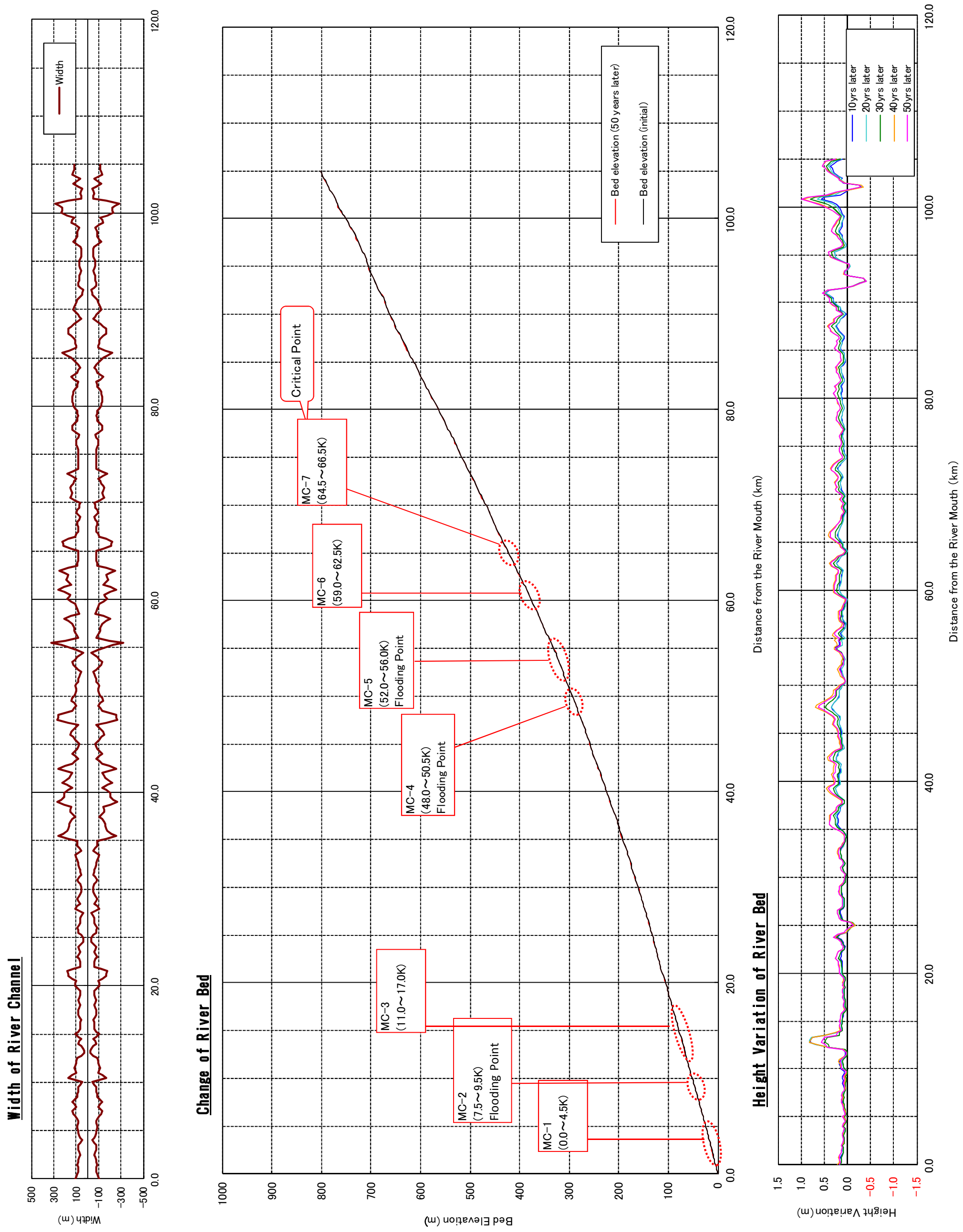


Figure 2.16 **Result of Analysis (Majes-Camana River)**

2.3 Examination on Necessity of Riverbed Maintenance

Based on the results of riverbed fluctuation analysis for the next fifty (50) years for targeted six (6) rivers, the locations requiring for the maintenance are identified.

Table 2.4 **Locations Requiring for the Maintenance (1)**

River		Excavation Section		Maintenance Method
Chira River		Location 1	Object Section: 64.0km-68.0km Object Soil Volume: 2,500,000m^3	Since it is predicted that the sediment will be deposited at the upstream of Sullana Weir, it is concerned the periodical excavation is needed. In case that sediment volume is huge and it is difficult to remove all the sediment, the excavation just upstream of fixed weir shall be focused on.
Canete River		Location 1	Object Section: 3.0km-7.0km Object Soil Volume: 135,000m^3	The periodical excavation shall be conducted since it is the existing inundation area and riverbed will gradually rise.
		Location 2	Object Section: 27.0km-31.0km Object Soil Volume: 287,000m^3	Since the object section is a narrow channel and the sediment cannot sufficiently flow, the risk on riverbed aggradation is high. Therefore, the planned excavation is considered to be required because riverbed will gradually rise and inundation will occur.
Chincha River	(Chico River)	Location 1	Object Section: 3.5km-4.5km Object Soil Volume: 53,000m^3	The periodical excavation shall be conducted since it is the existing inundation area and riverbed will gradually rise.
	(Matagente River)	Location 1	Object Section: 10.5km-13.5km Object Soil Volume: 229,000m^3	At the section, river channel is wide and sediment is deposited easily. Therefore, the planned excavation is considered to be required because riverbed will gradually rise and inundation will occur.
		Location 2	Object Section: 21.0km-23.5km Object Soil Volume: 197,000m^3	
Pisco River		Location 1	Object Section: 18.0km-20.5km Object Soil Volume: 314,000m^3	The periodical excavation shall be conducted since it is the existing inundation area and riverbed will gradually rise.
		Location 2	Object Section: 34.0km-35.0km Object Soil Volume: 255,000m^3	At the section where is just upstream of existing irrigation weir, the sediment is easily deposited due to the unconstrained location. The implementation of periodical excavation at the section will reduce the risk on the riverbed aggradation all the river course.
Yauca River		Location 1	Object Section: 25.5km-26.5km Object Soil Volume: 60,000m^3	The periodical excavation is needed to maintain the function of existing irrigation weir since the object section is just upstream of existing irrigation weir.

* object soil volume means a total sand deposit for fifty (50) years

Table 2.5 **Locations Requiring for the Maintenance (2)**

River	Excavation Section		Maintenance Method
Majes-Camana River	Location 1	Object Section: 12.0km-13.0km Object Soil Volume: 70,000m^3	Since the river channel is comparatively narrow, it is predicted to be possible that remarkable riverbed aggradation will occur even in the small amount of sediment. In consideration of the influence on intake facilities, periodical maintenance excavation every year is desirable.
	Location 2	Object Section: 100.0km-101.0km Object Soil Volume: 460,000m^3	By carrying out maintenance such as excavation in the section, effective control of riverbed aggradation in middle stream is also expectable. It is considered the place where scheduled maintenance shall be carried out from a viewpoint on river improvement.

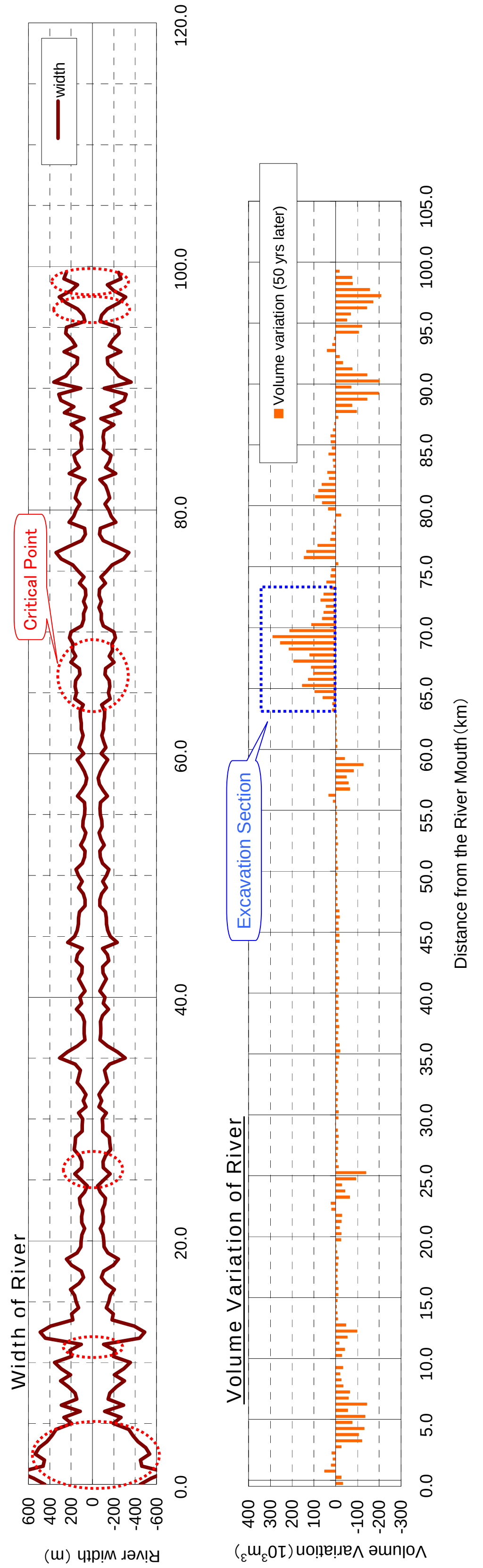


Figure 2.3-1 **Section for Requiring Maintenance (Chira River)**

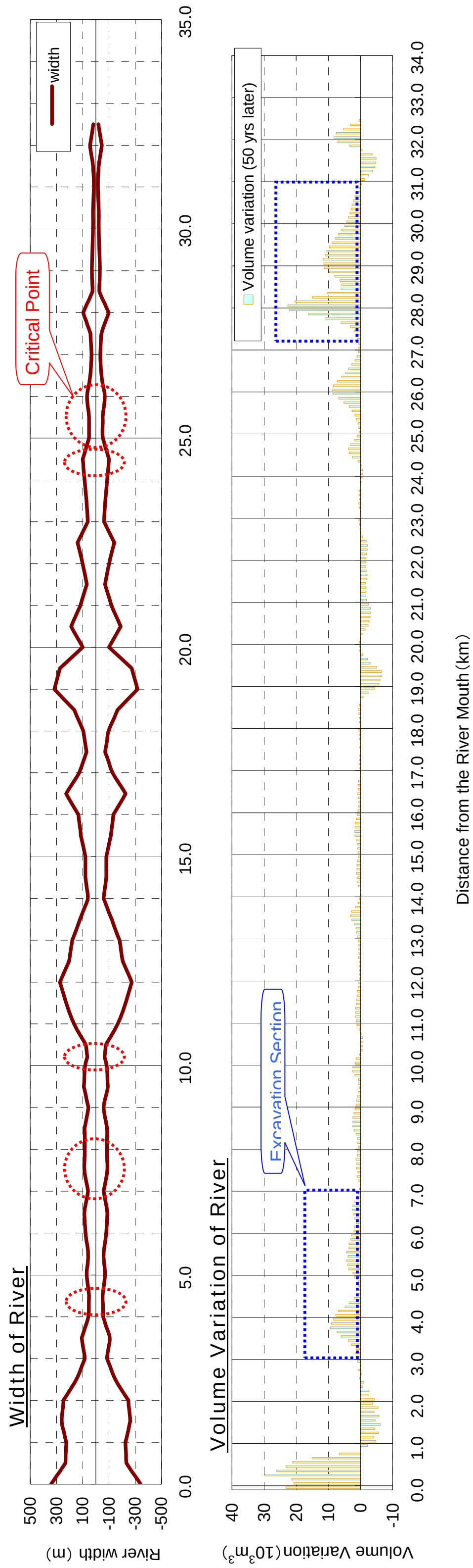


Figure 2.17 **Section for Requiring Maintenance (Canete River)**

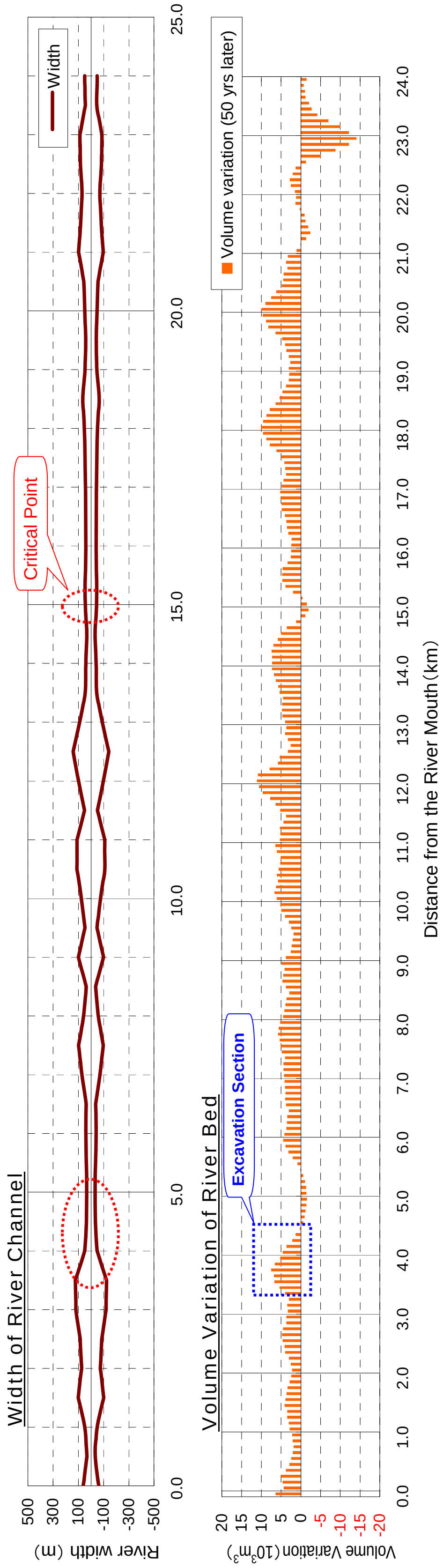


Figure 2.3-3 **Section for Requiring Maintenance (Chincha River (Chico River))**

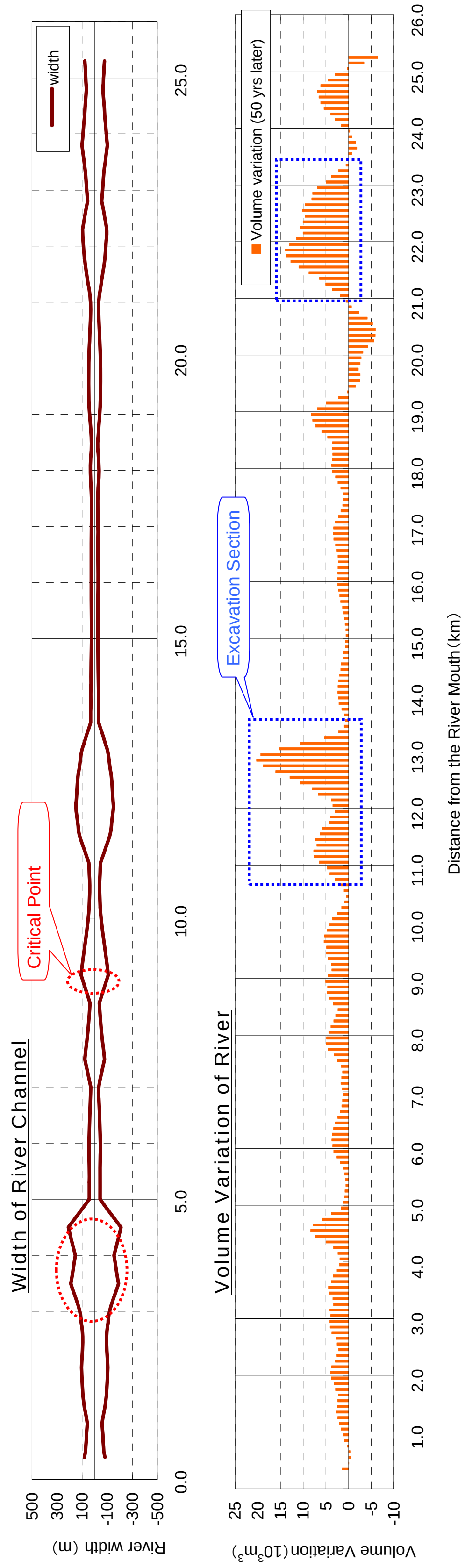


Figure 2.18 **Section for Requiring Maintenance (Chincha River (Matagente River))**

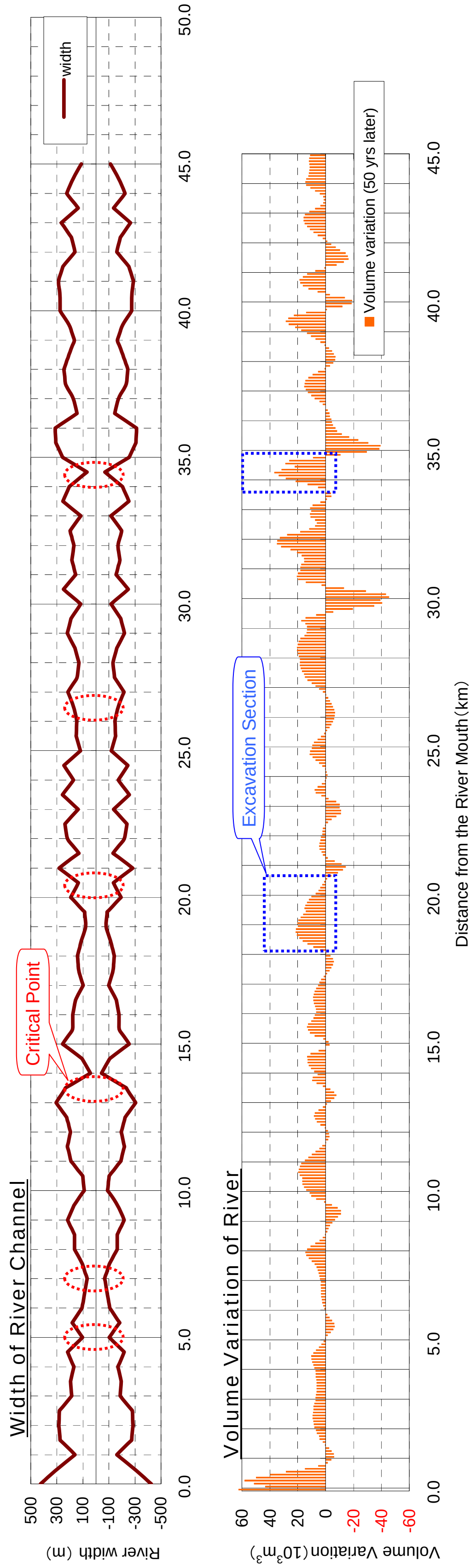


Figure 3.3-5 **Section for Requiring Maintenance (Pisco River)**

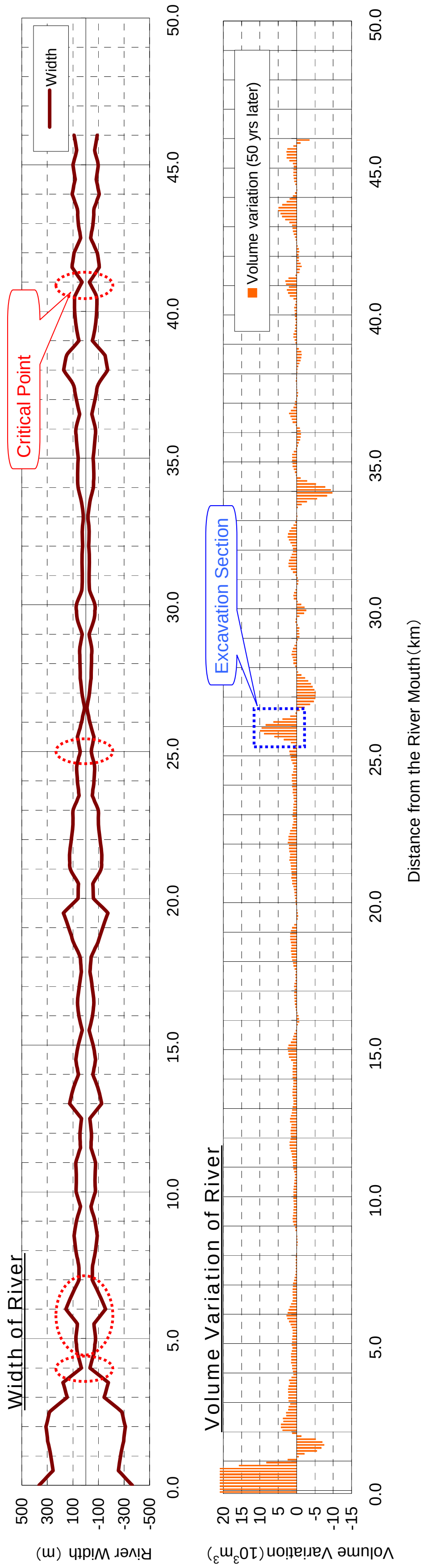


Figure 2.19 **Section for Requiring Maintenance (Yauca River)**

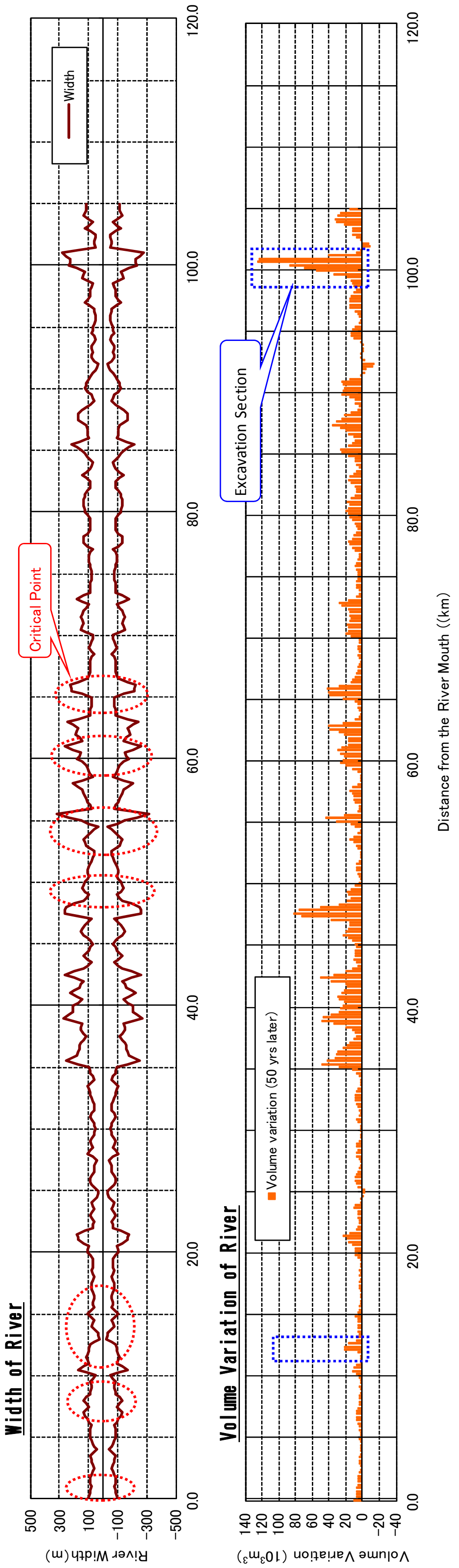


Figure 2.20 **Section for Requiring Maintenance (Majes-Camana River)**

2.4 Examination of Necessity for Countermeasures

Based on the result of analysis on the targeted five (5) rivers, the locations requiring for the countermeasures are identified in accordance with the current sediment deposit conditions as shown in ***Table 2.6***. The current sediment deposit conditions were determined by the average riverbed longitudinal profiles and vertical gradients.

Table 2.6 **Location of Sediment Deposits**

No.	River	Location	Condition	Remarks
1	Chira River	64.0km upstream (upstream of Sullana Weir)	Since the average bed slope at the upstream of Sullana Weir is very gentle, sediment deposit condition is easily identified.	Refer to ***Figure 2.4-1***
2	Canete River	4.0km	Since the average bed slope is gentle compared to that of upstream and downstream, it is assumed that the sediment is deposited.	Refer to ***Figure 2.4-2***
3	Canete River	10.0km	Ditto	Refer to ***Figure 2.4-2***
4	Chincha River (Matagente River)	9.0km	Ditto	Refer to ***Figure 2.4-3***
5	Pisco River	7.5km	Ditto	Refer to ***Figure 2.4-4***
6	Yauca River	4.5km	The average bed slope becomes gentle from the downstream of 5km point. Therefore, it is assumed that the sediment is deposited at the just downstream of 5km point.	Refer to ***Figure 2.4-5***
7	Majes-Camana River	96.0km	Since the average riverbed gradient is gentle as compared with the upstream and the downstream, it is assumed that the sediment is deposited.	Refer to ***Figure 2.4-6***

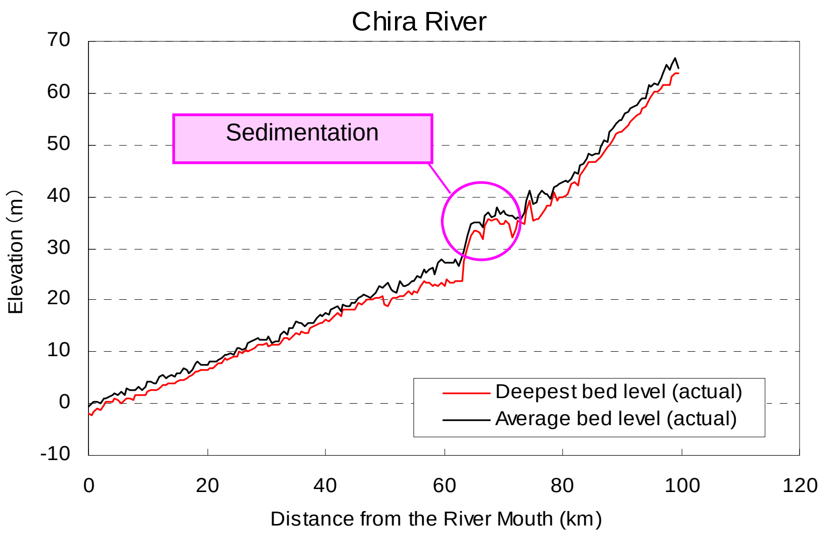


Figure 2.21 **Longitudinal Profile for Average Bed Slope in Chira River**

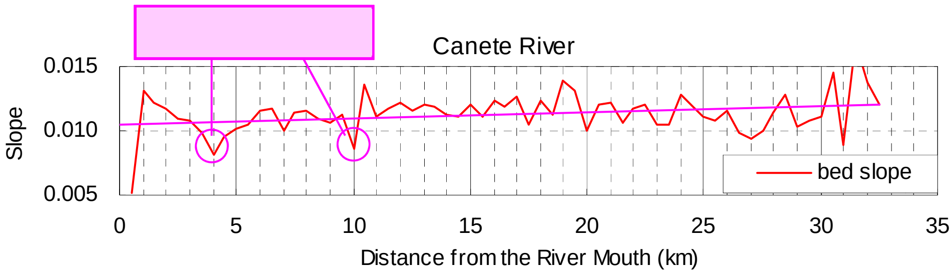


Figure 2.22 **Longitudinal Profile for Average Bed Slope in Canete River**

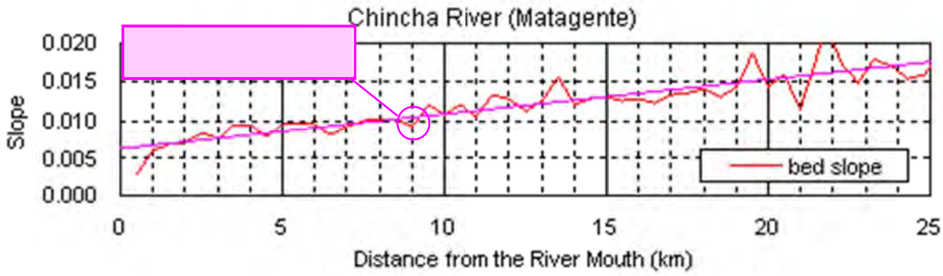


Figure 2.23 **Longitudinal profile for Average Bed Slope in Matagente River**

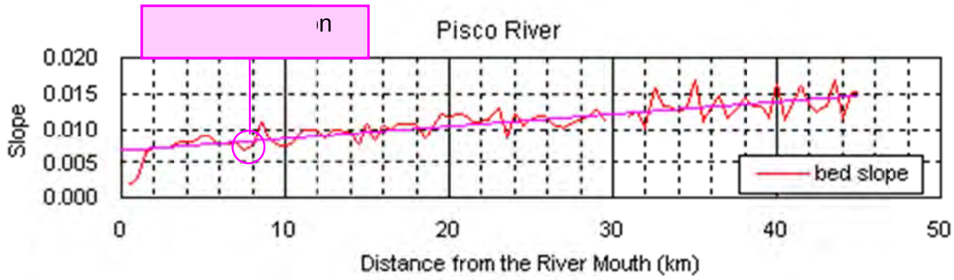


Figure 2.24 **Longitudinal Profile for Average Bed Slope in Pisco River**

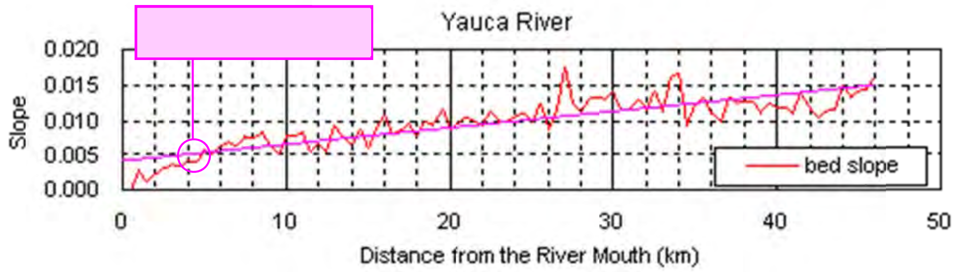


Figure 2.25 **Longitudinal profile for Average Bed Slope in Yauca River**

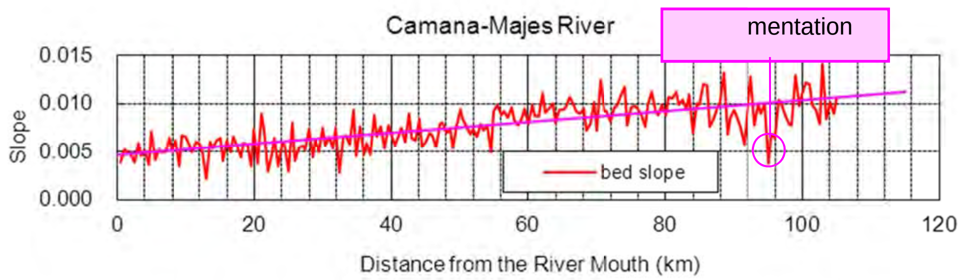


Figure 2.26 **Longitudinal Profile for Average Bed Slope in Majes-Camana River**

Ministry of Agriculture
Republic of Peru

THE PREPARATORY STUDY
ON
PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU

FINAL REPORT
I-6 SUPPORTING REPORT
ANNEX-4 FLOOD CONTROL PLAN

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.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ANCASH
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リマ州
JUNIN
MADRE DE DIOS
CUSCO
HUANCAVELICA
AYACUCHO
APURIMAC
PUNO
ICA
イカ州
AREQUIPA
アレキパ州
MOQUEGUA
TACNA
PIURA
ピウラ州
TUMBES
Chira
River
Canete
River
Chincha
River
Pisco
River
Yauca
River
Majes-Camana
River
Amazon
Legend
International boundary
Province boundary
Project Area (関連州)
Taget Rivers (対象河川)
National capital
Department capital
Railroad
Road
200 Km
200 Miles

Study Area

ABBREVIATION

Abbreviation	Official Form or Meaning
ANA	Autoridad Nacional del Agua/National Water Authority
ALA	Autoridad Local del Agua/Local Water Authority
B/C	Costo Benefit Ratio/Benefit Cost Ratio
GDP	Gross Domestic Product/Gross Domestic Product
GIS	Geographic Information System/Geographic Information System
DGAA	Dirección General de Asuntos Ambientales/General Directorate of Environmental Affairs
DGFFS	Dirección General de Forestal y de Fauna Silvestre/Directorate General of Forest and Wildlife
DGIH	Dirección General de Infraestructura Hidráulica/Directorate General for Water Infrastructure
DGPI (Paleo-DGPM)	Dirección General de Política de Inversiones/Directorate General of Investment Policy
DNEP	Dirección Nacional de Endeudamiento Público/ National Directorate of Public Debt
DRA	Dirección Regional de Aguricultura/Regional Directorate Aguriculture
EIA	Evaluación de Impacto Ambiental/Environmental Impact Assessment
FAO	Agricultura y la Alimentación Organización de las Naciones Unidas/Food and Agriculture Organization of the United Nations
F/S	Estudio de factibilidad/ Feasibility Study
GORE	Gobierno Regional/Regional Government
HEC-HMS	Centros de Ingeniería Hidrológica Sistema de Modelación Hidrológica Método/Hydrologic Engineering Centers Hydrologic Modeling System Method
HEC-RAS	Centros de Ingeniería Hidrológica del Río de Análisis del Sistema Método/Hydrologic Engineering Centers River Analysis System Method
IGN	Instituto Geográfico Nacional/National Geographic Institute
IGV	Impuesto General a Ventas/General Sales Tax
INDECI	Instituto Nacional de Defensa Civil/National Institute of Civil Defense
INEI	Instituto Nacional de Estadística/National Institute of Statistics
INGEMMET	Instituto Nacional Geológico Minero Metalúrgico/National Geological and Mining Metallurgical Institute
INRENA	Instituto Nacional de Recursos Naturales/Natural Resources Institute
IRR	Tasa Interna de Retorno (TIR)/Internal Rate of Return
JICA	Japonés de Cooperación Internacional /Japan International Cooperation Agency

JNUDRP	Junta Nacional de Usuarios de Distritos del Perú/National Board of Peru Districts Users
L/A	Convenio de Préstamo/Loan Agreement
MEF	Ministerio de Economía y Finanzas/Ministry of Economy and Finance
MINAG	Ministerio de Agricultura/Ministry of Agriculture
M/M	Acta de la reunion/Minutes of Meeting
NPV	Valor Actual Neto (VAN)/NET PRESENT VALUE
O&M	Operación y mantenimiento/Operation and maintenance
OGA	Oficina General de Administración/General Office of Administration
ONERRN	Oficina Nacional de Evaluación de Recursos Naturales/National Bureau of Natural Resource Evaluation
OPI (OPP)	Oficina de Programación e Inversiones/Programming and Investment Office (Oficina de Planificación e Prespuesto/Office of Planning and Budget)
PBI	Producto Bruto Interno/Gross Domestic Product
PE	Exp. Proyecto Especial (PE) Chira-Piura/Exp. Special Project Chira-Piura
PES	Pago por Servicos Ambientales (PSA)/Payment for Environmental Services
PERFIL	PERFIL/PROFILE (Preparatory survey of project before investment)
Pre F/S	Estudio de Prefactibilidad /Pre-Feasibility Study
PERPEC	Programa de Encauzamiento de Ríos y protección de Estructura de Captación
PRONAMACHIS	Programa Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos/ National Program of River Basin and Soil Conservation Management
PSI	Programa de Sub Sectorial de Irrigaciones/Program of Sub Irrigation Sector
SCF	Factor de conversión estándar/Standard conversion factor
SENAMHI	Servicio Nacional de Meteorología y Hidrología/National Service of Meteorology and Hydrology
SNIP	Sistema Nacional de Inversión Pública/National Public Investment System
UF	Unidad formuladora/Formulator unit
VALLE	Valle/ Valley
VAT	Impuesto al valor agregado/ Value-added tax

THE PREPARATORY STUDY ON PROJECT OF THE PROTECTION

OF

FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD

IN THE REPUBLIC OF PERU

FEASIBILITY STUDY REPORT

SUPPORTING REPORT

Annex-4

Flood Control Plan

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CHAPTER 1 BASIC POLICY

The flood control policy in Peru puts the viewpoint on agricultural sector fundamentally. It not only protects farmland from floods, but advances to examine as means which prevent expanding flood water to adjoining lands, bridges, traffic roads, and surrounding villages. The characteristics of rivers are that a lot of sediment flows down with flood water, then erosion of the riverbank and riverbed aggradation go on. The discharge capacity is reduced caused by them and inundation occurs frequently as a result. The flood control plan for rivers with those characteristics is advanced by the following policy.

1.1 Issues on Flood Control

- Flood exceeds the height of riverbank and overflows.
- River is usually steep with riverbed gradient of about 1/30 to 1/300, therefore, the flow velocity and sediment transportation capacity are large.
- The sedimentation is large volume in river channel. Double-row sandbar is formed, and water route and water colliding front are unstable in the river, and often change and move.
- The erosion of riverbank is large. The reduction of the area of farmland occurs, and the danger of collapse in main local roads exists, therefore, the protection of them is needed.
- Moreover, intakes for agricultural waterways are damaged and destroyed by sedimentation.

1.2 Necessity for Examination of Integrated Flood Control Plan

In an alluvial fan river with huge sediment discharge, when sediment is pushed in river channel by embankment, riverbed aggradation goes up, namely a raised-bed river is formed, and a vulnerable condition for flood is made. In the flood control plan, it is necessary to take such changes in advance in order to formulate river improvement plan. The future changes of river are simulated by riverbed-fluctuation calculation, and the optimal integrated flood control plan is formulated by setup of a design flood.

- Identification of protect areas for flood based on inundation analysis
- Examination of afforestation, vegetation works and erosion control for prevention from channel blockade and riverbed aggradation caused by sediment inflow and deposition
- Setup of design riverbed level, design water level, and maintenance method based on riverbed-fluctuation analysis
- Flood control facilities (revetments, dikes, retarding reservoirs, and other erosion control facilities, etc.) using local technique and material with easy procurement
- River facility plan in consideration of cost effectiveness and examination for alternatives
- Formulation of integrated flood control plan

The following items need to be examined in the integrated flood control plan.

The outline of facilities for the flood control in consideration of the characteristics of target rivers mentioned in the above basic policy is shown in below. For the design and construction method, cost, technique of local contractors and utilization of material with easy procurement shall be considered and designed.

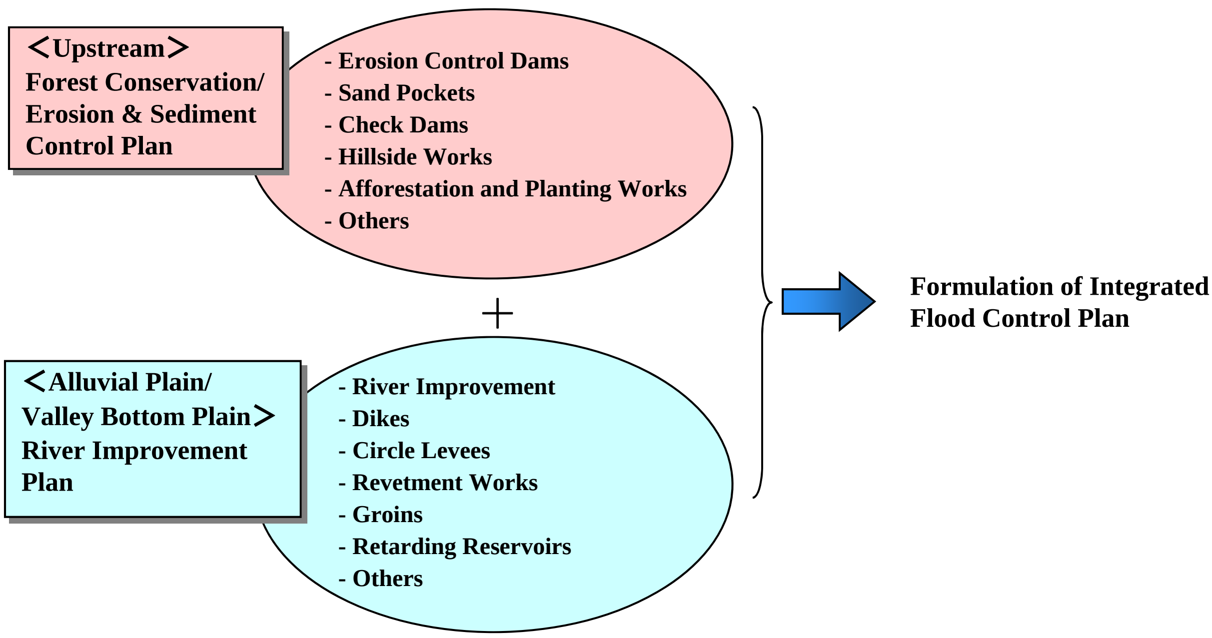

Figure 1.1 **Measures Items for Integrated Flood Control Plan**

Table 1.1 Major Measures for Integrated Flood Control Plan

Envisaged Measures	Main Point for Facility Plan and Design
(1) Dike which fixes channel, the riverbed excavation and channel widening which secures the flow capacity	In steep river with large sediment discharge like object rivers, The collapse of dike by scouring and erosion of riverbank is the key factor for flood disaster. Therefore, it is important to make the channel fix with dike and take the sufficient depth of embedment of dike and revetment in consideration of moving water colliding front. Moreover, installation of foot protection for dike and revetment is also important.
(2) Revetment work which protects dike (including groin work)	Since object river has big riverbed gradient parts and also great curving parts, it is considered that the flow velocity becomes high and partial scouring generates especially in water colliding parts. Therefore, maintenance of revetment becomes important for protection of dike. As the maintenance method, it is effective to maintain revetment and groin utilizing boulder with large diameter, etc.
(3) Retarding Reservoir which controls flood discharge	Retarding reservoir and sand pocket can be considered as the reduction measures of flood discharge and sediment discharge to downstream. It is expected that retarding reservoir is filled immediately by sediment inflow with flood water, and securement of design storage becomes difficult. Therefore, arrangement of the facility which has the function of both retarding reservoir and sand pocket can be considered. In this case, land acquisition and planned sediment removal (maintenance) are required.
(4) The erosion control facility which controls sediment discharge (sand pocket etc.)	The sediment control facility such as sand pocket, etc. is planned in order to control sediment discharge and prevent channel blockade and riverbed aggradation

CHAPTER 2 CURRENT CHARACTERISTICS OF RIVERS

The channel characteristics of object 6 rivers are shown as follows.

2.1 Current Discharge Capacity

In order to grasp the current situation of channel characteristic, the discharge capacity was calculated based on longitudinal survey result for each river. The figure of discharge capacity for each river is shown as below. (Chira River, Canete River, Chincha River, Pisco River, Yauca River, Majes-Camana River)

Moreover, it is also shown collectively on the relationship between the required dike height and the present dike height for each river, and the channel width along the longitudinal profiles.

(1) Chira River

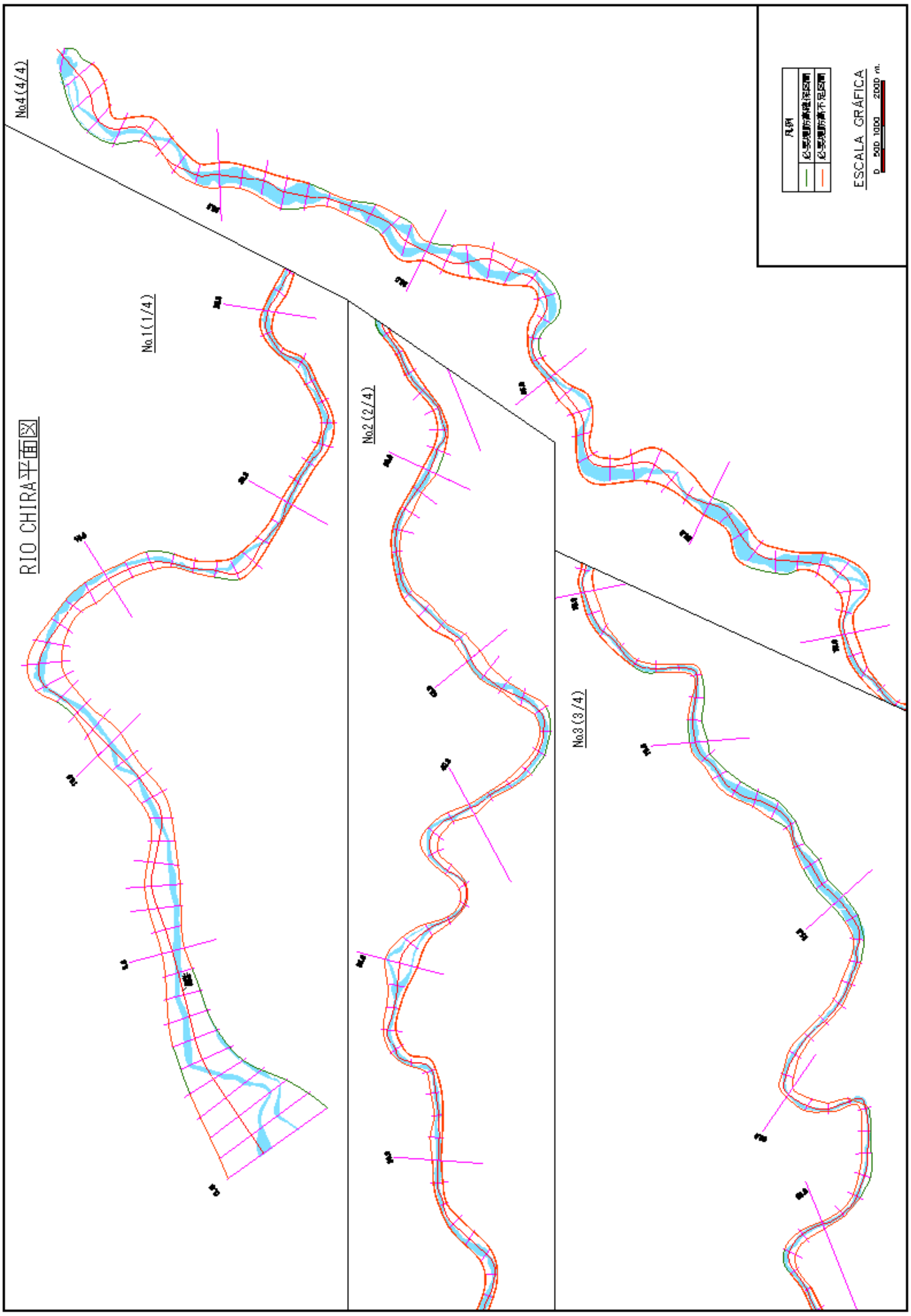

Figure 2.1 **Plan of the Chira River**

Table 2.1 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Chira River

Chira

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	1.43	0.48	1.19	1.50	1.86	2.10	2.33	-0.68	-1.62	3.30	1.88	2.82
0.5	3.78	1.37	1.45	1.74	2.09	2.34	2.56	1.44	-0.97	3.54	-0.24	2.17
1.0	4.16	1.44	1.77	2.04	2.37	2.60	2.81	1.57	-1.16	3.80	-0.37	2.36
1.5	4.70	2.58	2.06	2.32	2.63	2.85	3.04	1.86	-0.27	4.05	-0.66	1.47
2.0	3.94	2.68	2.29	2.58	2.91	3.14	3.35	0.80	-0.46	4.34	0.40	1.66
2.5	4.40	3.95	2.50	2.79	3.13	3.36	3.57	1.04	0.59	4.56	0.16	0.61
3.0	4.48	5.77	2.80	3.08	3.41	3.65	3.85	0.84	2.13	4.85	0.36	-0.93
3.5	5.18	2.02	3.05	3.34	3.67	3.90	4.10	1.29	-1.88	5.10	-0.09	3.08
4.0	5.58	2.73	3.41	3.70	4.04	4.27	4.48	1.31	-1.55	5.47	-0.11	2.75
4.5	5.98	3.30	3.81	4.11	4.46	4.70	4.91	1.28	-1.40	5.90	-0.08	2.60
5.0	6.17	3.46	4.18	4.50	4.85	5.15	5.46	1.02	-1.69	6.35	0.18	2.89
5.5	6.47	3.84	4.57	4.96	5.40	5.74	6.06	0.73	-1.90	6.94	0.47	3.10
6.0	6.92	3.31	4.82	5.39	6.05	6.52	6.97	0.40	-3.21	7.72	0.80	4.41
6.5	7.29	4.66	5.41	6.02	6.74	7.24	7.73	0.05	-2.58	8.44	1.15	3.78
7.0	7.52	4.40	5.62	6.16	6.82	7.29	7.74	0.23	-2.89	8.49	0.98	4.09
7.5	7.79	5.37	5.98	6.54	7.22	7.70	8.16	0.09	-2.34	8.90	1.11	3.54
8.0	8.08	4.73	6.19	6.77	7.47	7.95	8.42	0.13	-3.23	9.15	1.07	4.43
8.5	8.21	5.28	6.31	6.90	7.60	8.10	8.56	0.12	-2.82	9.30	1.08	4.02
9.0	4.85	5.67	6.39	6.97	7.66	8.15	8.60	-3.30	-2.48	9.35	4.50	3.68
9.5	6.23	6.84	6.51	7.10	7.81	8.30	8.76	-2.07	-1.46	9.50	3.27	2.66
10.0	6.78	8.22	6.64	7.21	7.91	8.40	8.86	-1.62	-0.18	9.60	2.82	1.38
10.5	7.71	6.69	6.80	7.34	7.99	8.44	8.88	-0.74	-1.75	9.64	1.94	2.95
11.0	6.39	5.90	7.12	7.68	8.33	8.78	9.21	-2.40	-2.88	9.98	3.60	4.08
11.5	6.48	10.02	7.39	7.91	8.55	9.00	9.43	-2.52	1.02	10.20	3.72	0.18
12.0	7.21	8.85	7.69	8.17	8.78	9.22	9.63	-2.01	-0.37	10.42	3.21	1.57
12.5	7.62	8.62	7.79	8.26	8.86	9.30	9.71	-1.68	-0.68	10.50	2.88	1.88
13.0	7.65	7.25	7.87	8.34	8.93	9.36	9.76	-1.71	-2.11	10.56	2.91	3.31
13.5	6.89	7.10	7.96	8.41	8.96	9.36	9.74	-2.47	-2.26	10.56	3.67	3.46
14.0	7.16	4.67	8.32	8.79	9.36	9.76	10.14	-2.60	-5.09	10.96	3.80	6.29
14.5	6.53	5.20	8.55	9.02	9.57	9.95	10.30	-3.42	-4.75	11.15	4.62	5.95
15.0	7.82	7.57	8.95	9.46	10.07	10.49	10.87	-2.67	-2.92	11.69	3.87	4.12
15.5	7.32	7.17	9.31	9.85	10.49	10.93	11.33	-3.61	-3.76	12.13	4.81	4.96
16.0	8.19	8.78	9.53	10.08	10.72	11.17	11.57	-2.97	-2.39	12.37	4.17	3.59
16.5	8.35	15.27	9.79	10.30	10.90	11.31	11.69	-2.96	3.96	12.51	4.16	-2.76
17.0	10.28	8.03	10.12	10.65	11.25	11.66	12.16	-1.38	-3.64	12.86	2.58	4.84
17.5	14.24	10.59	10.52	11.14	11.84	12.33	12.86	1.91	-1.74	13.53	-0.71	2.94
18.0	34.72	10.34	10.87	11.53	12.30	12.84	13.38	21.89	-2.50	14.04	-20.69	3.70
18.5	9.67	10.89	11.05	11.69	12.44	12.97	13.50	-3.30	-2.07	14.17	4.50	3.27
19.0	11.28	10.86	11.25	11.88	12.62	13.14	13.66	-1.86	-2.28	14.34	3.06	3.48
19.5	10.21	12.41	11.44	12.06	12.77	13.27	13.76	-3.06	-0.86	14.47	4.26	2.06
20.0	11.30	11.88	11.73	12.37	13.11	13.62	14.12	-2.33	-1.74	14.82	3.53	2.94
20.5	11.00	11.31	12.00	12.63	13.36	13.86	14.35	-2.87	-2.55	15.06	4.07	3.75
21.0	13.85	10.33	12.36	13.03	14.16	14.69	15.17	-0.84	-4.36	15.89	2.04	5.56
21.5	14.24	9.88	12.97	13.72	14.85	15.42	15.94	-1.19	-5.54	16.62	2.39	6.74
22.0	14.82	10.66	13.20	13.95	15.03	15.60	16.11	-0.78	-4.94	16.80	1.98	6.14
22.5	10.06	11.63	13.34	14.07	15.11	15.66	16.15	-5.60	-4.04	16.86	6.80	5.24
23.0	12.96	13.73	13.66	14.42	15.47	16.06	16.59	-3.10	-2.34	17.26	4.30	3.54
23.5	11.55	10.33	13.88	14.64	15.67	16.26	16.79	-4.71	-5.93	17.46	5.91	7.13
24.0	13.59	13.89	14.00	14.72	15.60	16.15	16.67	-2.55	-2.25	17.35	3.75	3.45
24.5	14.03	13.98	14.62	15.40	16.33	16.95	17.52	-2.92	-2.97	18.15	4.12	4.17
25.0	12.22	13.66	14.85	15.63	16.55	17.16	17.73	-4.94	-3.50	18.36	6.14	4.70
25.5	12.14	13.49	15.10	15.90	16.84	17.47	18.05	-5.33	-3.98	18.67	6.53	5.18
26.0	14.51	12.67	15.16	15.94	16.86	17.47	18.04	-2.96	-4.81	18.67	4.16	6.01
26.5	14.53	13.79	15.34	16.11	17.03	17.64	18.21	-3.11	-3.85	18.84	4.31	5.05
27.0	17.09	14.09	15.56	16.34	17.26	17.88	18.45	-0.79	-3.79	19.08	1.99	4.99
27.5	16.97	14.95	15.81	16.60	17.53	18.16	18.74	-1.19	-3.21	19.36	2.39	4.41
28.0	15.03	14.79	15.94	16.71	17.63	18.26	18.83	-3.23	-3.47	19.46	4.43	4.67
28.5	16.01	15.74	16.10	16.85	17.76	18.38	18.95	-2.37	-2.64	19.58	3.57	3.84
29.0	14.75	15.11	16.26	16.97	17.82	18.41	18.95	-3.66	-3.30	19.61	4.86	4.50
29.5	15.95	15.33	16.59	17.31	18.17	18.77	19.32	-2.82	-3.44	19.97	4.02	4.64
30.0	15.81	16.33	16.83	17.54	18.38	18.97	19.50	-3.15	-2.64	20.17	4.35	3.84
30.5	14.10	16.91	17.15	17.89	18.78	19.39	19.95	-5.29	-2.48	20.59	6.49	3.68
31.0	16.48	15.29	17.24	17.95	18.78	19.36	19.88	-2.88	-4.07	20.56	4.08	5.27
31.5	16.94	15.38	17.57	18.33	19.23	19.84	20.40	-2.90	-4.46	21.04	4.10	5.66
32.0	19.58	16.29	17.64	18.40	19.28	19.88	20.42	-0.30	-3.59	21.08	1.50	4.79
32.5	14.61	16.28	18.04	18.87	19.83	20.47	21.05	-5.87	-4.19	21.67	7.07	5.39
33.0	16.00	17.47	18.29	19.15	20.14	20.81	21.40	-4.81	-3.34	22.01	6.01	4.54
33.5	17.31	17.76	18.40	19.26	20.25	20.92	21.52	-3.61	-3.16	22.12	4.81	4.36
34.0	17.93	17.63	18.51	19.34	20.31	20.97	21.56	-3.04	-3.34	22.17	4.24	4.54
34.5	17.70	16.95	18.82	19.63	20.60	21.26	21.86	-3.56	-4.31	22.46	4.76	5.51
35.0	18.56	17.79	18.95	19.77	20.74	21.41	22.02	-2.85	-3.62	22.61	4.05	4.82
35.5	15.47	15.63	19.02	19.82	20.77	21.44	22.04	-5.97	-5.81	22.64	7.17	7.01
36.0	21.32	17.51	19.10	19.86	20.79	21.43	22.01	-0.11	-3.92	22.63	1.31	5.12
36.5	19.34	16.99	19.25	20.00	20.91	21.55	22.12	-2.20	-4.56	22.75	3.40	5.76
37.0	23.95	18.53	19.83	20.60	21.54	22.19	22.79	1.75	-3.66	23.39	-0.55	4.86
37.5	18.08	18.56	20.31	21.08	22.00	22.65	23.24	-4.58	-4.09	23.85	5.78	5.29
38.0	19.29	20.59	20.68	21.50	22.47	23.15	23.77	-3.86	-2.56	24.35	5.06	3.76
38.5	20.13	22.45	20.92	21.72	22.68	23.35	23.96	-3.22	-0.90	24.55	4.42	2.10
39.0	20.34	21.60	21.26	22.08	23.05	23.74	24.37	-3.40	-2.15	24.94	4.60	3.35
39.5	20.69	19.15	21.36	22.15	23.10	23.77	24.37	-3.08	-4.62	24.97	4.28	5.82
40.0	21.32	20.54	21.58	22.38	23.33	24.01	24.62	-2.68	-3.47	25.21	3.88	4.67
40.5	21.20	20.54	21.73	22.45	23.30	23.90	24.45	-2.71	-3.36	25.10	3.91	4.56
41.0	23.56	20.27	22.27	23.06	24.00	24.66	25.26	-1.10	-4.39	25.86	2.30	5.59
41.5	24.89	21.57	22.60	23.40	24.35	25.02	25.63	-0.13	-3.45	26.22	1.33	4.65
42.0	31.86	21.40	22.77	23.53	24.45	25.09	25.68	6.77	-3.69	26.29	-5.57	4.89
42.5	37.02	21.16	23.13	23.90	24.82	25.47	26.05	11.55	-4.31	26.67	-10.35	5.51
43.0	27.98	20.48	23.32	24.12	25.06	25.73	26.33	2.25	-5.25	26.93	-1.05	6.45
43.5	23.52	21.90	23.45	24.24	25.18	25.85	26.45	-2.33	-3.95	27.05	3.53	5.15
44.0	24.10	22.25	23.54	24.31	25.23	25.87	26.46	-1.77	-3.62	27.07	2.97	4.82
44.5	22.56	22.45	23.79	24.58	25.51	26.17	26.76	-3.61	-3.72	27.37	4.81	4.92
45.0	23.08	24.17	23.94	24.74	25.69	26.36	26.96	-3.28	-2.19	27.56	4.48	3.39
45.5	23.18	24.53	24.03	24.80	25.73	26.38	26.98	-3.20	-1.85	27.58	4.40	3.05
46.0	24.00	24.07	24.29	25.03	25.92	26.55	27.13	-2.55	-2.48	27.75	3.75	3.68
46.5	24.59	27.88	24.64	25.34	26.20	26.82	27.39	-2.23	1.06	28.02	3.43	0.14
47.0	24.69	24.60	24.96	25.62	26.44	27.03	27.58	-2.34	-2.43	28.23	3.54	3.63
47.5	25.00	23.54	25.11	25.75	26.53	27.09	27.61	-2.09	-3.55	28.29	3.29	4.75
48.0	22.35	24.08	25.48	26.13	26.91	27.46	27.97	-5.11	-3.38	28.66	6.31	4.58

Chira

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
48.5	24.80	25.61	25.93	26.63	27.47	28.05	28.58	−3.25	−2.44	29.25	4.45	3.64
49.0	24.46	25.71	26.32	27.07	27.95	28.58	29.14	−4.12	−2.87	29.78	5.32	4.07
49.5	25.58	28.08	26.55	27.27	28.12	28.72	29.27	−3.14	−0.64	29.92	4.34	1.84
50.0	29.39	29.77	26.86	27.62	28.58	29.19	29.76	0.20	0.58	30.39	1.00	0.62
50.5	41.99	25.10	27.03	27.80	28.77	29.33	29.86	12.66	−4.23	30.53	−11.46	5.43
51.0	29.20	23.78	27.17	27.91	28.85	29.40	29.91	−0.20	−5.62	30.60	1.40	6.82
51.5	26.38	25.91	27.32	28.08	29.01	29.58	30.08	−3.20	−3.67	30.78	4.40	4.87
52.0	28.69	26.32	27.48	28.27	29.22	29.81	30.33	−1.12	−3.49	31.01	2.32	4.69
52.5	29.06	25.39	27.70	28.55	29.52	30.13	30.68	−1.07	−4.74	31.33	2.27	5.94
53.0	27.82	24.56	27.90	28.74	29.69	30.28	30.80	−2.46	−5.72	31.48	3.66	6.92
53.5	26.29	30.30	28.11	28.95	29.90	30.50	31.02	−4.21	−0.20	31.70	5.41	1.40
54.0	26.71	33.91	28.48	29.37	30.39	31.05	31.63	−4.34	2.86	32.25	5.54	−1.66
54.5	29.67	29.65	28.64	29.55	30.59	31.26	31.85	−1.59	−1.61	32.46	2.79	2.81
55.0	31.29	28.20	28.85	29.76	30.77	31.43	32.02	−0.14	−3.23	32.63	1.34	4.43
55.5	30.31	31.63	29.05	30.01	31.18	31.77	32.35	−1.46	−0.14	32.97	2.66	1.34
56.0	31.64	29.27	29.49	30.49	31.58	32.09	32.58	−0.45	−2.82	33.29	1.65	4.02
56.5	35.26	30.28	29.81	30.84	31.99	32.57	33.13	2.68	−2.30	33.77	−1.48	3.50
57.0	34.64	30.04	29.96	30.94	32.04	32.61	33.15	2.03	−2.57	33.81	−0.83	3.77
57.5	36.39	33.42	30.12	31.04	32.73	33.70	34.13	2.69	−0.28	34.90	−1.49	1.48
58.0	58.58	34.00	30.72	32.43	33.77	34.42	34.92	24.16	−0.42	35.62	−22.96	1.62
58.5	28.33	32.15	31.51	33.14	34.47	35.15	35.68	−6.82	−3.00	36.35	8.02	4.20
59.0	31.38	35.27	31.65	33.25	34.58	35.27	35.82	−3.89	0.00	36.47	5.09	1.20
59.5	32.22	36.10	31.88	33.42	34.75	35.45	36.02	−3.23	0.64	36.65	4.43	0.56
60.0	32.00	34.99	31.95	33.42	34.71	35.38	35.92	−3.38	−0.39	36.58	4.58	1.59
60.5	33.67	33.70	32.35	33.76	35.05	35.77	36.36	−2.10	−2.07	36.97	3.30	3.27
61.0	34.42	35.01	32.44	33.81	35.10	35.82	36.40	−1.40	−0.81	37.02	2.60	2.01
61.5	33.54	32.93	32.53	33.88	35.14	35.85	36.42	−2.31	−2.92	37.05	3.51	4.12
62.0	32.88	34.00	32.71	34.04	35.31	36.03	36.61	−3.15	−2.03	37.23	4.35	3.23
62.5	37.71	34.00	32.86	34.18	35.45	36.18	36.78	1.53	−2.18	37.38	−0.33	3.38
63.0	37.27	32.51	32.93	34.23	35.49	36.21	36.81	1.06	−3.70	37.41	0.14	4.90
63.5	37.55	34.05	33.11	34.36	35.59	36.32	36.92	1.23	−2.27	37.52	−0.03	3.47
64.0	60.11	36.40	36.09	36.84	37.74	38.32	38.84	21.79	−1.92	39.52	−20.59	3.12
64.5	60.11	37.30	37.10	37.60	38.51	39.12	39.68	20.99	−1.82	40.32	−19.79	3.02
65.0	51.58	41.61	37.60	38.32	38.91	39.46	39.97	12.13	2.16	40.66	−10.93	−0.96
65.5	51.58	41.75	38.14	38.85	39.46	39.97	40.45	11.62	1.79	41.17	−10.42	−0.59
66.0	51.58	44.00	38.41	39.09	39.72	40.22	40.69	11.36	3.78	41.42	−10.16	−2.58
66.5	51.58	37.56	38.57	39.26	39.89	40.39	40.85	11.19	−2.83	41.59	−9.99	4.03
67.0	51.58	38.19	39.18	39.74	40.38	40.84	41.24	10.75	−2.65	42.04	−9.55	3.85
67.5	55.36	42.37	39.77	40.34	41.04	41.52	41.96	13.84	0.84	42.72	−12.64	0.36
68.0	55.36	38.72	40.03	40.60	41.27	41.75	42.18	13.61	−3.03	42.95	−12.41	4.23
68.5	55.36	37.76	40.15	40.73	41.43	41.91	42.35	13.45	−4.15	43.11	−12.25	5.35
69.0	55.36	40.42	40.32	40.88	41.55	42.02	42.44	13.34	−1.60	43.22	−12.14	2.80
69.5	70.76	39.82	40.74	41.29	41.96	42.43	42.85	28.33	−2.60	43.63	−27.13	3.80
70.0	70.76	39.82	40.80	41.36	42.03	42.50	42.92	28.26	−2.67	43.70	−27.06	3.87
70.5	70.76	43.43	40.91	41.48	42.13	42.58	42.99	28.18	0.85	43.78	−26.98	0.35
71.0	67.10	40.21	41.16	41.74	42.33	42.74	43.11	24.36	−2.53	43.94	−23.16	3.73
71.5	67.10	41.06	41.44	42.09	42.79	43.27	43.72	23.83	−2.21	44.47	−22.63	3.41
72.0	40.21	38.70	41.59	42.25	42.93	43.40	43.81	−3.19	−4.70	44.60	4.39	5.90
72.5	39.42	41.65	41.90	42.66	43.49	44.07	44.60	−4.65	−2.42	45.27	5.85	3.62
73.0	40.46	44.78	42.00	42.76	43.59	44.17	44.68	−3.71	0.62	45.37	4.91	0.58
73.5	41.35	41.75	42.16	42.94	43.79	44.38	44.91	−3.03	−2.63	45.58	4.23	3.83
74.0	41.81	42.85	42.60	43.44	44.40	45.06	45.66	−3.25	−2.21	46.26	4.45	3.41
74.5	42.27	42.84	44.11	44.57	45.10	45.47	45.98	−3.21	−2.63	46.67	4.41	3.83
75.0	42.85	43.61	44.57	45.06	45.63	46.02	46.49	−3.17	−2.41	47.22	4.37	3.61
75.5	42.85	41.22	44.63	45.14	45.74	46.16	46.64	−3.31	−4.94	47.36	4.51	6.14
76.0	42.90	42.85	44.66	45.17	45.77	46.19	46.66	−3.29	−3.34	47.39	4.49	4.54
76.5	43.41	43.66	44.78	45.31	45.93	46.36	46.84	−2.96	−2.70	47.56	4.16	3.90
77.0	44.33	44.17	44.93	45.48	46.12	46.57	47.05	−2.24	−2.40	47.77	3.44	3.60
77.5	45.28	45.12	44.98	45.53	46.18	46.63	47.11	−1.35	−1.51	47.83	2.55	2.71
78.0	43.59	48.49	45.05	45.61	46.25	46.70	47.17	−3.11	1.79	47.90	4.31	−0.59
78.5	44.89	49.89	45.13	45.69	46.33	46.77	47.23	−1.88	3.12	47.97	3.08	−1.92
79.0	45.47	43.72	45.43	46.04	46.74	47.22	47.71	−1.76	−3.50	48.42	2.96	4.70
79.5	45.66	45.28	45.55	46.14	46.82	47.29	47.76	−1.63	−2.01	48.49	2.83	3.21
80.0	48.26	45.32	45.81	46.38	47.04	47.50	47.95	0.76	−2.18	48.70	0.44	3.38
80.5	45.56	44.82	46.39	47.05	47.84	48.38	48.87	−2.82	−3.56	49.58	4.02	4.76
81.0	46.31	46.40	46.99	47.71	48.57	49.17	49.71	−2.86	−2.77	50.37	4.06	3.97
81.5	47.01	46.93	47.11	47.83	48.68	49.27	49.81	−2.26	−2.34	50.47	3.46	3.54
82.0	48.12	47.87	47.69	48.24	48.88	49.35	49.85	−1.22	−1.48	50.55	2.42	2.68
82.5	47.49	47.13	48.54	49.33	50.27	50.93	51.53	−3.44	−3.80	52.13	4.64	5.00
83.0	47.63	46.29	49.37	50.08	50.93	51.60	52.22	−3.97	−5.31	52.80	5.17	6.51
83.5	48.82	48.12	49.97	50.72	51.62	52.30	52.93	−3.48	−4.18	53.50	4.68	5.38
84.0	49.54	48.83	50.30	51.03	51.92	52.60	53.22	−3.06	−3.77	53.80	4.26	4.97
84.5	47.57	50.20	50.73	51.34	52.17	52.82	53.41	−5.25	−2.62	54.02	6.45	3.82
85.0	51.69	48.16	51.23	51.94	52.69	53.21	53.67	−1.52	−5.05	54.41	2.72	6.25
85.5	51.82	49.96	51.80	52.51	53.28	53.81	54.29	−1.99	−3.85	55.01	3.19	5.05
86.0	63.61	50.00	52.21	52.90	53.66	54.19	54.66	9.42	−4.19	55.39	−8.22	5.39
86.5	69.13	51.94	52.66	53.31	54.07	54.60	55.08	14.53	−2.66	55.80	−13.33	3.86
87.0	56.61	53.49	53.33	53.99	54.80	55.37	55.88	1.24	−1.88	56.57	−0.04	3.08
87.5	70.38	53.01	54.62	55.33	56.17	56.75	57.27	13.64	−3.74	57.95	−12.44	4.94
88.0	53.86	55.45	55.27	56.05	56.97	57.62	58.19	−3.76	−2.17	58.82	4.96	3.37
88.5	55.92	55.78	55.74	56.26	57.10	57.72	58.29	−1.80	−1.94	58.92	3.00	3.14
89.0	56.71	55.79	56.19	56.61	57.31	57.87	58.40	−1.16	−2.08	59.07	2.36	3.28
89.5	57.20	55.74	56.55	56.96	57.58	58.09	58.58	−0.89	−2.35	59.29	2.09	3.55
90.0	63.07	56.69	58.03	58.62	59.31	59.78	60.21	3.29	−3.09	60.98	−2.09	4.29
90.5	55.90	55.77	58.62	59.25	60.01	60.55	61.02	−4.65	−4.78	61.75	5.85	5.98
91.0	76.15	58.17	58.77	59.36	60.09	60.60	61.06	15.55	−2.43	61.80	−14.35	3.63
91.5	60.48	61.40	59.12	59.65	60.31	60.79	61.23	−0.31	0.61	61.99	1.51	0.59
92.0	63.03	60.76	60.05	60.57	61.17	61.57	61.94	1.46	−0.81	62.77	−0.26	2.01
92.5	58.64	61.19	60.58	61.10	61.70	62.11	62.47	−3.47	−0.92	63.31	4.67	2.12
93.0	64.36	61.35	61.06	61.62	62.27	62.73	63.13	1.64	−1.38	63.93	−0.43	2.58
93.5	61.19	63.94	61.59	62.06	62.61	62.99	63.33	−1.80	0.95	64.19	3.00	0.25
94.0	62.54	62.02	62.08	62.58	63.15	63.56	63.91	−1.02	−1.54	64.76	2.22	2.73
94.5	63.79	63.98	63.40	63.77	64.19	64.48	64.74	−0.69	−0.50	65.68	1.89	1.70
95.0	65.13	64.80	63.87	64.25	64.70	65.00	65.27	0.13	−0.20	66.20	1.07	1.40
95.5	64.58	64.65	65.59	65.97	66.43	66.74	67.02	−2.16	−2.09	67.94	3.36	3.29
96.0	65.68	63.40	65.94	66.29	66.74	67.32	67.83	−1.63	−3.92	68.52	2.83	5.12
96.5	67.11	65.02	66.32	66.82	67.46	68.08	68.63	−0.97	−3.06	69.28	2.17	4.26
97.0	67.67	66.58	66.63	67.17	67.86	68.47	69.03	−0.80	−1.89	69.67	2.00	3.09
97.5	69.14	77.54	66.82	67.44	68.11	68.67	69.20	0.47	8.87	69.87	0.73	−7.67
98.0	65.73	69.83	67.19	67.85	68.46	68.95	69.41	−3.21	0.89	70.15	4.41	0.31
98.5	68.48	71.57	68.10	68.62	69.22	69.64	70.01	−1.16	1.93	70.84	2.36	−0.73
99.0	70.30	80.96	68.69	69.24	69.87	70.32	70.72	−0.02	10.64	71.52	1.22	−9.44
99.5	71.59	85.56	69.00	69.53	70.15	70.58	70.97	1.01	14.98	71.78	0.19	−13.78

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

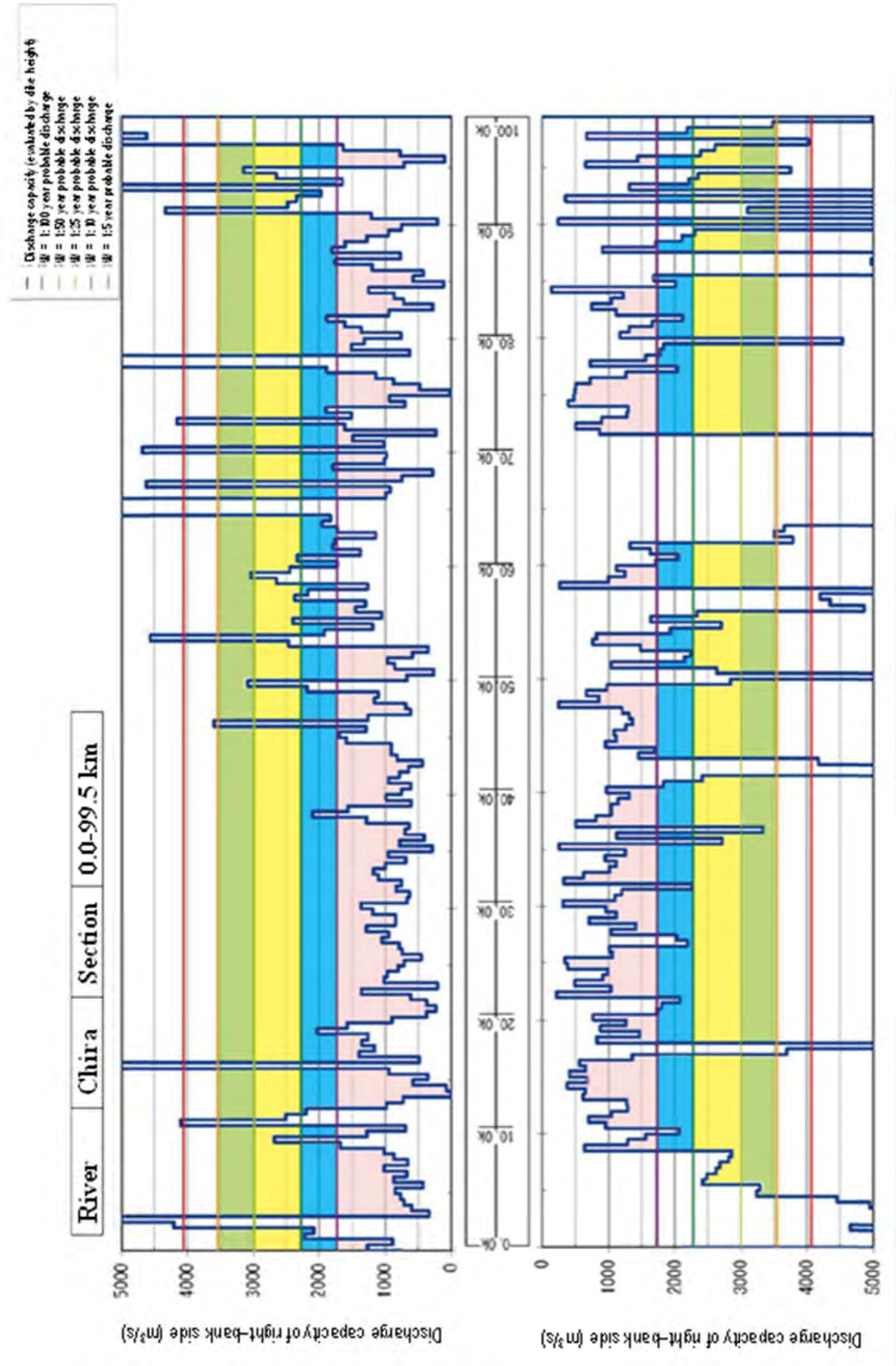

Figure 2.2 **Discharge Capacity in the Chira River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

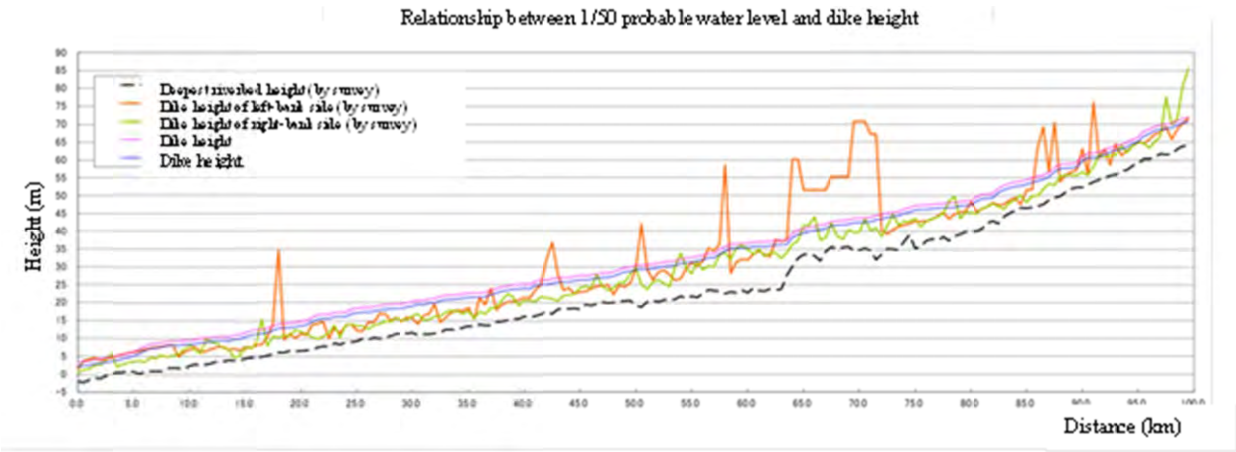

Figure 2.3 **Relation of Water Level of 1/50 Year Discharge and Dike Height in Chira River**

2) Chanel Width

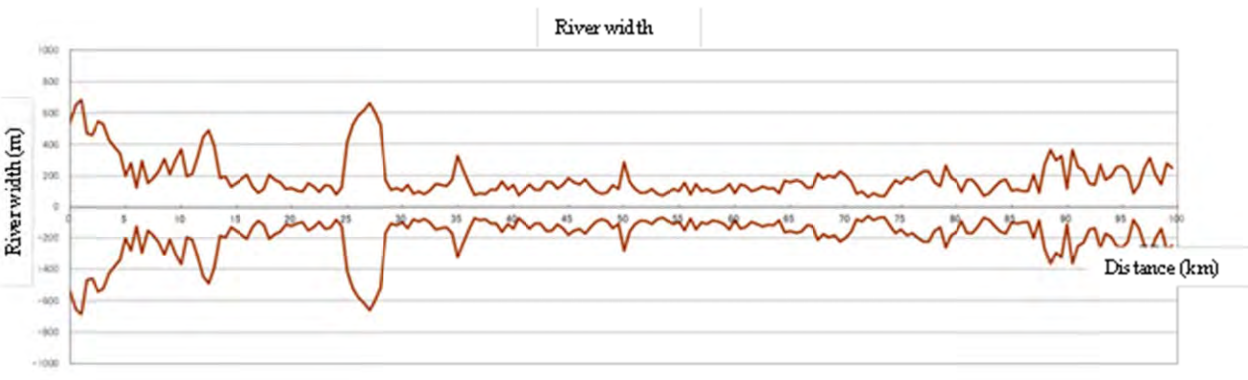

Figure 2.4 **Change of Chanel Width in the Chira River**

3) Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge)

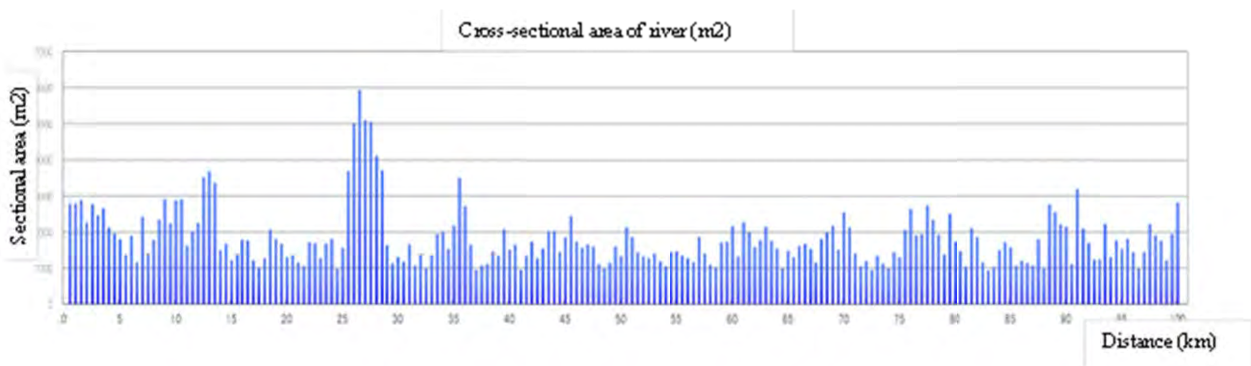

Figure 2.5 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Chira River**

(2) Canete River

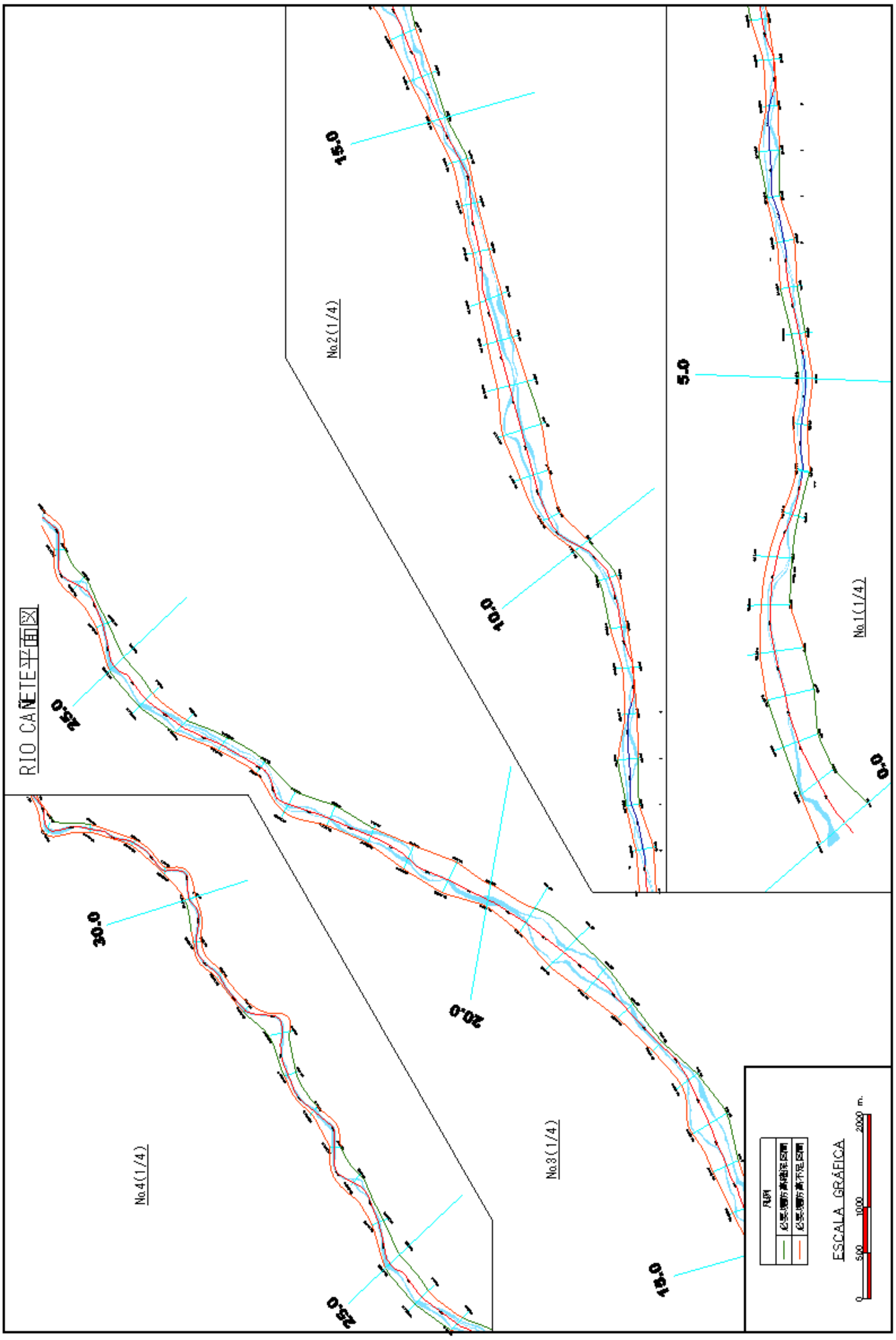

Figure 2.6 **Plan of the Canete River**

Table 2.2 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Canete River

Canete

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	3.04	2.42	2.6	3.0	3.5	3.9	4.17	-0.84	-1.46	5.08	2.04	2.66
0.5	10.85	6.43	4.7	5.4	6.1	6.7	7.11	4.16	-0.26	7.89	-2.96	1.46
1.0	19.26	15.46	10.2	10.7	11.2	11.7	12.05	7.61	3.81	12.86	-6.41	-2.61
1.5	23.14	22.02	17.5	17.9	18.3	18.5	18.77	4.59	3.47	19.75	-3.39	-2.27
2.0	28.54	24.14	23.4	23.8	24.2	24.5	24.67	4.07	-0.33	25.67	-2.87	1.53
2.5	29.77	30.43	29.3	29.6	30.1	30.4	30.69	-0.65	0.01	31.62	1.85	1.19
3.0	39.57	36.32	34.9	35.4	36.0	36.5	36.95	3.03	-0.22	37.74	-1.83	1.42
3.5	44.29	41.17	39.6	40.3	41.0	41.5	41.90	2.77	-0.35	42.72	-1.57	1.55
4.0	50.87	44.51	44.1	44.4	45.2	45.9	46.45	4.97	-1.39	47.10	-3.77	2.59
4.5	50.77	50.90	49.3	50.0	50.8	51.5	52.00	-0.71	-0.58	52.68	1.91	1.78
5.0	56.72	55.97	54.5	55.1	56.1	56.7	57.14	0.02	-0.73	57.90	1.18	1.93
5.5	61.60	62.63	59.3	60.1	60.6	61.3	61.81	0.30	1.33	62.50	0.90	-0.13
6.0	67.94	67.29	64.8	65.4	66.0	66.8	67.18	1.19	0.54	67.95	0.01	0.66
6.5	71.98	72.26	70.6	71.1	71.7	72.2	72.60	-0.23	0.05	73.41	1.43	1.15
7.0	75.91	77.89	75.9	76.5	77.2	77.9	78.37	-1.96	0.02	79.07	3.16	1.18
7.5	84.54	83.93	81.3	81.8	82.6	83.1	83.56	1.40	0.79	84.34	-0.20	0.41
8.0	87.14	86.94	87.2	87.8	88.6	89.2	89.74	-2.10	-2.30	90.44	3.30	3.50
8.5	92.88	94.92	93.0	93.6	94.4	95.1	95.68	-2.24	-0.20	96.32	3.44	1.40
9.0	97.59	99.58	97.5	98.4	99.2	99.9	100.46	-2.35	-0.36	101.15	3.55	1.57
9.5	103.52	106.09	103.3	103.9	104.4	104.9	105.21	-1.35	1.23	106.07	2.55	-0.03
10.0	113.17	112.15	108.0	108.7	109.6	110.2	110.66	2.99	1.97	111.38	-1.79	-0.77
10.5	115.92	115.66	115.0	115.5	116.2	116.7	117.09	-0.77	-1.03	117.89	1.97	2.23
11.0	120.02	120.74	120.1	120.6	121.3	121.9	122.26	-1.84	-1.12	123.06	3.04	2.32
11.5	126.04	125.46	125.6	125.9	126.3	126.6	126.97	-0.51	-1.09	127.75	1.71	2.29
12.0	133.58	131.61	131.7	132.0	132.3	132.6	132.87	0.94	-1.03	133.84	0.26	2.23
12.5	138.25	137.29	137.3	137.7	138.2	138.6	138.96	-0.40	-1.36	139.85	1.60	2.56
13.0	144.87	144.19	143.6	144.0	144.6	145.0	145.38	-0.17	-0.85	146.24	1.37	2.05
13.5	151.37	149.50	149.5	150.0	150.6	151.1	151.52	0.23	-1.64	152.34	0.97	2.84
14.0	157.25	155.68	155.4	156.0	156.7	157.3	157.80	-0.07	-1.64	158.52	1.27	2.84
14.5	163.04	162.65	160.8	161.3	162.0	162.7	163.10	0.34	-0.04	163.90	0.85	1.24
15.0	169.07	168.02	166.9	167.4	168.0	168.5	168.96	0.54	-0.51	169.73	0.66	1.71
15.5	174.33	173.29	172.1	172.6	173.3	173.8	174.18	0.53	-0.51	175.00	0.67	1.71
16.0	178.76	179.67	178.3	178.7	179.2	179.6	179.84	-0.80	0.11	180.76	2.00	1.09
16.5	189.69	184.90	183.9	184.3	184.7	185.0	185.23	4.69	-0.10	186.20	-3.49	1.30
17.0	198.92	190.23	190.7	191.2	191.8	192.3	192.69	6.61	-2.08	193.51	-5.41	3.28
17.5	204.00	196.35	196.1	196.7	197.4	198.0	198.52	5.95	-1.70	199.25	-4.75	2.90
18.0	208.64	202.64	202.2	202.7	203.2	203.7	204.03	4.96	-1.04	204.88	-3.76	2.24
18.5	216.02	208.07	207.5	207.9	208.3	208.9	209.24	7.12	-0.83	210.10	-5.92	2.03
19.0	231.58	214.00	214.2	214.6	214.9	215.2	215.35	16.41	-1.17	216.37	-15.21	2.37
19.5	234.50	219.81	220.6	220.9	221.3	221.6	221.80	12.92	-1.77	222.78	-11.72	2.97
20.0	227.59	225.71	226.4	226.8	227.4	227.8	228.18	-0.24	-2.12	229.03	1.44	3.32
20.5	232.17	231.84	232.1	232.4	232.8	233.2	233.57	-0.99	-1.32	234.36	2.19	2.51
21.0	239.69	238.14	238.4	238.8	239.3	239.7	240.00	-0.01	-1.56	240.90	1.21	2.76
21.5	243.75	244.32	244.0	244.5	245.2	245.7	246.12	-1.95	-1.38	246.90	3.15	2.58
22.0	258.48	248.71	249.5	250.1	250.6	251.1	251.56	7.36	-2.41	252.32	-6.16	3.61
22.5	261.54	255.90	255.3	255.9	256.3	256.7	256.99	4.84	-0.80	257.90	-3.64	2.00
23.0	277.79	260.72	261.1	261.7	262.5	263.2	263.70	14.62	-2.45	264.37	-13.42	3.65
23.5	286.32	266.55	266.2	266.8	267.7	268.3	268.79	17.98	-1.79	269.54	-16.78	2.99
24.0	293.96	274.25	272.5	273.1	273.7	274.2	274.57	19.77	0.06	275.39	-18.57	1.14
24.5	279.29	280.51	278.4	278.8	279.3	279.7	280.17	-0.44	0.78	280.93	1.64	0.42
25.0	305.10	286.83	284.3	284.8	285.4	285.9	286.30	19.16	0.89	287.14	-17.96	0.31
25.5	310.22	289.46	289.7	290.4	291.2	292.0	292.55	18.26	-2.50	293.16	-17.06	3.70
26.0	317.26	295.71	295.1	295.9	296.6	297.3	297.79	19.94	-1.61	298.52	-18.74	2.81
26.5	307.24	302.64	300.5	301.4	302.4	303.3	304.00	3.90	-0.70	304.54	-2.70	1.90
27.0	307.18	306.25	305.5	306.6	307.6	308.6	309.45	-1.44	-2.36	309.81	2.64	3.56
27.5	335.69	311.92	310.5	311.2	312.6	313.5	314.17	22.22	-1.55	314.67	-21.02	2.75
28.0	342.51	321.75	315.2	315.9	316.5	317.2	317.70	25.30	4.55	318.41	-24.10	-3.35
28.5	323.24	329.22	322.9	324.1	325.5	326.6	327.53	-3.39	2.59	327.83	4.59	-1.39
29.0	331.04	327.61	328.0	329.0	330.3	331.3	332.08	-0.27	-3.70	332.51	1.47	4.90
29.5	335.86	332.81	333.4	334.5	335.9	336.9	337.59	-0.99	-4.05	338.05	2.19	5.25
30.0	340.36	343.00	339.3	340.2	341.2	342.0	342.64	-1.63	1.01	343.19	2.83	0.19
30.5	346.28	347.78	346.5	347.4	348.4	349.4	350.19	-3.13	-1.64	350.62	4.33	2.84
31.0	352.37	355.00	351.6	352.8	354.3	355.5	356.64	-3.18	-0.54	356.74	4.38	1.74
31.5	363.03	362.32	359.2	360.4	361.9	363.1	363.96	-0.11	-0.82	364.34	1.31	2.02
32.0	372.35	365.18	365.8	366.5	367.5	368.4	369.09	3.96	-3.21	369.59	-2.76	4.41
32.5	375.30	373.38	372.4	373.6	375.3	376.7	377.89	-1.40	-3.32	377.90	2.60	4.52

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m）
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m）

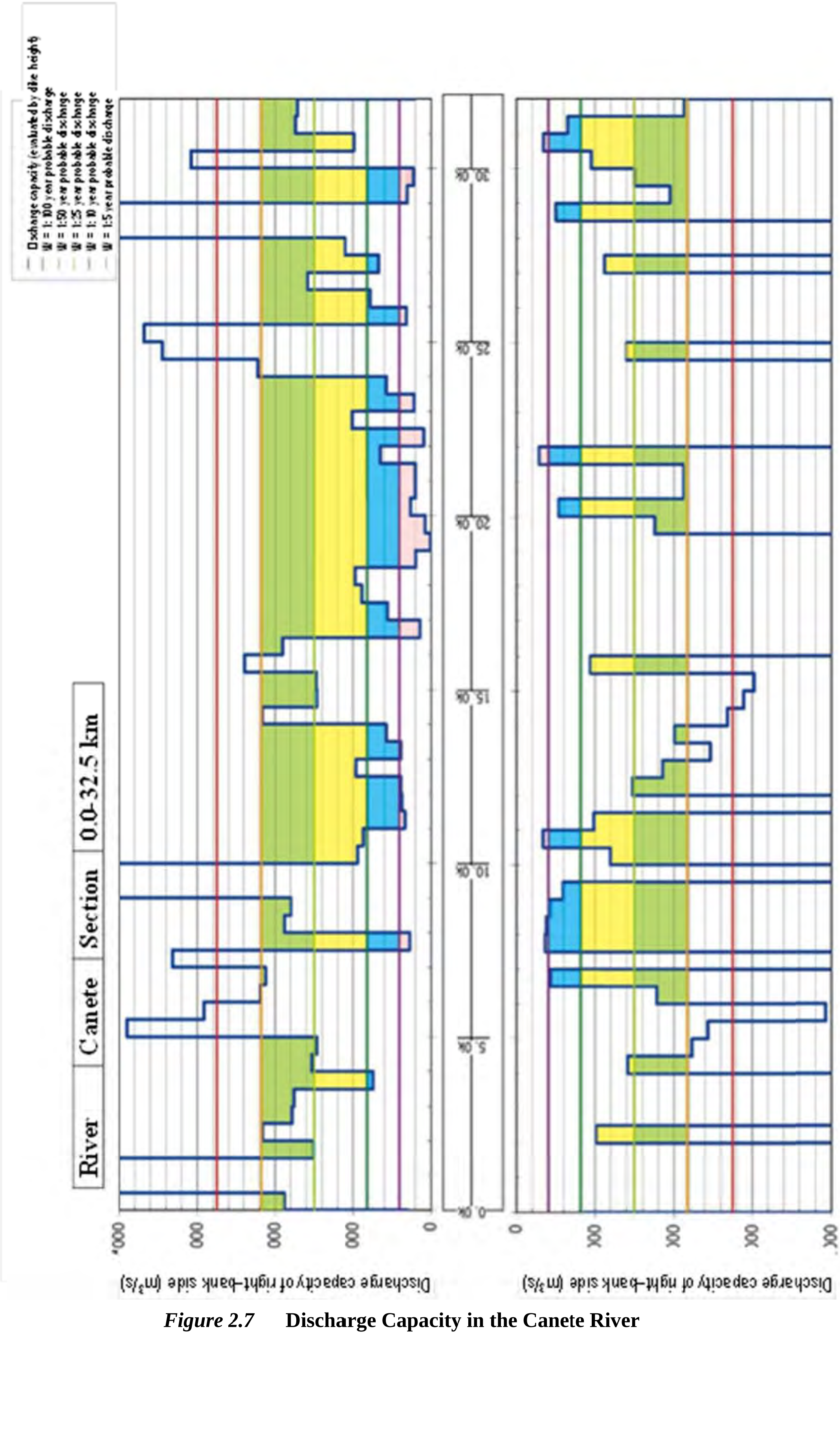

Figure 2.7 **Discharge Capacity in the Canete River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

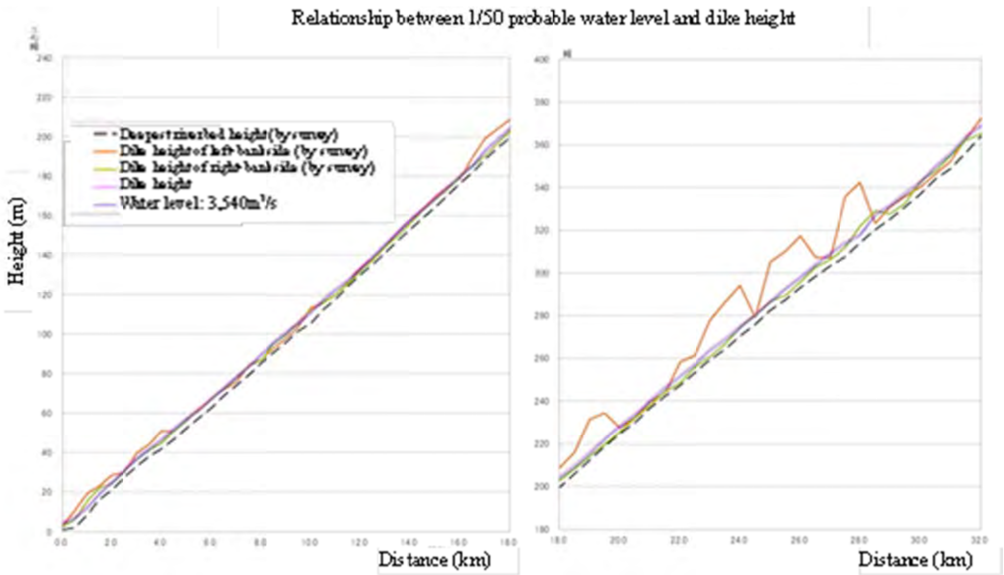

Figure 2.8 **Relation of Water Level of 1/50 Year Discharge and Dike Height in Canete River**

2) Chanel Width

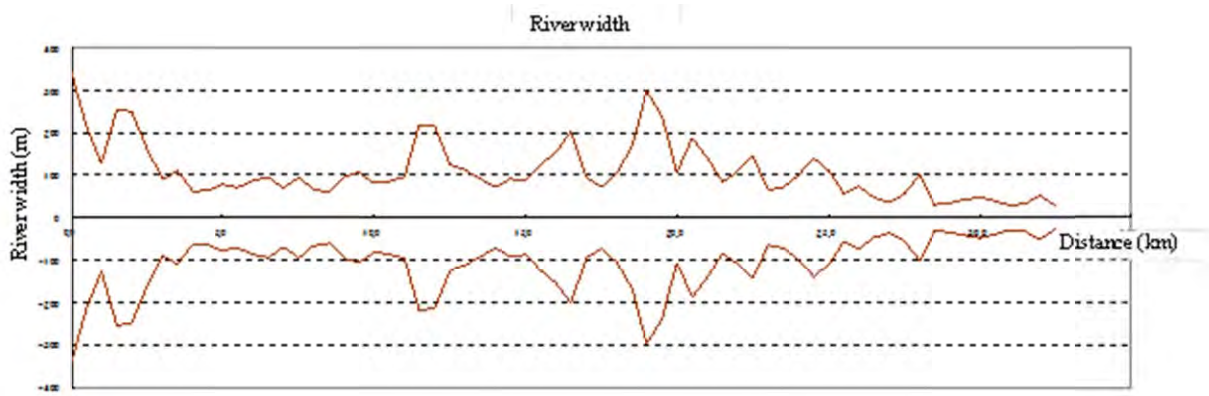

Figure 2.9 **Change of Chanel Width in the Canete River**

3) Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge)

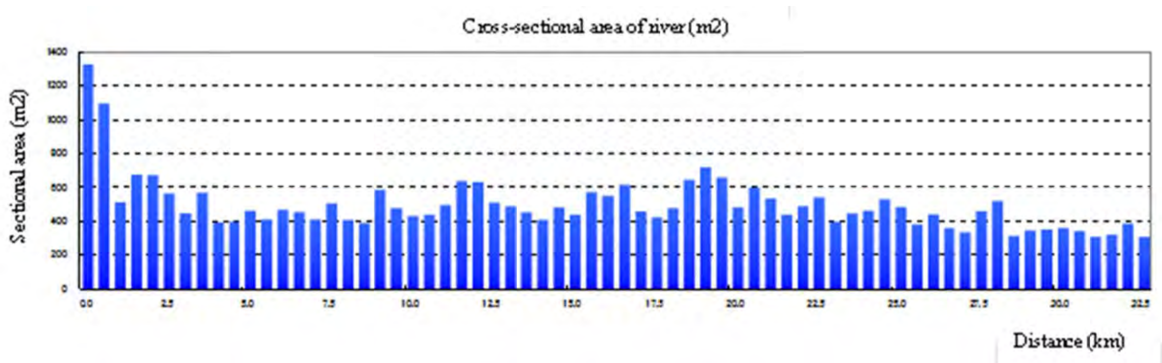

Figure 2.10 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Canete River**

(3) Chincha River（Chico River，Matagente River）

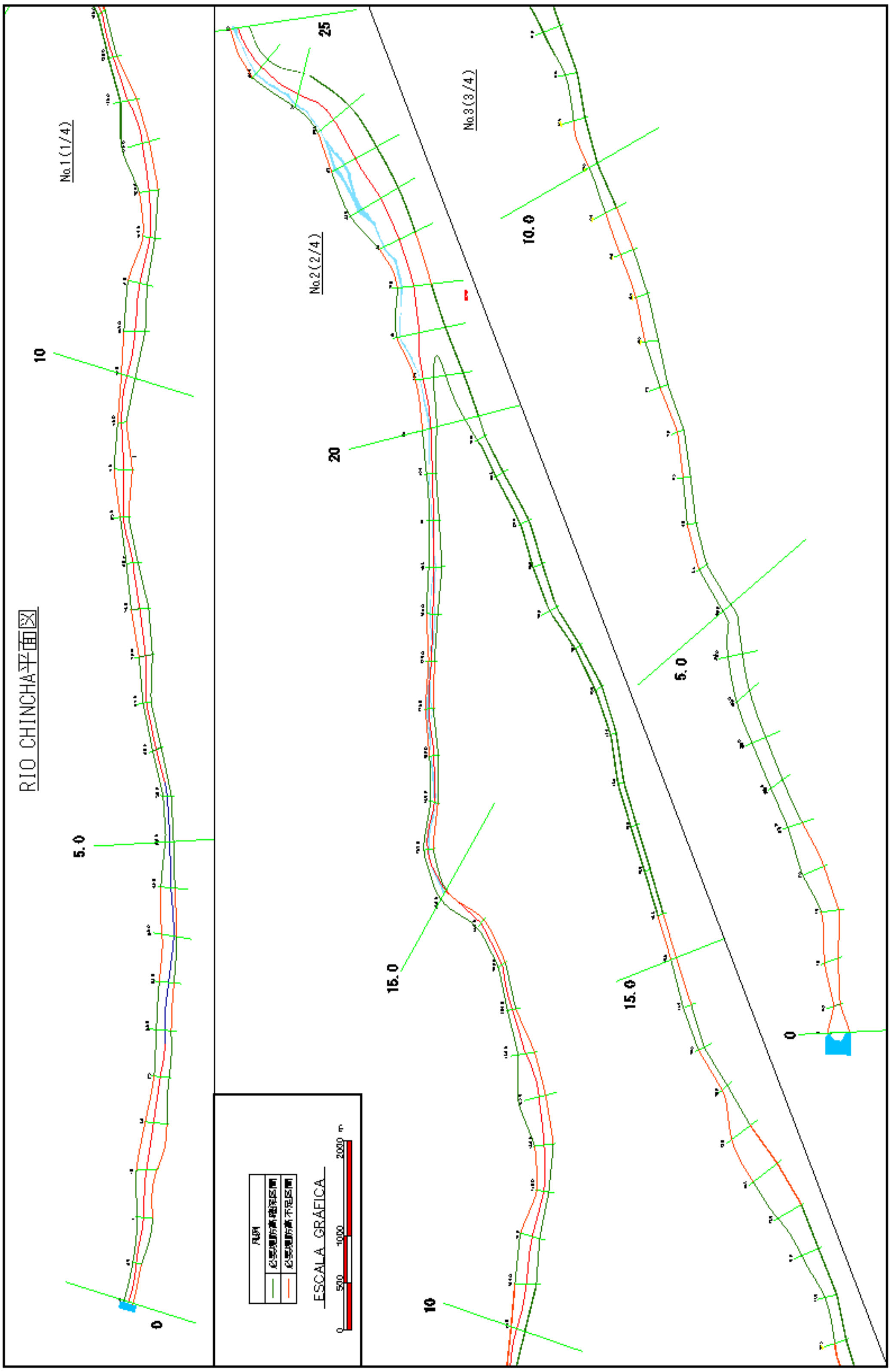

Figure 2.11 **Plan of the Chincha River**

Table 2.3 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Chico River

Chico

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	3.71	4.12	2.44	2.57	2.83	2.94	3.20	0.77	1.18	3.74	0.03	−0.38
0.5	6.72	8.25	5.64	5.83	6.21	6.38	6.78	0.33	1.87	7.18	0.47	−1.07
1.0	10.89	10.80	9.85	9.97	10.20	10.30	10.54	0.59	0.50	11.10	0.21	0.30
1.5	15.17	20.55	14.52	14.64	14.88	14.98	15.23	0.19	5.57	15.78	0.61	−4.77
2.0	19.56	19.55	19.55	19.63	19.77	19.83	19.97	−0.26	−0.28	20.63	1.06	1.08
2.5	24.95	24.12	24.30	24.38	24.54	24.62	24.79	0.34	−0.49	25.42	0.46	1.29
3.0	30.48	30.30	29.64	29.72	29.86	29.93	30.07	0.55	0.37	30.73	0.25	0.43
3.5	34.82	35.29	34.84	34.91	35.05	35.11	35.24	−0.29	0.18	35.91	1.09	0.62
4.0	40.27	42.10	39.58	39.66	39.84	39.92	40.07	0.35	2.18	40.72	0.45	−1.38
4.5	46.38	48.59	46.85	47.05	47.42	47.57	47.93	−1.19	1.02	48.37	1.99	−0.22
5.0	53.20	51.85	50.38	50.54	50.83	50.96	51.27	2.24	0.89	51.76	−1.44	−0.09
5.5	58.00	58.31	55.25	55.43	55.78	55.93	56.30	2.06	2.37	56.73	−1.26	−1.57
6.0	62.36	62.11	59.51	59.64	59.89	60.00	60.26	2.36	2.11	60.80	−1.56	−1.31
6.5	65.97	67.28	64.71	64.85	65.12	65.23	65.71	0.73	2.04	66.03	0.07	−1.24
7.0	70.68	71.22	69.95	70.04	70.23	70.31	70.50	0.37	0.91	71.11	0.43	−0.11
7.5	76.17	75.60	75.49	75.56	75.71	75.78	75.94	0.39	−0.18	76.58	0.41	0.98
8.0	81.79	82.51	81.06	81.16	81.35	81.44	81.65	0.35	1.07	82.24	0.45	−0.27
8.5	87.91	88.23	86.72	86.86	87.13	87.25	87.53	0.66	0.98	88.05	0.14	−0.18
9.0	92.69	92.27	92.15	92.23	92.38	92.44	92.82	0.24	−0.17	93.24	0.56	0.97
9.5	98.27	99.23	98.09	98.23	98.47	98.58	98.82	−0.30	0.66	99.38	1.10	0.14
10.0	104.25	103.92	103.53	103.63	103.80	103.88	104.06	0.37	0.05	104.68	0.43	0.75
10.5	110.34	109.64	109.45	109.53	109.66	109.72	109.86	0.62	−0.09	110.52	0.18	0.89
11.0	117.19	116.83	115.44	115.55	115.71	115.78	115.94	1.41	1.05	116.58	−0.61	−0.25
11.5	122.77	122.32	121.98	122.09	122.34	122.43	122.66	0.34	−0.11	123.23	0.46	0.91
12.0	130.13	128.13	127.76	127.84	127.99	128.06	128.22	2.07	0.07	128.86	−1.26	0.73
12.5	134.47	135.27	134.59	134.64	134.76	134.81	134.92	−0.34	0.47	135.61	1.14	0.33
13.0	141.10	143.66	141.04	141.12	141.29	141.36	141.53	−0.26	2.30	142.16	1.06	−1.50
13.5	147.52	148.33	147.45	147.58	147.82	147.93	148.19	−0.41	0.41	148.73	1.21	0.40
14.0	155.34	154.91	153.31	153.44	153.70	153.81	154.07	1.53	1.10	154.61	−0.73	−0.30
14.5	159.29	160.51	159.53	159.65	159.88	159.98	160.22	−0.69	0.53	160.78	1.49	0.28
15.0	166.80	173.71	167.51	167.66	167.94	168.06	168.31	−1.26	5.66	168.86	2.06	−4.85
15.5	174.12	173.81	173.07	173.18	173.39	173.49	173.71	0.63	0.32	174.29	0.17	0.48
16.0	180.87	182.06	180.26	180.41	180.70	180.83	181.14	0.04	1.23	181.63	0.76	−0.43
16.5	188.22	187.95	186.78	186.91	187.16	187.27	187.53	0.95	0.68	188.07	−0.15	0.12
17.0	194.87	193.23	193.60	193.73	193.97	194.08	194.35	0.79	−0.86	194.88	0.01	1.66
17.5	202.01	200.70	201.44	201.60	201.90	202.04	202.37	−0.03	−1.33	202.84	0.83	2.13
18.0	209.54	208.18	207.79	207.91	208.12	208.22	208.42	1.32	−0.03	209.02	−0.52	0.83
18.5	217.27	217.43	215.77	215.87	216.07	216.16	216.37	1.11	1.27	216.96	−0.31	−0.47
19.0	224.75	225.09	223.54	223.66	223.89	224.00	224.25	0.75	1.10	224.80	0.05	−0.29
19.5	232.65	233.30	231.16	231.29	231.54	231.65	231.91	1.00	1.66	232.45	−0.20	−0.86
20.0	240.35	254.51	238.15	238.22	238.36	238.42	238.56	1.93	16.09	239.22	−1.13	−15.29
20.5	250.05	246.58	246.88	246.99	247.20	247.29	247.51	2.76	−0.71	248.09	−1.96	1.51
21.0	256.42	254.14	255.04	255.13	255.31	255.38	255.61	1.03	−1.24	256.18	−0.23	2.04
21.5	263.72	263.40	261.60	261.68	261.82	261.89	262.09	1.84	1.52	262.69	−1.04	−0.72
22.0	271.34	270.77	271.12	271.25	271.45	271.53	271.74	−0.19	−0.77	272.33	0.99	1.57
22.5	280.04	284.63	278.86	278.93	279.06	279.11	279.23	0.93	5.51	279.91	−0.13	−4.71
23.0	289.05	290.36	287.49	287.55	287.68	287.73	287.86	1.32	2.63	288.53	−0.52	−1.83
23.5	295.99	294.21	294.42	294.51	294.68	294.76	294.94	1.23	−0.55	295.56	−0.43	1.35
24.0	304.42	306.21	302.93	303.04	303.25	303.34	303.55	1.08	2.87	304.14	−0.28	−2.07
24.5	315.48	314.46	311.68	311.78	311.98	312.07	312.26	3.40	2.39	312.87	−2.60	−1.59
25.0	324.92	319.10	319.06	319.15	319.33	319.40	319.59	5.51	−0.31	320.20	−4.71	1.11

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

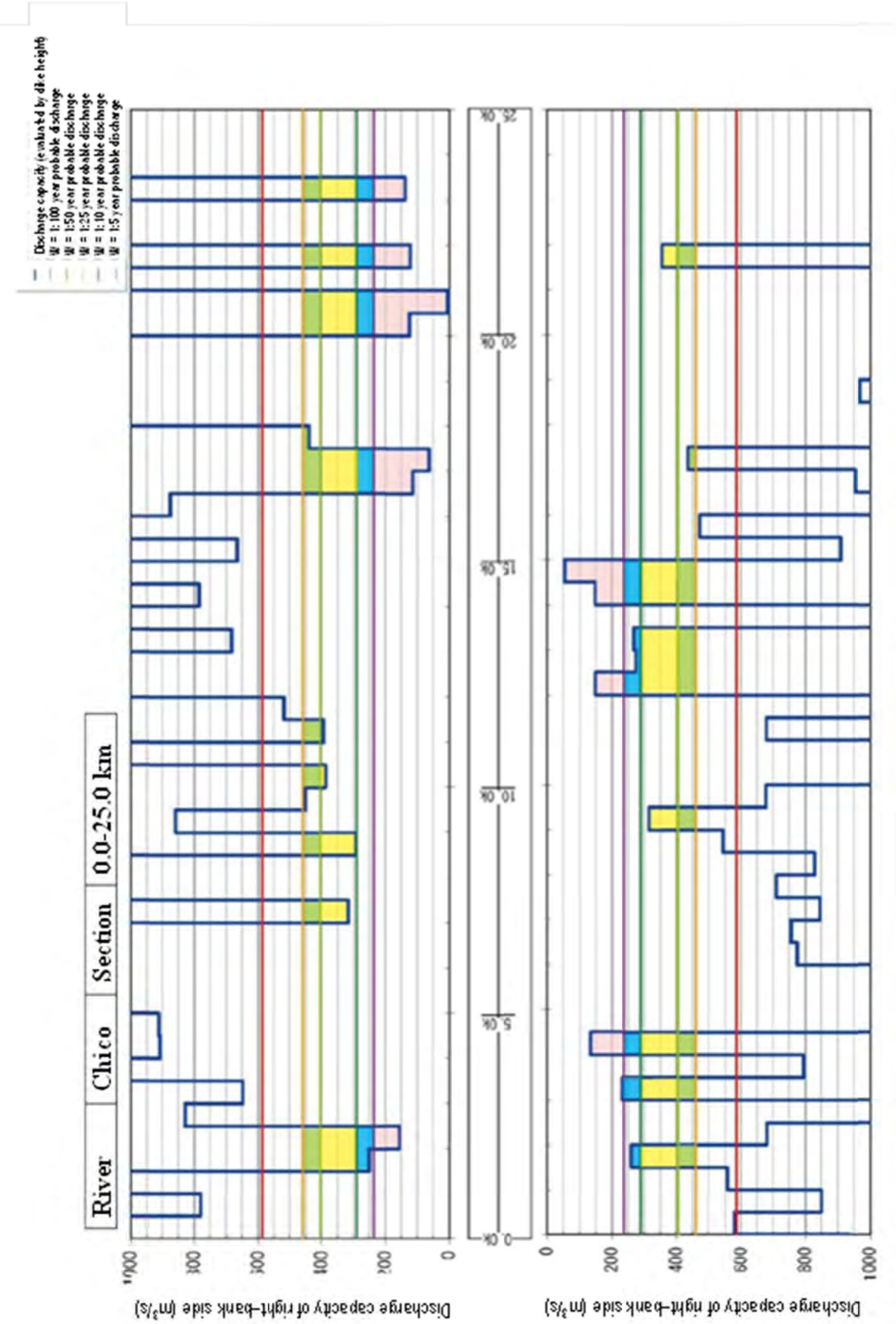

Figure 2.12 **Discharge Capacity in the Chico River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

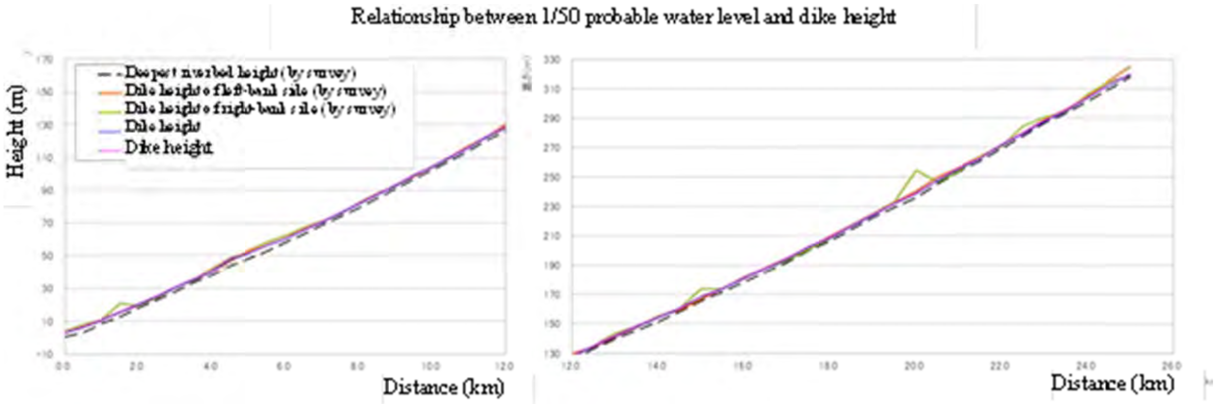

Figure 2.13 **Relation of Water Level of 1/50 Year Discharge and Dike Height in Chico River**

2) Change of Chanel Width

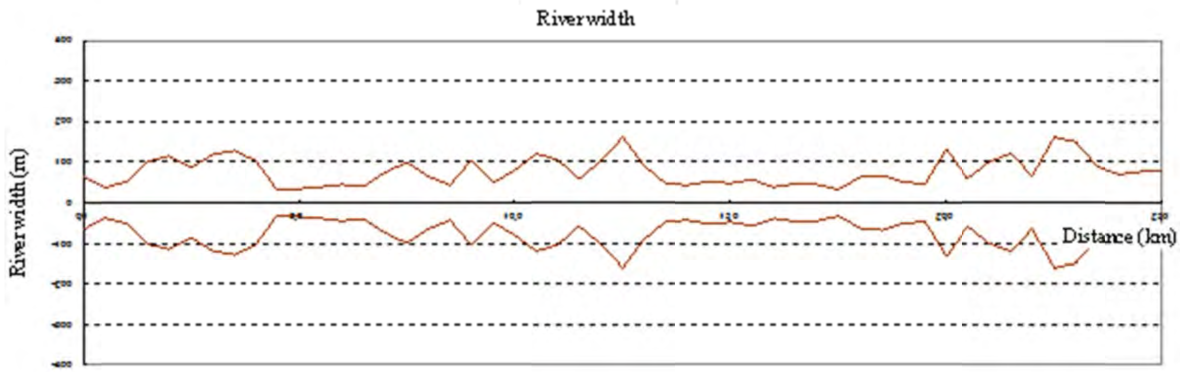

Figure 2.14 **Change of Chanel Width in the Chico River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)

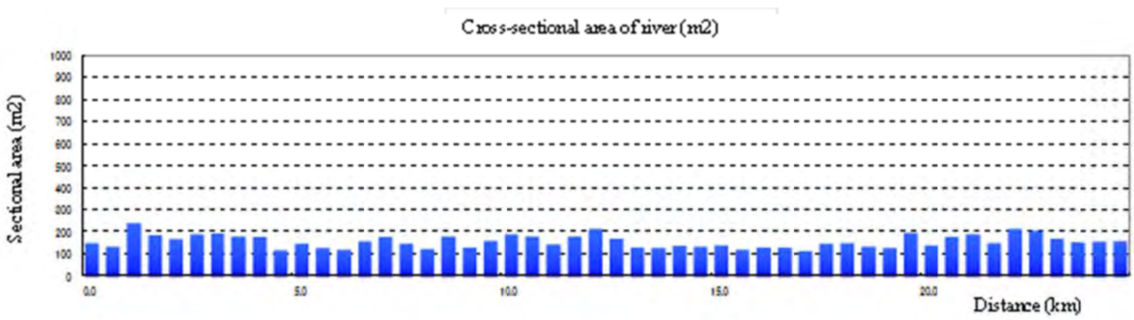

Figure 2.15 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Chico River**

Table 2.4 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Matagente River

Matagente

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	2.58	2.16	1.94	2.02	2.16	2.22	2.36	0.36	−0.05	3.02	0.44	0.85
0.5	3.40	4.85	4.77	4.90	5.15	5.26	5.50	−1.86	−0.41	6.06	2.66	1.21
1.0	6.55	6.50	6.67	6.77	7.10	7.22	7.52	−0.67	−0.72	8.02	1.47	1.52
1.5	10.00	10.11	10.03	10.14	10.09	10.17	10.34	−0.17	−0.05	10.97	0.97	0.85
2.0	13.43	15.09	13.23	13.31	13.63	13.71	13.89	−0.28	1.38	14.51	1.08	−0.58
2.5	17.07	20.06	17.43	17.51	17.64	17.69	17.82	−0.63	2.37	18.49	1.43	−1.57
3.0	22.03	24.12	21.20	21.32	21.53	21.63	21.85	0.41	2.50	22.43	0.39	−1.70
3.5	27.56	27.50	25.77	25.87	26.05	26.13	26.32	1.43	1.37	26.93	−0.63	−0.57
4.0	31.51	31.24	29.93	30.15	30.37	30.47	30.65	1.04	0.76	31.27	−0.24	0.04
4.5	35.58	35.32	34.18	34.27	34.43	34.51	34.68	1.07	0.81	35.31	−0.27	−0.01
5.0	41.98	40.32	39.53	39.66	39.90	40.01	40.27	1.96	0.31	40.81	−1.16	0.49
5.5	45.86	45.19	44.31	44.45	44.72	44.84	45.12	1.02	0.35	45.64	−0.22	0.45
6.0	50.08	48.81	48.55	48.71	49.01	49.14	49.45	0.94	−0.33	49.94	−0.14	1.13
6.5	54.35	55.04	52.82	52.97	53.27	53.40	53.70	0.95	1.64	54.20	−0.15	−0.84
7.0	59.08	57.82	57.44	57.61	57.93	58.08	58.41	1.00	−0.26	58.88	−0.20	1.06
7.5	63.40	62.51	62.45	62.59	62.86	62.98	63.26	0.42	−0.47	63.78	0.38	1.27
8.0	68.88	67.69	66.81	66.93	67.18	67.28	67.56	1.60	0.41	68.08	−0.80	0.39
8.5	73.29	72.83	72.12	72.28	72.58	72.72	73.06	0.57	0.11	73.52	0.23	0.69
9.0	78.20	77.68	77.99	78.15	78.46	78.60	78.94	−0.40	−0.92	79.40	1.20	1.72
9.5	83.40	82.77	82.90	82.99	83.17	83.25	83.44	0.14	−0.48	84.05	0.66	1.28
10.0	89.48	89.30	88.49	88.62	88.87	88.98	89.23	0.51	0.32	89.78	0.29	0.48
10.5	96.85	95.26	94.51	94.64	94.89	95.01	95.31	1.84	0.25	95.81	−1.04	0.55
11.0	101.96	101.83	99.80	99.95	100.25	100.37	100.63	1.59	1.46	101.17	−0.79	−0.66
11.5	107.51	106.67	105.75	105.82	105.97	106.03	106.18	1.48	0.64	106.83	−0.68	0.16
12.0	115.71	113.02	112.01	112.08	112.21	112.27	112.40	3.45	0.75	113.07	−2.65	0.05
12.5	120.34	120.84	119.80	119.95	120.25	120.40	120.73	−0.06	0.44	121.20	0.86	0.36
13.0	126.80	126.53	126.08	126.23	126.54	126.68	127.02	0.11	−0.15	127.48	0.69	0.95
13.5	133.51	133.18	132.43	132.57	132.86	133.00	133.33	0.51	0.18	133.80	0.29	0.62
14.0	139.51	138.84	138.46	138.61	138.93	139.07	139.41	0.44	−0.23	139.87	0.36	1.03
14.5	146.29	146.59	144.87	145.02	145.32	145.46	145.79	0.84	1.14	146.26	−0.04	−0.34
15.0	152.42	153.14	151.48	151.65	152.01	152.17	152.56	0.25	0.97	152.97	0.55	−0.17
15.5	158.48	157.91	157.70	157.86	158.20	158.34	158.70	0.13	−0.44	159.14	0.67	1.24
16.0	166.41	165.40	163.98	164.14	164.49	164.64	165.01	1.76	0.76	165.44	−0.96	0.04
16.5	171.68	171.66	170.15	170.31	170.66	170.82	171.19	0.86	0.85	171.62	−0.06	−0.05
17.0	178.50	178.55	176.72	176.88	177.22	177.38	177.74	1.13	1.18	178.18	−0.33	−0.38
17.5	185.97	184.93	183.52	183.70	184.06	184.22	184.60	1.75	0.71	185.02	−0.95	0.09
18.0	193.35	191.73	190.26	190.40	190.68	190.81	191.12	2.54	0.91	191.61	−1.74	−0.11
18.5	199.11	198.68	197.09	197.27	197.63	197.79	198.17	1.32	0.89	198.59	−0.52	−0.09
19.0	206.87	205.53	203.84	203.98	204.23	204.36	204.65	2.51	1.17	205.16	−1.71	−0.37
19.5	214.30	214.28	213.14	213.25	213.47	213.56	213.81	0.74	0.72	214.36	0.06	0.09
20.0	222.43	221.28	220.37	220.50	220.74	220.84	221.09	1.60	0.44	221.64	−0.80	0.36
20.5	229.93	230.02	228.44	228.57	228.83	228.96	229.26	0.96	1.06	229.76	−0.16	−0.26
21.0	237.01	236.42	234.26	234.41	234.75	234.90	235.28	2.11	1.52	235.70	−1.31	−0.72
21.5	238.88	240.30	237.63	237.84	238.18	238.30	238.75	0.58	2.00	239.10	0.22	−1.20
22.0	246.95	250.05	244.73	244.81	244.97	245.04	245.21	1.91	5.01	245.84	−1.10	−4.21
22.5	255.59	256.42	253.15	253.24	253.40	253.48	253.72	2.12	2.94	254.28	−1.32	−2.14
23.0	267.12	263.72	260.84	260.95	261.16	261.25	261.47	5.87	2.47	262.05	−5.07	−1.67
23.5	275.04	271.34	269.78	269.87	270.04	270.12	270.42	4.92	1.22	270.92	−4.12	−0.42
24.0	279.22	280.04	278.03	278.11	278.25	278.31	278.49	0.91	1.74	279.11	−0.11	−0.94
24.5	299.88	289.05	285.69	285.75	285.87	285.93	286.04	13.96	3.13	286.73	−13.16	−2.33
25.0	303.56	295.99	293.32	293.40	293.55	293.62	293.78	9.94	2.37	294.42	−9.14	−1.57
25.5	304.42	306.21	302.90	303.00	303.20	303.29	303.50	1.13	2.92	304.09	−0.33	−2.12

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2ｍ)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2ｍ)

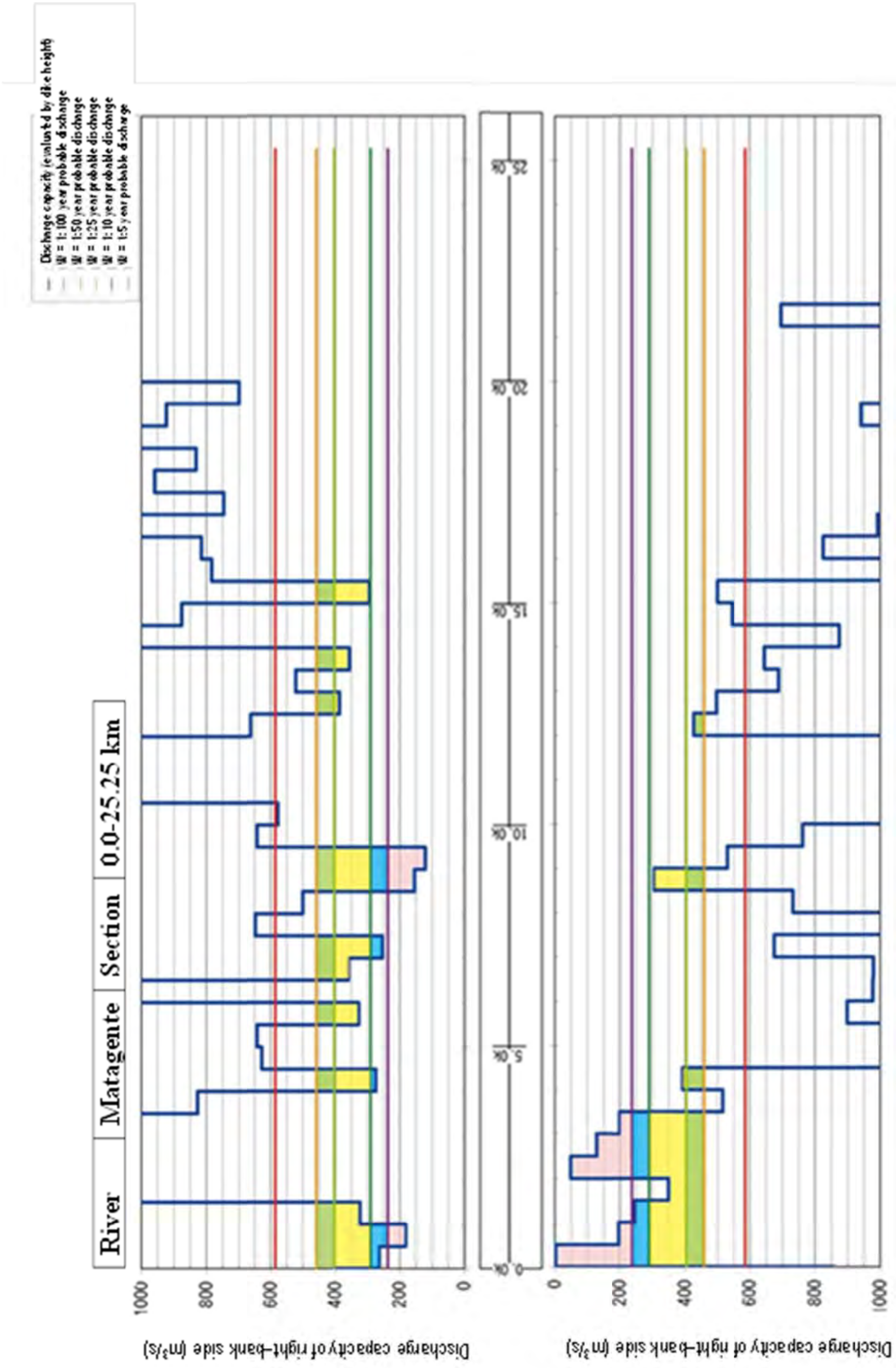

Figure 2.16 **Discharge Capacity in the Matagente River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

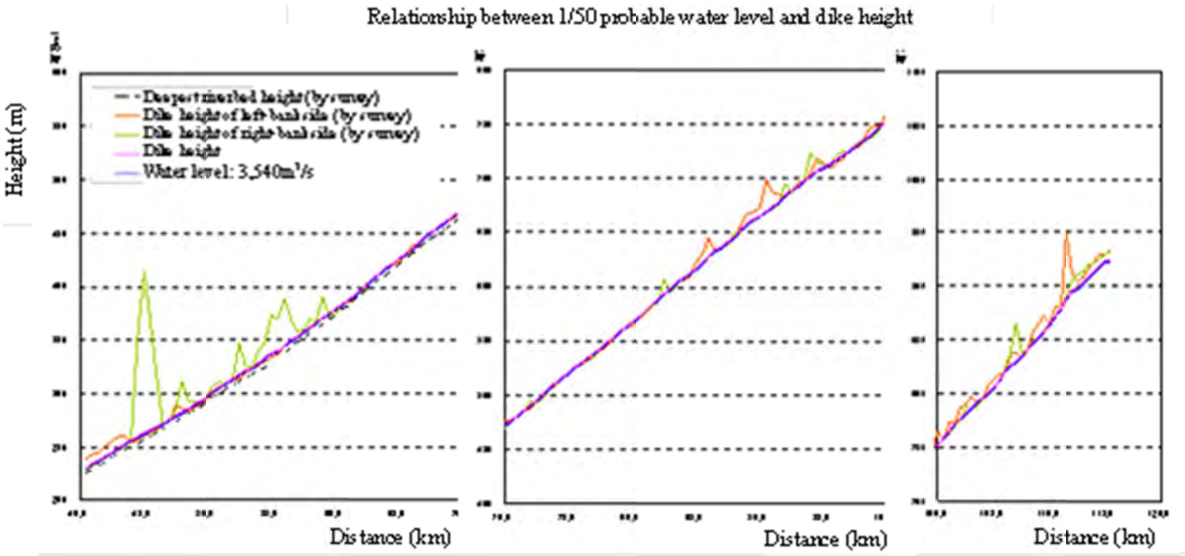

Figure 2.17 **Relation of Water Level of 1/50 Year Discharge and Dike Height in Matagente River**

2) Chanel Width

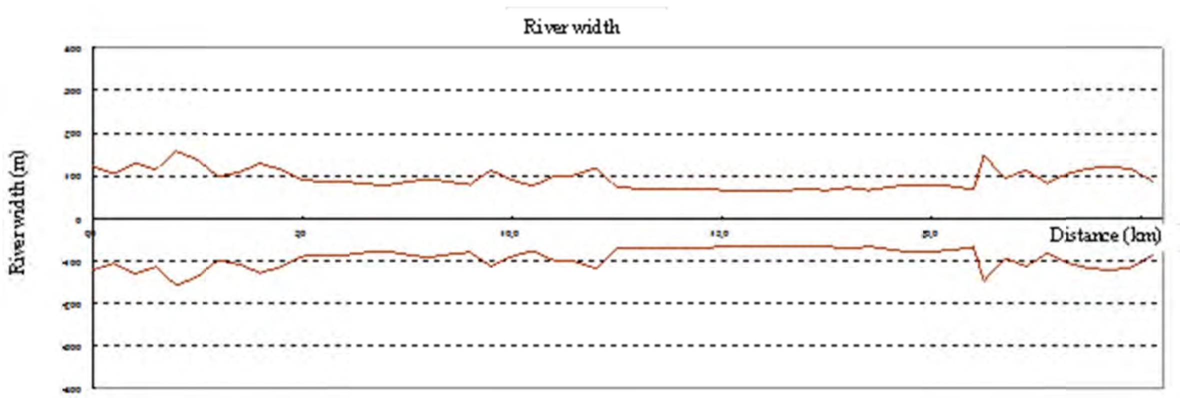

Figure 2.18 **Change of Chanel Width in the Matagente River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)

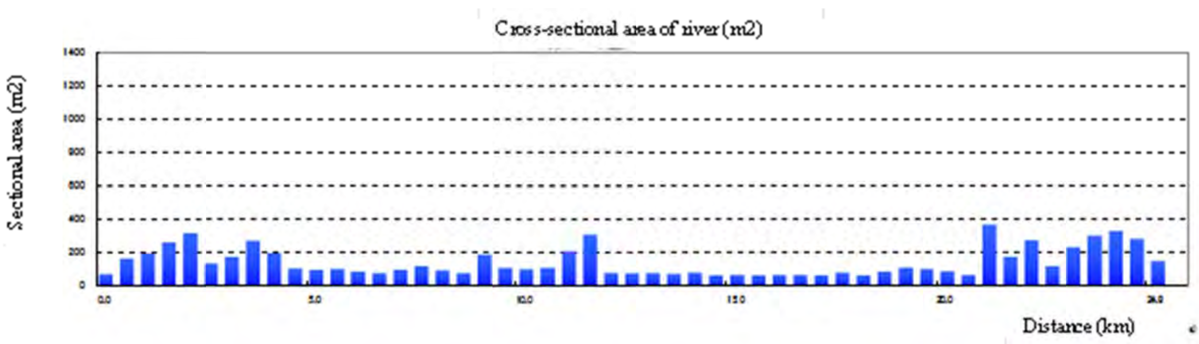

Figure 2.19 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Matagente River**

(4) Pisco River

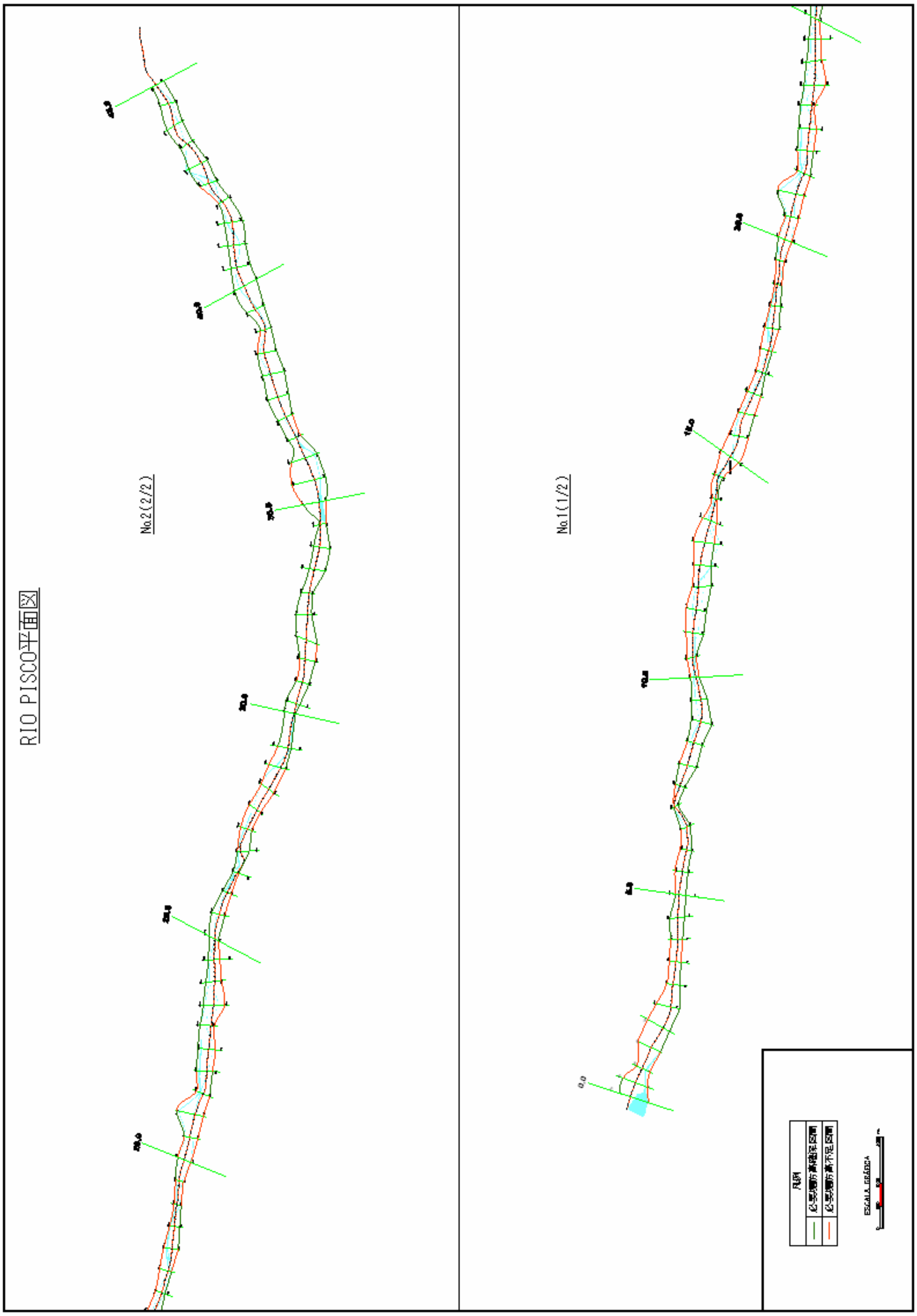

Figure 2.20 **Plan of the Pisco River**

Table 2.5 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Pisco River

Pisco

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	2.47	2.71	2.66	2.88	3.14	3.30	3.41	−0.83	−0.59	4.30	1.83	1.59
0.5	3.80	5.11	3.43	3.75	3.98	4.12	4.21	−0.31	1.00	5.12	1.31	0.00
1.0	5.28	5.20	5.08	5.35	5.61	5.76	5.86	−0.48	−0.56	6.76	1.48	1.56
1.5	7.89	8.34	8.20	8.35	8.54	8.65	8.67	−0.76	−0.31	9.65	1.76	1.31
2.0	13.15	11.82	11.70	11.86	12.04	12.16	12.23	1.00	−0.34	13.16	0.00	1.34
2.5	16.51	14.57	15.34	15.50	15.69	15.80	15.88	0.71	−1.23	16.80	0.29	2.23
3.0	25.64	19.07	19.01	19.22	19.46	19.62	19.72	6.02	−0.55	20.62	−5.02	1.55
3.5	24.20	23.61	22.97	23.17	23.40	23.54	23.63	0.66	0.07	24.54	0.34	0.93
4.0	27.00	26.93	26.92	27.12	27.36	27.51	27.61	−0.51	−0.58	28.51	1.51	1.58
4.5	31.55	31.66	30.91	31.09	31.30	31.43	31.52	0.12	0.23	32.43	0.88	0.77
5.0	37.35	37.31	35.70	35.99	36.33	36.54	36.68	0.81	0.77	37.54	0.19	0.23
5.5	40.53	40.09	39.67	39.96	40.21	40.35	40.44	0.18	−0.26	41.35	0.82	1.26
6.0	44.98	43.66	43.73	43.98	44.27	44.45	44.57	0.53	−0.79	45.45	0.47	1.79
6.5	49.78	48.97	47.51	47.87	48.27	48.52	48.68	1.26	0.45	49.52	−0.26	0.55
7.0	56.31	56.69	51.61	51.99	52.44	52.72	52.91	3.58	3.97	53.72	−2.58	−2.97
7.5	56.28	55.40	55.29	55.56	55.90	55.91	56.05	0.37	−0.51	56.91	0.63	1.51
8.0	60.66	60.23	58.93	59.20	59.45	59.52	59.60	1.15	0.72	60.52	−0.15	0.28
8.5	64.92	64.20	63.82	64.06	64.32	64.49	64.59	0.44	−0.28	65.49	0.56	1.29
9.0	69.49	69.05	68.02	68.21	68.43	68.58	68.67	0.91	0.47	69.58	0.09	0.53
9.5	73.22	73.24	72.49	72.70	72.96	73.13	73.23	0.09	0.12	74.13	0.91	0.88
10.0	78.17	87.08	75.55	75.87	76.25	76.49	76.64	1.69	10.59	77.49	−0.69	−9.59
10.5	79.60	79.39	79.49	79.76	80.09	80.30	80.44	−0.70	−0.91	81.30	1.70	1.91
11.0	85.06	84.53	84.16	84.38	84.64	84.78	84.87	0.28	−0.25	85.78	0.72	1.25
11.5	91.61	89.30	89.04	89.26	89.51	89.65	89.74	1.96	−0.35	90.65	−0.95	1.35
12.0	96.04	94.38	93.69	94.00	94.42	94.58	94.67	1.46	−0.20	95.58	−0.46	1.20
12.5	99.09	98.36	98.17	98.39	98.62	98.76	98.85	0.33	−0.39	99.76	0.67	1.39
13.0	103.98	103.27	103.00	103.25	103.50	103.65	103.72	0.32	−0.38	104.65	0.68	1.38
13.5	107.23	108.24	108.05	108.29	108.56	108.74	108.85	−1.51	−0.50	109.74	2.51	1.50
14.0	112.45	113.10	112.79	113.11	113.50	113.75	113.90	−1.29	−0.64	114.75	2.29	1.64
14.5	118.77	116.28	116.49	116.76	117.09	117.30	117.43	1.47	−1.02	118.30	−0.47	2.02
15.0	125.85	122.38	121.61	121.82	122.06	122.20	122.29	3.65	0.18	123.20	−2.65	0.82
15.5	126.60	126.39	125.91	126.11	126.35	126.52	126.63	0.08	−0.13	127.52	0.92	1.13
16.0	131.82	131.42	131.06	131.29	131.56	131.71	131.81	0.11	−0.29	132.71	0.89	1.29
16.5	136.08	136.32	136.03	136.24	136.50	136.65	136.76	−0.57	−0.34	137.65	1.57	1.34
17.0	143.80	141.45	141.24	141.55	141.88	142.09	142.23	1.71	−0.64	143.09	−0.71	1.64
17.5	147.98	147.40	146.44	146.72	147.10	147.30	147.42	0.69	0.11	148.30	0.31	0.89
18.0	151.54	152.41	151.59	151.84	152.14	152.32	152.43	−0.77	0.09	153.32	1.77	0.91
18.5	157.07	155.95	156.00	156.26	156.58	156.77	156.90	0.30	−0.82	157.77	0.70	1.82
19.0	166.46	161.42	160.91	161.26	161.68	161.94	162.11	4.52	−0.52	162.94	−3.52	1.52
19.5	166.46	168.01	166.91	167.27	167.69	167.92	168.07	−1.46	0.09	168.92	2.46	0.91
20.0	173.43	174.70	172.88	173.09	173.35	173.49	173.58	−0.06	1.21	174.49	1.06	−0.21
20.5	178.93	179.30	178.92	179.15	179.42	179.59	179.69	−0.66	−0.28	180.59	1.66	1.29
21.0	184.96	187.88	184.57	184.78	185.02	185.15	185.24	−0.19	2.73	186.15	1.19	−1.73
21.5	190.89	190.81	190.17	190.44	190.73	190.91	191.02	−0.02	−0.10	191.91	1.02	1.10
22.0	196.74	196.23	195.64	195.92	196.19	196.34	196.44	0.40	−0.11	197.34	0.60	1.11
22.5	201.23	202.48	201.47	201.71	201.93	202.07	202.15	−0.84	0.41	203.07	1.84	0.59
23.0	208.45	208.82	207.59	207.97	208.29	208.47	208.58	−0.01	0.35	209.47	1.01	0.65
23.5	212.59	214.69	212.19	212.38	212.57	212.69	212.76	−0.10	2.00	213.69	1.10	−1.00
24.0	218.64	219.69	218.25	218.46	218.70	218.85	218.95	−0.21	0.84	219.85	1.21	0.16
24.5	224.51	225.32	223.41	223.76	224.18	224.45	224.61	0.06	0.88	225.45	0.94	0.13
25.0	229.61	231.33	228.76	229.08	229.45	229.69	229.81	−0.07	1.65	230.69	1.07	−0.65
25.5	236.02	235.32	234.88	235.16	235.45	235.64	235.76	0.38	−0.32	236.64	0.62	1.32
26.0	241.27	241.61	240.27	240.64	241.07	241.33	241.48	−0.06	0.28	242.33	1.06	0.72
26.5	247.52	256.44	246.16	246.61	247.14	247.48	247.69	0.04	8.96	248.48	0.96	−7.96
27.0	254.12	263.85	250.92	251.20	251.51	251.69	251.82	2.43	12.16	252.69	−1.43	−11.16
27.5	257.70	255.68	256.29	256.57	256.87	257.05	257.17	0.65	−1.37	258.05	0.35	2.37
28.0	261.99	262.22	261.79	262.09	262.38	262.55	262.67	−0.56	−0.33	263.55	1.56	1.33
28.5	267.82	268.20	267.75	268.03	268.28	268.44	268.54	−0.62	−0.24	269.44	1.62	1.24
29.0	274.48	274.33	274.16	274.43	274.66	274.80	274.89	−0.32	−0.47	275.80	1.32	1.47
29.5	281.84	280.46	279.84	280.08	280.38	280.56	280.68	1.28	−0.10	281.56	−0.28	1.10
30.0	291.17	316.87	289.19	289.46	289.79	290.00	290.13	1.17	26.87	291.00	−0.17	−25.87
30.5	292.63	320.90	291.62	291.85	292.12	292.30	292.41	0.33	28.60	293.30	0.67	−27.60
31.0	300.50	298.22	297.25	297.50	297.84	298.01	298.12	2.49	0.21	299.01	−1.49	0.79
31.5	306.03	304.11	303.58	303.80	304.08	304.24	304.34	1.79	−0.13	305.24	−0.79	1.13
32.0	308.19	311.58	308.71	308.93	309.20	309.37	309.48	−1.18	2.21	310.37	2.18	−1.21
32.5	318.33	322.80	316.73	316.95	317.20	317.35	317.45	0.98	5.45	318.35	0.02	−4.45
33.0	325.11	329.73	322.62	322.91	323.25	323.46	323.60	1.65	6.27	324.46	−0.65	−5.27
33.5	331.02	330.64	329.15	329.55	329.93	330.17	330.29	0.85	0.47	331.17	0.15	0.53
34.0	348.32	337.51	334.70	335.09	335.58	335.88	336.05	12.44	1.63	336.88	−11.44	−0.63
34.5	343.73	344.76	340.35	340.84	341.49	341.81	342.01	1.92	2.95	342.81	−0.92	−1.95
35.0	351.25	354.05	351.22	351.62	352.10	352.39	352.58	−1.14	1.66	353.39	2.14	−0.66
35.5	359.29	357.35	356.76	357.05	357.41	357.63	357.77	1.66	−0.28	358.63	−0.66	1.28
36.0	402.55	363.51	362.94	363.25	363.55	363.73	363.85	38.82	−0.22	364.73	−37.82	1.22
36.5	371.86	373.96	369.38	369.67	369.96	370.13	370.25	1.73	3.83	371.13	−0.73	−2.83
37.0	375.78	379.66	375.41	375.62	375.88	376.03	376.13	−0.25	3.63	377.03	1.25	−2.63
37.5	425.76	386.95	381.89	382.07	382.30	382.44	382.53	43.32	4.51	383.44	−42.32	−3.51
38.0	432.47	393.78	388.86	389.18	389.46	389.60	389.69	42.87	4.18	390.60	−41.87	−3.18
38.5	439.56	400.77	395.22	395.46	395.74	395.90	396.00	43.66	4.87	396.90	−42.66	−3.87
39.0	449.06	402.74	401.98	402.26	402.56	402.74	402.84	46.32	0.00	403.74	−45.32	1.00
39.5	457.67	413.14	408.05	408.28	408.52	408.67	408.76	49.00	4.47	409.67	−48.00	−3.47
40.0	449.76	421.44	416.20	416.47	416.70	416.83	416.91	32.93	4.61	417.83	−31.93	−3.61
40.5	441.31	430.28	421.68	421.90	422.11	422.24	422.33	19.07	8.04	423.24	−18.07	−7.04
41.0	437.72	434.93	428.62	428.86	429.18	429.32	429.40	8.40	5.61	430.32	−7.40	−4.61
41.5	447.00	441.37	436.75	436.94	437.17	437.31	437.40	9.69	4.06	438.31	−8.69	−3.06
42.0	453.31	451.72	442.83	443.09	443.44	443.63	443.75	9.68	8.09	444.63	−8.68	−7.09
42.5	455.27	450.09	449.59	449.83	450.09	450.24	450.33	5.03	−0.15	451.24	−4.03	1.15
43.0	464.45	464.02	456.12	456.42	456.80	456.92	457.00	7.53	7.09	457.92	−6.53	−6.09
43.5	472.01	489.37	464.04	464.29	464.60	464.80	464.92	7.21	24.57	465.80	−6.21	−23.57
44.0	483.96	480.24	470.31	470.51	470.76	470.90	470.99	13.06	9.34	471.90	−12.06	−8.34
44.5	484.27	485.63	477.06	477.70	478.00	478.17	478.28	6.10	7.47	479.17	−5.10	−6.47
45.0	495.46	494.34	484.34	484.67	485.07	485.30	485.48	10.15	9.03	486.30	−9.15	−8.03

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

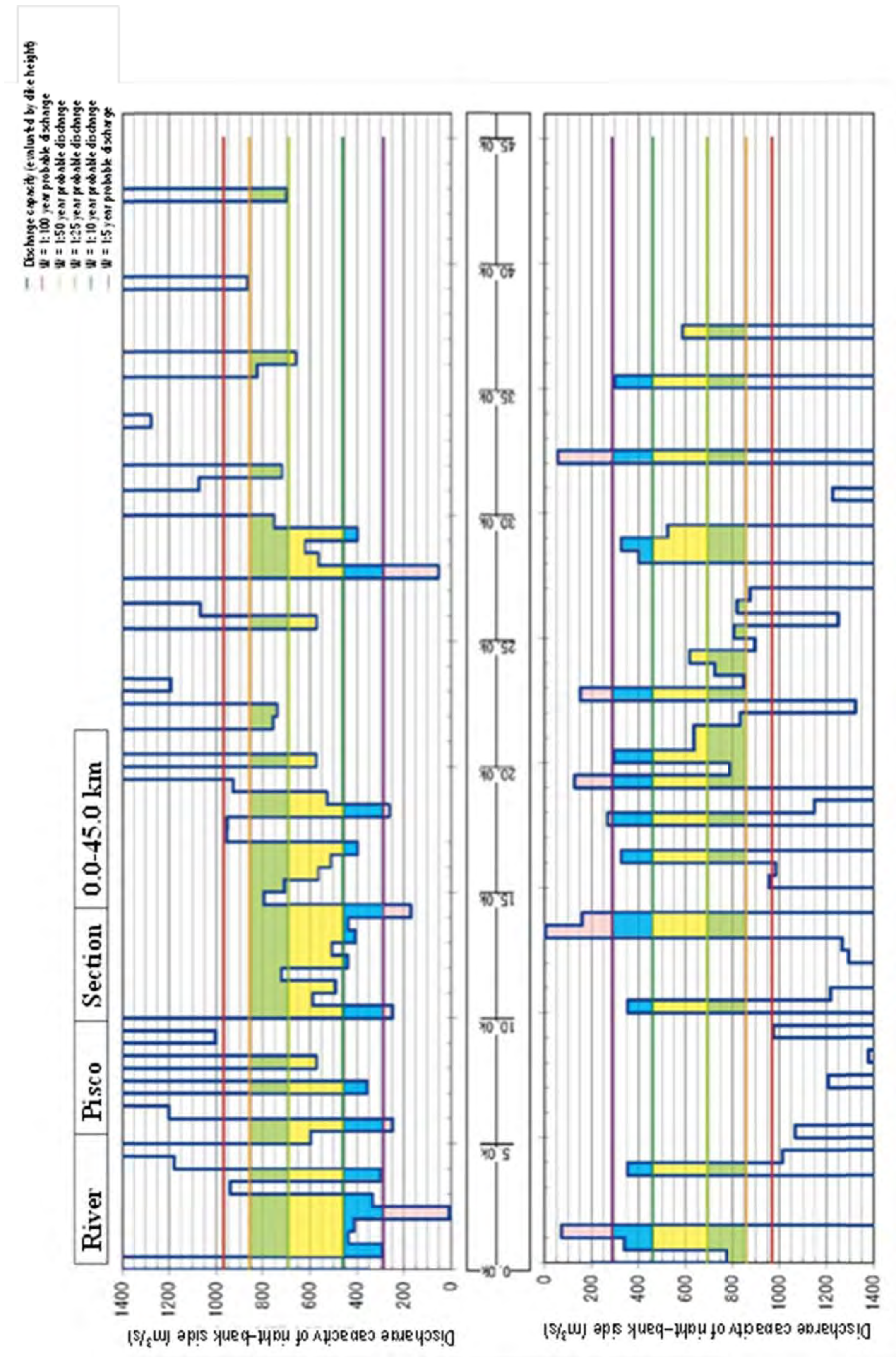

Figure 2.21 **Discharge Capacity in the Pisco River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

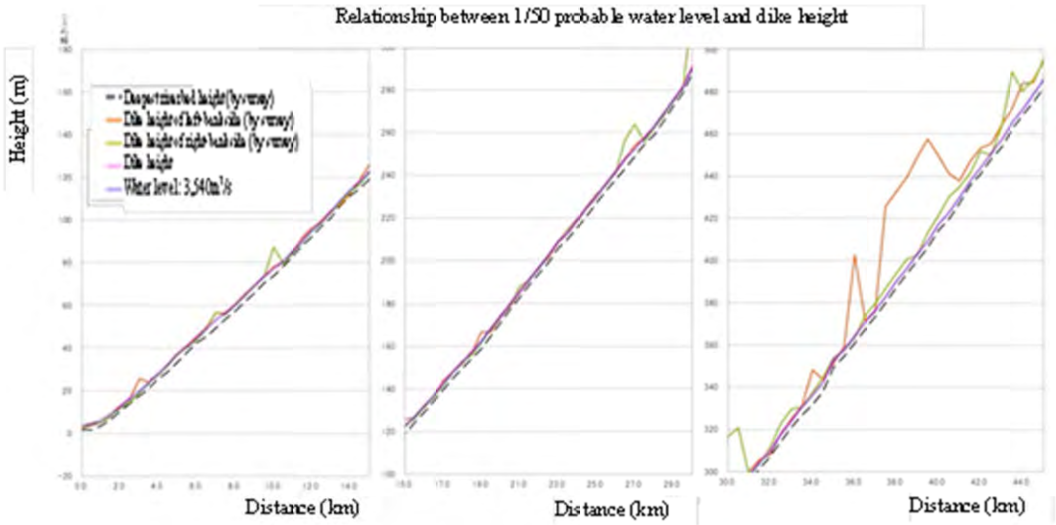

Figure 2.22 **Relation of Water Level of 1/50 Year Discharge and Dike Height in the Pisco River**

2) Chanel Width

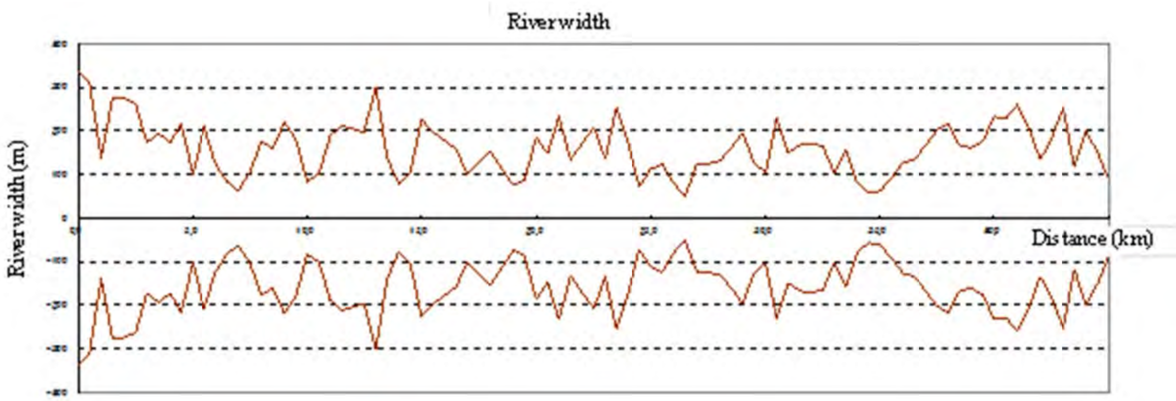

Figure 2.23 **Change of Chanel Width in the Pisco River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)

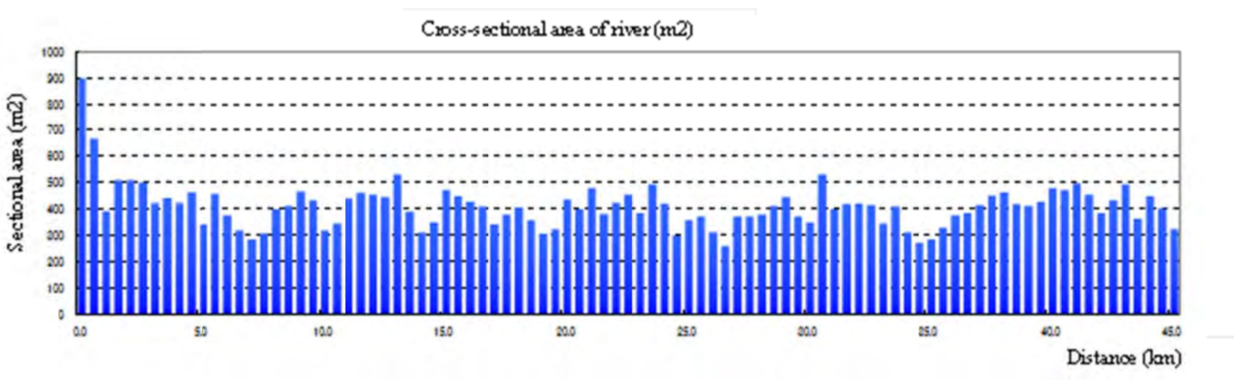

Figure 2.24 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Pisco River**

(5) Yauca River

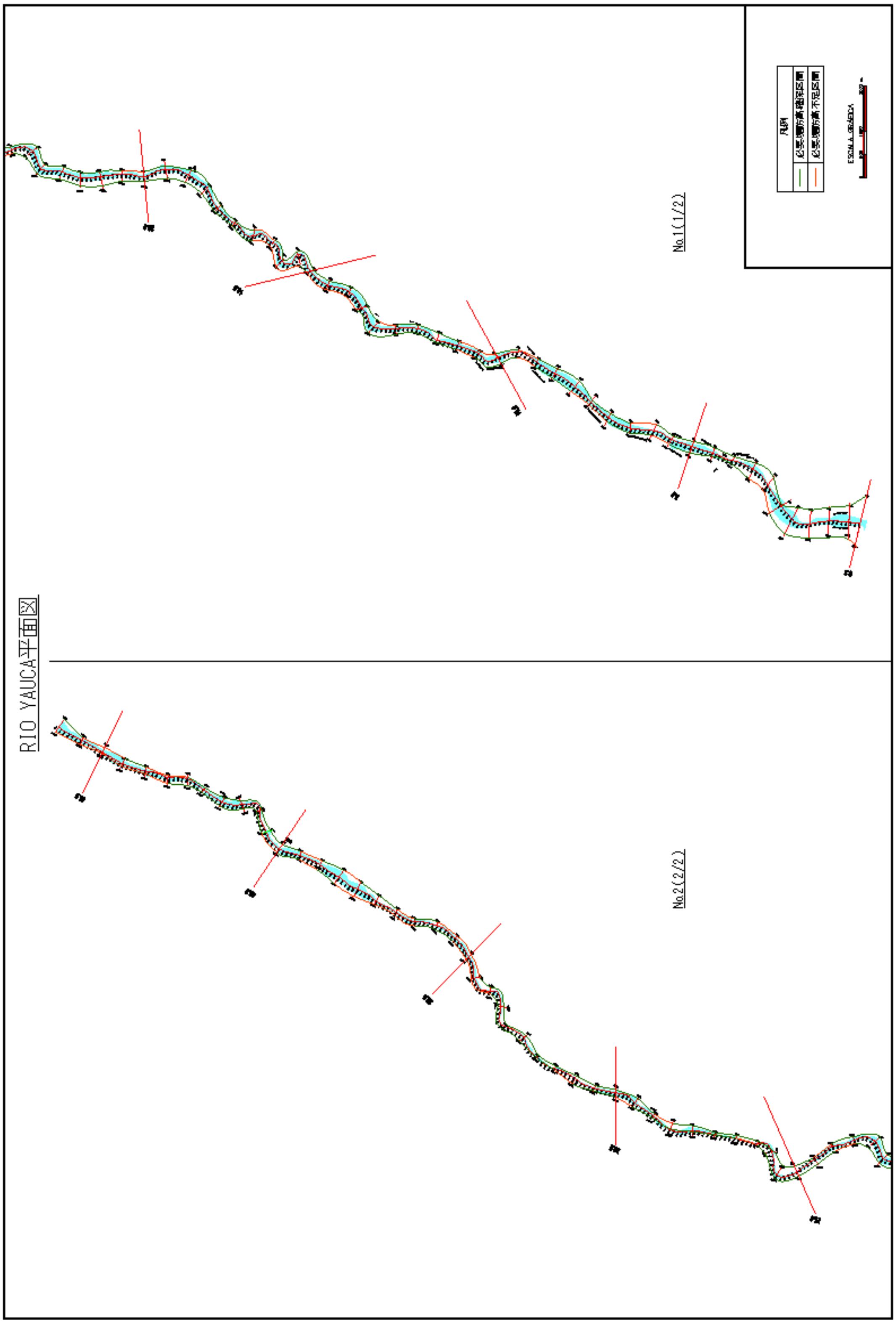

Figure 2.25 **Plan of the Yauva River**

Table 2.6 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Yauca River

Yauca

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	4.97	2.94	1.55	1.73	1.94	2.11	2.28	2.86	0.83	2.91	−2.06	−0.03
0.5	3.27	1.76	1.76	1.96	2.18	2.37	2.56	0.90	−0.61	3.17	−0.10	1.41
1.0	10.87	3.64	2.41	2.65	2.92	3.10	3.29	7.77	0.54	3.90	−6.97	0.26
1.5	4.97	4.97	3.43	3.67	3.91	4.10	4.31	0.87	0.87	4.90	−0.07	−0.07
2.0	5.80	7.83	4.13	4.50	4.75	4.90	5.07	0.90	2.94	5.70	−0.10	−2.14
2.5	7.47	7.31	6.09	6.45	6.68	6.96	7.17	0.50	0.35	7.76	0.30	0.45
3.0	14.25	8.72	7.65	8.04	8.42	8.61	8.84	5.64	0.11	9.41	−4.84	0.69
3.5	37.20	10.24	9.94	10.22	10.43	10.62	10.84	26.59	−0.37	11.42	−25.79	1.17
4.0	27.20	14.89	11.93	12.50	12.98	13.45	13.96	13.75	1.44	14.25	−12.95	−0.64
4.5	41.61	16.73	13.94	14.34	14.66	15.01	15.46	26.60	1.71	15.81	−25.80	−0.91
5.0	48.40	18.05	17.17	16.63	17.03	17.08	17.50	31.32	0.97	17.88	−30.52	−0.17
5.5	49.60	21.82	19.11	19.38	19.86	20.69	20.39	28.91	1.13	21.49	−28.11	−0.33
6.0	66.64	22.59	22.45	22.80	22.41	22.57	23.08	44.07	0.02	23.37	−43.27	0.78
6.5	26.15	27.58	25.36	25.67	26.22	26.44	26.23	−0.30	1.14	27.24	1.10	−0.34
7.0	31.56	30.44	29.08	29.42	29.30	29.54	30.35	2.02	0.90	30.34	−1.22	−0.10
7.5	35.06	33.45	32.45	32.76	33.42	33.74	33.57	1.32	−0.29	34.54	−0.52	1.09
8.0	55.64	36.76	36.21	36.50	36.38	36.54	37.41	19.10	0.22	37.34	−18.30	0.58
8.5	92.42	42.03	39.56	39.93	40.75	40.95	40.93	51.47	1.07	41.75	−50.67	−0.27
9.0	47.78	51.89	43.30	43.83	43.71	43.97	44.83	3.81	7.92	44.77	−3.01	−7.12
9.5	46.33	47.03	45.89	46.24	47.35	47.70	47.19	−1.36	−0.67	48.50	2.16	1.47
10.0	63.63	57.95	49.61	50.00	49.87	50.05	51.08	13.58	7.90	50.85	−12.78	−7.10
10.5	54.18	54.90	53.11	53.43	54.08	54.33	54.25	−0.15	0.57	55.13	0.95	0.23
11.0	58.49	57.64	57.58	57.79	58.01	58.23	58.81	0.25	−0.59	59.03	0.55	1.39
11.5	67.51	65.23	60.91	61.30	61.67	62.01	61.78	5.50	3.21	62.81	−4.70	−2.41
12.0	78.41	69.53	62.77	63.59	64.21	64.45	65.10	13.96	5.07	65.25	−13.16	−4.27
12.5	80.32	87.31	66.61	67.38	67.89	68.29	68.06	12.03	19.02	69.09	−11.23	−18.22
13.0	71.34	71.52	70.39	70.72	70.97	71.17	71.38	0.17	0.35	71.97	0.63	0.45
13.5	83.84	83.32	74.61	74.94	75.25	75.46	75.70	8.38	7.86	76.26	−7.58	−7.06
14.0	79.35	78.03	77.37	77.89	78.46	78.67	78.93	0.68	−0.65	79.47	0.12	1.45
14.5	94.44	83.42	82.11	82.55	82.91	83.15	83.44	11.29	0.27	83.95	−10.49	0.53
15.0	103.94	85.08	85.65	86.11	85.89	86.11	86.39	17.83	−1.03	86.91	−17.03	1.83
15.5	91.45	93.23	89.59	90.04	90.65	90.89	91.32	0.56	2.34	91.69	0.24	−1.54
16.0	103.13	94.80	94.22	94.69	95.31	95.66	96.70	7.47	−0.86	96.46	−6.67	1.66
16.5	101.27	99.13	98.50	99.13	99.19	99.45	100.72	1.82	−0.32	100.25	−1.02	1.12
17.0	105.25	104.77	104.58	104.78	104.97	105.16	105.38	0.09	−0.39	105.96	0.71	1.19
17.5	117.49	114.65	108.02	108.51	109.20	109.53	109.90	7.96	5.11	110.33	−7.16	−4.32
18.0	115.48	124.95	111.87	112.31	112.59	112.85	113.13	2.64	12.10	113.65	−1.84	−11.30
18.5	120.59	118.49	115.93	116.74	117.23	117.47	117.75	3.11	1.02	118.27	−2.31	−0.22
19.0	122.18	122.34	120.79	121.13	121.40	121.71	121.96	0.48	0.63	122.51	0.32	0.17
19.5	128.61	130.38	126.43	126.78	127.29	127.62	127.86	0.99	2.76	128.42	−0.19	−1.96
20.0	132.85	134.29	130.94	131.50	132.10	132.42	132.70	0.43	1.87	133.22	0.37	−1.07
20.5	136.79	141.05	136.37	136.75	137.12	137.34	137.59	−0.54	3.71	138.14	1.34	−2.91
21.0	146.87	158.06	141.17	141.49	141.82	141.99	142.44	4.88	16.07	142.79	−4.07	−15.27
21.5	152.18	167.34	145.17	145.79	146.94	147.07	147.25	5.11	20.28	147.87	−4.31	−19.48
22.0	166.56	166.11	150.66	151.10	151.56	151.74	151.95	14.81	14.37	152.54	−14.01	−13.57
22.5	167.23	176.01	156.46	156.81	157.08	157.30	157.55	9.93	18.72	158.10	−9.13	−17.92
23.0	200.98	174.62	160.61	161.12	161.61	162.00	162.59	38.98	12.62	162.80	−38.18	−11.82
23.5	179.36	168.30	166.60	166.88	167.17	167.46	168.12	11.91	0.84	168.26	−11.11	−0.04
24.0	192.88	172.51	171.69	172.06	172.38	172.67	172.94	20.21	−0.16	173.47	−19.41	0.96
24.5	177.96	190.53	177.02	177.31	177.62	177.87	178.18	0.09	12.66	178.67	0.71	−11.86
25.0	207.59	202.14	182.31	182.69	183.08	183.38	183.62	24.21	18.76	184.18	−23.41	−17.96
25.5	207.43	215.11	187.52	188.01	188.57	188.96	189.47	18.47	26.15	189.76	−17.67	−25.35
26.0	238.50	207.55	192.57	193.12	193.69	193.98	194.56	44.51	13.57	194.78	−43.71	−12.77
26.5	208.54	208.50	199.35	199.97	200.66	201.43	202.43	7.11	7.07	202.23	−6.31	−6.27
27.0	217.45	208.19	206.56	207.08	207.58	208.06	208.64	9.39	0.12	208.86	−8.59	0.68
27.5	222.97	215.11	211.92	212.38	212.85	213.55	214.13	9.42	1.56	214.35	−8.62	−0.76
28.0	231.57	220.68	218.64	218.99	219.36	219.73	220.14	11.84	0.94	220.53	−11.04	−0.14
28.5	237.11	230.00	224.61	225.05	225.71	226.05	227.60	11.06	3.95	226.85	−10.26	−3.15
29.0	233.54	236.00	232.18	232.65	233.00	233.35	234.03	0.19	2.65	234.15	0.61	−1.85
29.5	243.36	239.69	238.25	238.59	238.85	239.11	239.36	4.25	0.58	239.91	−3.45	0.22
30.0	247.66	246.30	245.60	245.86	246.05	246.24	246.46	1.42	0.06	247.04	−0.62	0.74
30.5	254.22	253.31	251.45	251.89	252.24	252.58	253.14	1.64	0.73	253.38	−0.84	0.07
31.0	262.98	262.55	257.37	257.73	258.11	258.54	259.45	4.43	4.01	259.34	−3.63	−3.21
31.5	268.93	264.18	263.59	264.13	264.46	264.74	265.09	4.19	−0.57	265.54	−3.39	1.37
32.0	271.56	271.80	268.96	269.57	270.10	270.59	271.11	0.98	1.21	271.39	−0.18	−0.41
32.5	294.15	281.23	276.46	276.92	277.33	277.73	278.11	16.41	3.49	278.53	−15.61	−2.69
33.0	289.54	285.00	282.48	282.89	283.27	283.63	284.42	5.91	1.37	284.43	−5.11	−0.57
33.5	314.58	292.43	290.24	290.62	290.92	291.29	291.60	23.28	1.14	292.09	−22.48	−0.34
34.0	301.91	300.00	296.35	296.99	297.78	298.40	299.35	3.51	1.60	299.20	−2.71	−0.80
34.5	309.96	303.26	302.91	303.34	303.81	304.17	304.56	5.79	−0.91	304.97	−4.99	1.71
35.0	309.63	308.91	309.12	309.38	309.59	309.80	310.04	−0.17	−0.89	310.60	0.97	1.69
35.5	316.12	315.88	315.35	315.69	316.03	316.26	316.53	−0.13	−0.38	317.06	0.94	1.18
36.0	321.67	322.81	320.45	320.86	321.32	321.73	322.00	−0.06	1.08	322.53	0.86	−0.28
36.5	327.48	342.42	325.46	325.86	326.35	326.88	327.28	0.60	15.54	327.68	0.20	−14.74
37.0	333.64	332.74	332.75	333.09	333.46	333.85	334.32	−0.21	−1.10	334.65	1.01	1.90
37.5	340.40	339.28	338.60	338.94	339.16	339.41	339.68	0.99	−0.13	340.21	−0.19	0.93
38.0	350.09	345.56	344.64	345.37	345.56	345.70	345.84	4.39	−0.13	346.50	−3.59	0.93
38.5	351.81	352.28	351.62	351.83	352.05	352.26	352.48	−0.45	0.02	353.06	1.25	0.78
39.0	386.18	358.72	356.61	357.01	357.35	357.64	357.98	28.54	1.08	358.44	−27.74	−0.28
39.5	364.24	363.43	363.04	363.45	363.85	364.22	364.54	0.02	−0.79	365.02	0.78	1.59
40.0	371.86	370.50	368.62	369.45	369.65	369.82	370.01	2.04	0.69	370.62	−1.24	0.12
40.5	376.35	375.80	374.88	375.14	375.43	375.71	376.03	0.64	0.09	376.51	0.16	0.71
41.0	384.23	399.63	380.71	381.18	381.58	381.90	382.28	2.33	17.73	382.70	−1.53	−16.93
41.5	395.43	406.83	387.22	387.52	387.78	388.05	388.24	7.38	18.78	388.85	−6.58	−17.98
42.0	406.80	394.91	391.92	392.36	392.75	393.12	393.63	13.68	1.78	393.92	−12.88	−0.98
42.5	410.39	408.45	398.11	398.51	399.08	399.38	399.69	11.01	9.07	400.18	−10.21	−8.27
43.0	405.33	418.83	403.96	404.28	404.58	404.79	405.04	0.54	14.04	405.59	0.26	−13.24
43.5	410.55	423.82	409.90	410.14	410.34	410.54	410.79	0.02	13.28	411.34	0.78	−12.48
44.0	417.99	417.91	417.63	417.84	418.03	418.22	418.45	−0.24	−0.31	419.02	1.04	1.11
44.5	438.95	424.57	423.80	424.04	424.30	424.52	424.75	14.43	0.05	425.32	−13.63	0.75
45.0	431.48	431.34	430.82	431.37	431.67	431.86	432.10	−0.38	−0.52	432.66	1.18	1.32
45.5	438.56	438.49	438.00	438.39	438.70	438.89	439.12	−0.32	−0.40	439.69	1.12	1.20
46.0	447.75	446.76	445.98	446.43	446.62	446.80	446.98	0.95	−0.04	447.60	−0.15	0.84

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

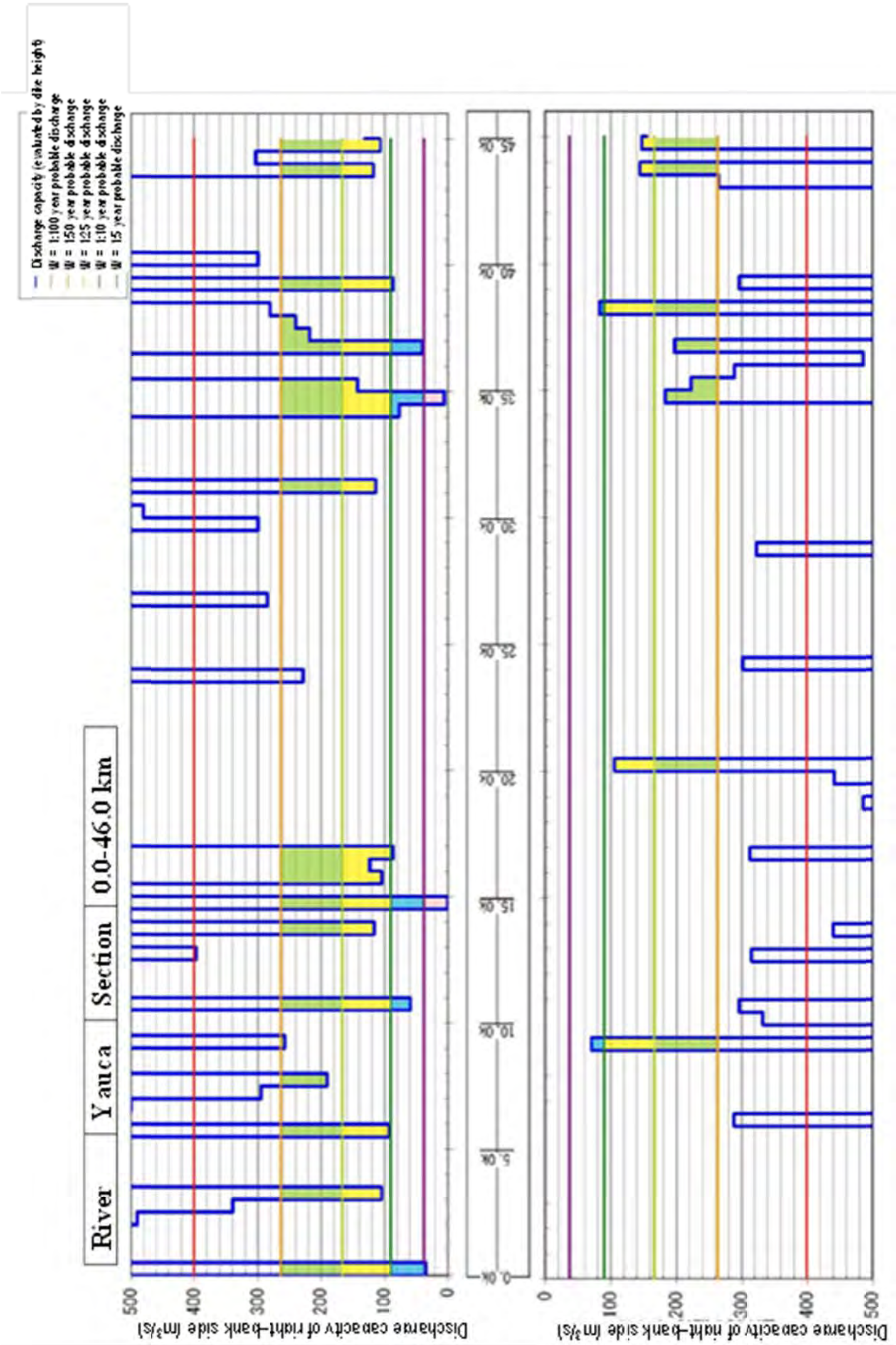

Figure 2.26 **Discharge Capacity in the Yauca River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

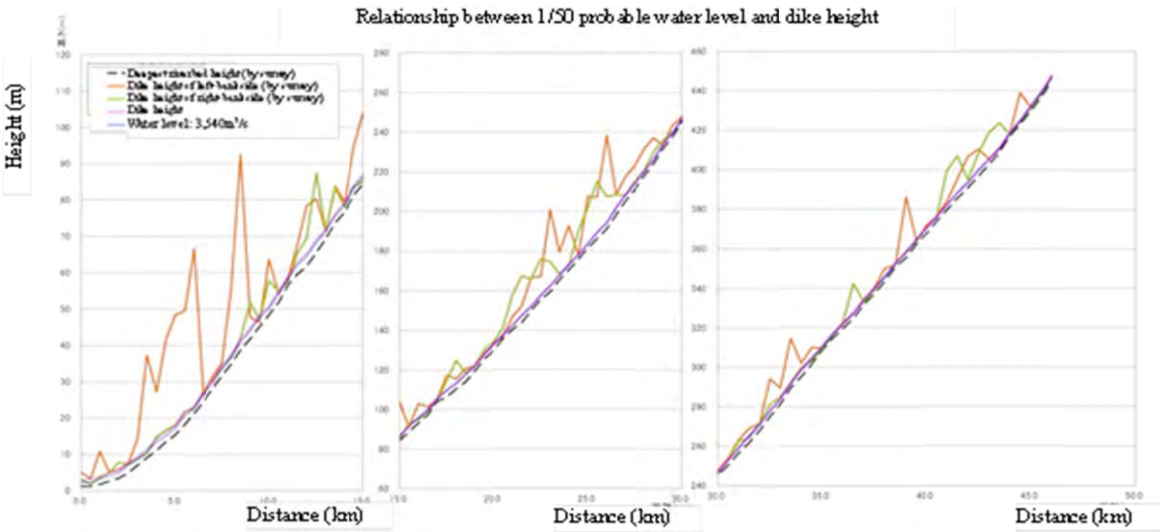

Figure 2.27 **Relation of Water Level of 1/50 Year Discharge and Dike Height in the Yauca River**

2) Chanel Width

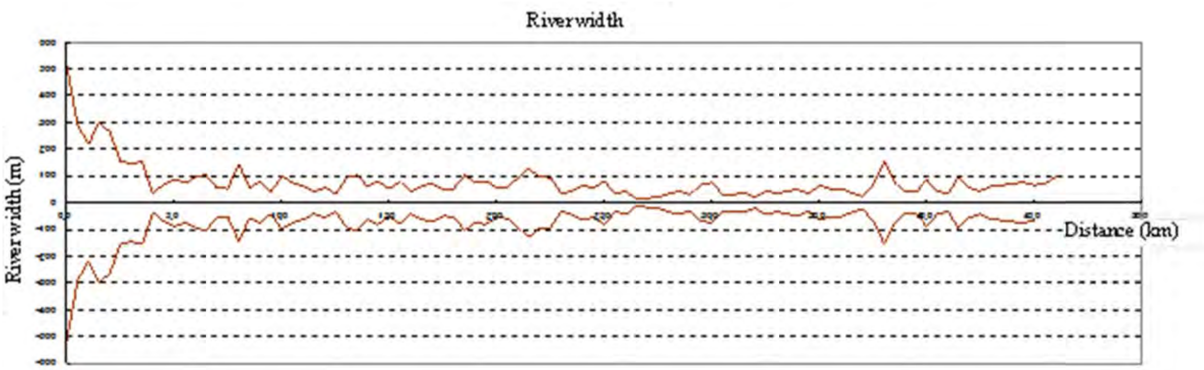

Figure 2.28 **Change of Chanel Width in the Yauca River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)in the Yauca River

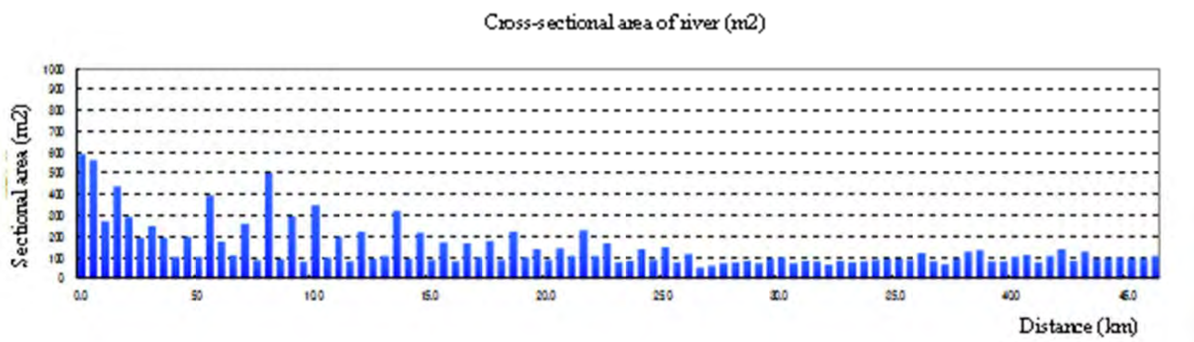

Figure 2.29 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Yauca River**

(6) Majes- Camana River

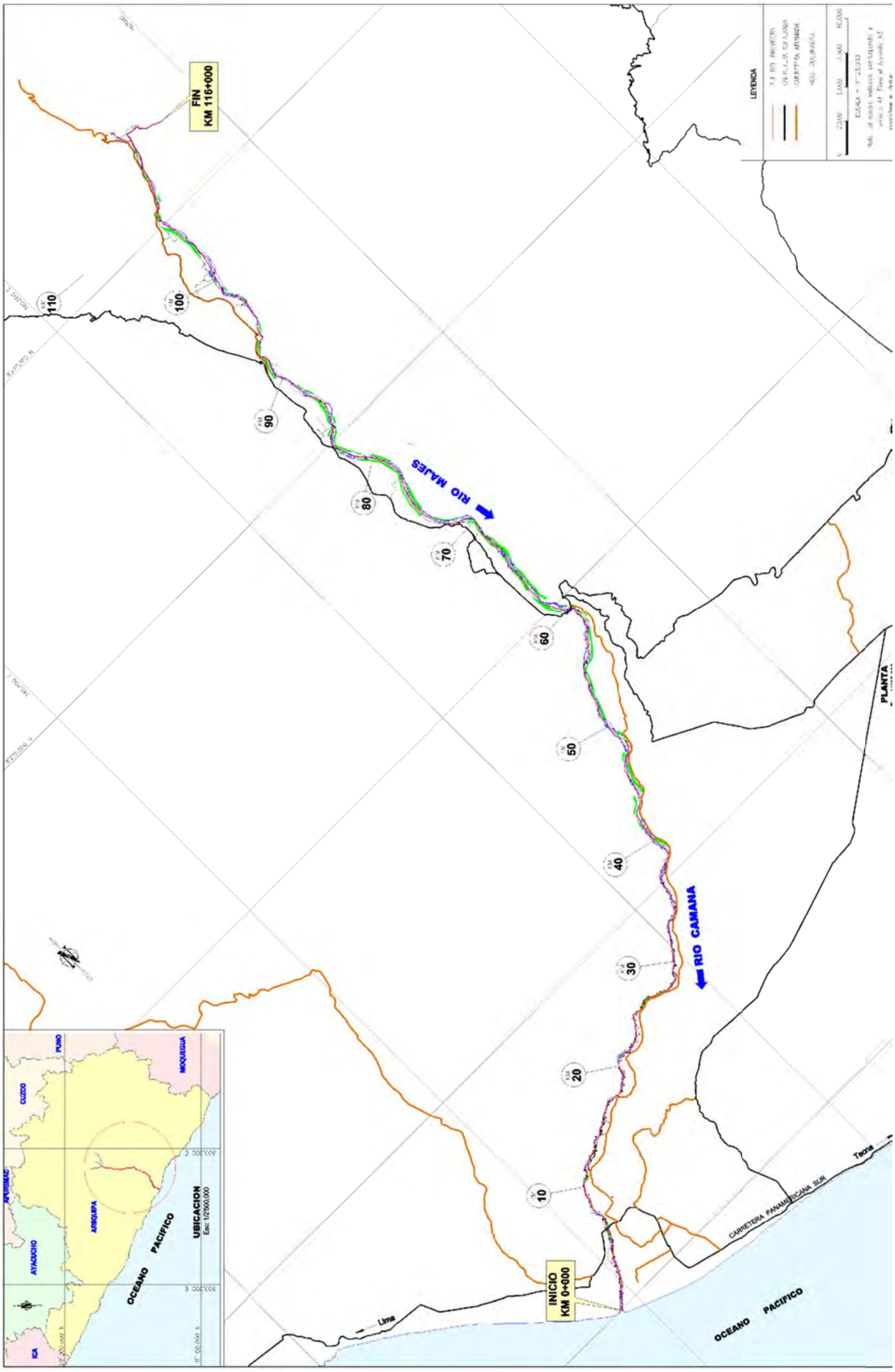

Figure 2.30 **Plan of the Majes-Camana River**

Table 2.7 Calculated Water Level and Required Dike Height Classified by Probable Discharge Scale in the Camana River

Camana

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	5.26	4.99	2.82	3.22	3.79	4.26	4.79	1.00	0.73	5.46	0.20	0.47
0.5	6.25	6.05	5.80	6.38	7.20	7.87	8.61	-1.62	-1.83	9.07	2.82	3.03
1.0	8.01	8.70	6.95	7.52	8.31	9.00	9.71	-1.00	-0.31	10.20	2.20	1.51
1.5	11.64	11.22	9.41	9.97	10.76	11.46	12.16	0.17	-0.24	12.66	1.03	1.44
2.0	13.01	12.62	11.81	12.38	13.17	13.83	14.54	-0.81	-1.21	15.03	2.01	2.41
2.5	15.09	22.64	14.18	14.73	15.54	16.21	16.98	-1.13	6.43	17.41	2.33	-5.23
3.0	18.47	23.25	16.64	17.15	17.85	18.41	19.02	0.06	4.83	19.61	1.14	-3.63
3.5	20.47	23.68	19.13	19.81	20.78	21.60	22.52	-1.13	2.08	22.80	2.33	-0.88
4.0	22.57	21.29	21.52	21.96	22.68	23.36	24.22	-0.80	-2.07	24.56	2.00	3.27
4.5	25.45	26.89	23.64	24.03	24.60	25.07	25.61	0.38	1.83	26.27	0.82	-0.63
5.0	28.79	27.41	26.28	27.03	27.92	28.75	29.75	0.04	-1.34	29.95	1.16	2.54
5.5	31.35	38.06	30.57	30.06	30.69	31.24	31.92	0.11	6.82	32.44	1.09	-5.62
6.0	32.90	51.69	31.59	31.92	32.68	33.32	34.02	-0.42	18.37	34.52	1.62	-17.17
6.5	35.90	46.14	33.85	34.61	35.47	36.21	37.01	-0.31	9.94	37.41	1.51	-8.74
7.0	37.81	43.39	36.07	36.49	37.18	37.80	38.48	0.01	5.59	39.00	1.19	-4.39
7.5	41.14	45.63	38.91	39.51	40.13	40.65	41.24	0.49	4.98	41.85	0.71	-3.78
8.0	43.87	49.52	43.18	43.75	44.31	44.85	45.48	-0.98	4.67	46.05	2.18	-3.47
8.5	47.06	50.55	44.77	45.47	46.07	46.56	47.10	0.50	3.99	47.76	0.70	-2.79
9.0	48.70	58.23	49.12	48.33	49.28	50.02	50.83	-1.32	8.21	51.22	2.52	-7.01
9.5	52.00	57.35	50.22	50.52	51.33	51.99	52.72	0.01	5.36	53.19	1.19	-4.16
10.0	55.01	60.22	52.43	53.45	54.30	55.01	55.72	0.00	5.21	56.21	1.20	-4.01
10.5	58.19	60.00	54.93	55.63	56.50	57.40	58.50	0.79	2.60	58.60	0.41	-1.40
11.0	60.14	60.96	58.33	58.84	59.45	59.99	60.59	0.15	0.97	61.19	1.05	0.23
11.5	62.71	71.89	61.77	62.45	63.73	64.27	64.89	-1.56	7.62	65.47	2.76	-6.42
12.0	67.26	71.79	64.54	64.95	65.60	66.12	66.69	1.14	5.67	67.32	0.06	-4.47
12.5	69.14	71.54	67.46	68.07	68.79	69.42	70.10	-0.28	2.12	70.62	1.48	-0.92
13.0	71.82	71.53	69.63	70.32	71.27	71.96	72.62	-0.14	-0.43	73.16	1.34	1.63
13.5	73.31	89.35	72.69	73.41	74.47	75.36	76.34	-2.05	13.99	76.56	3.25	-12.79
14.0	77.69	84.03	74.65	75.16	75.98	76.73	77.60	0.97	7.31	77.93	0.23	-6.11
14.5	78.61	94.88	77.11	77.71	78.57	79.28	80.09	-0.67	15.60	80.48	1.87	-14.40
15.0	82.06	90.00	81.38	81.93	82.83	83.62	84.56	-1.56	6.38	84.82	2.76	-5.18
15.5	83.91	94.56	82.62	83.21	84.04	84.68	85.39	-0.77	9.88	85.88	1.97	-8.68
16.0	87.18	88.81	85.62	86.30	87.34	88.20	89.34	-1.02	0.61	89.40	2.22	0.59
16.5	90.33	99.09	88.43	89.05	89.92	90.61	91.44	-0.28	8.48	91.81	1.48	-7.28
17.0	91.77	93.73	91.21	91.92	92.97	93.90	94.91	-2.13	-0.17	95.10	3.33	1.37
17.5	95.34	101.83	94.02	94.53	95.27	95.91	96.65	-0.56	5.93	97.11	1.77	-4.72
18.0	98.31	99.56	96.51	97.25	98.22	98.93	99.62	-0.62	0.63	100.13	1.82	0.57
18.5	100.52	107.63	99.15	99.83	100.90	101.84	102.93	-1.32	5.79	103.04	2.52	-4.59
19.0	104.47	112.23	102.25	102.76	103.47	104.09	104.85	0.38	8.14	105.29	0.82	-6.94
19.5	106.02	116.45	104.57	105.42	106.57	107.45	108.36	-1.43	9.00	108.65	2.63	-7.80
20.0	109.64	118.45	106.73	107.50	108.35	109.15	110.09	0.50	9.31	110.35	0.70	-8.11
20.5	111.77	120.01	111.15	110.03	110.61	111.15	111.80	0.62	8.86	112.35	0.58	-7.66
21.0	116.33	116.11	112.66	113.02	113.61	114.30	114.86	2.03	1.81	115.50	-0.83	-0.61
21.5	121.18	123.21	117.26	117.49	118.03	117.68	118.05	3.50	5.53	118.88	-2.30	-4.33
22.0	119.60	126.53	118.89	119.37	120.01	120.62	121.34	-1.02	5.91	121.82	2.22	-4.71
22.5	123.59	130.43	121.76	122.62	123.88	124.72	125.60	-1.13	5.71	125.92	2.33	-4.51
23.0	125.50	150.14	124.21	124.79	125.70	126.50	127.41	-1.00	23.64	127.70	2.20	-22.44
23.5	128.40	131.49	126.79	127.35	128.09	128.75	129.43	-0.35	2.74	129.95	1.55	-1.54
24.0	130.06	130.94	129.02	129.70	130.75	131.68	132.70	-1.62	-0.74	132.88	2.82	1.94
24.5	133.45	132.02	132.29	133.05	134.14	135.07	136.13	-1.62	-3.05	136.27	2.82	4.25
25.0	137.05	134.85	136.45	137.21	138.33	139.29	140.37	-2.24	-4.44	140.49	3.44	5.64
25.5	139.43	141.44	137.57	138.47	139.85	141.12	142.61	-1.69	0.32	142.32	2.89	0.88
26.0	140.95	142.25	139.43	140.09	141.11	142.13	143.40	-1.18	0.12	143.33	2.38	1.08
26.5	146.60	142.12	142.26	142.79	143.52	144.14	144.88	2.46	-2.02	145.34	-1.26	3.22
27.0	167.92	146.57	145.52	146.22	147.21	147.99	148.78	19.93	-1.42	149.19	-18.73	2.62
27.5	165.14	147.71	148.19	148.89	149.82	150.66	151.72	14.48	-2.95	151.86	-13.28	4.15
28.0	157.32	152.67	151.45	152.38	153.95	155.19	156.48	2.13	-2.52	156.39	-0.93	3.72
28.5	155.64	155.76	153.55	154.12	155.07	155.94	156.92	-0.30	-0.18	157.14	1.50	1.38
29.0	158.95	162.66	156.67	157.29	158.08	158.75	159.57	0.20	3.91	159.95	1.00	-2.71
29.5	162.56	182.70	159.24	159.82	160.60	161.21	161.84	1.35	21.49	162.41	-0.15	-20.29
30.0	164.97	172.07	162.88	163.73	164.64	165.42	166.33	-0.45	6.65	166.62	1.65	-5.45
30.5	167.68	173.08	167.15	167.22	168.36	169.28	170.30	-1.60	3.80	170.48	2.80	-2.60
31.0	170.61	182.03	168.79	169.32	170.22	171.02	171.95	-0.41	11.01	172.22	1.61	-9.81
31.5	173.60	180.56	171.47	172.44	173.22	173.86	174.63	-0.26	6.70	175.06	1.46	-5.50
32.0	177.87	185.81	174.43	175.62	177.32	178.25	178.96	-0.38	7.56	179.45	1.58	-6.36
32.5	181.11	182.27	177.05	177.94	179.50	180.41	181.52	0.70	1.86	181.61	0.50	-0.66
33.0	180.74	183.57	179.60	180.31	181.16	181.88	182.76	-1.14	1.69	183.08	2.34	-0.49
33.5	185.23	183.68	184.07	183.77	184.33	184.86	185.46	0.37	-1.18	186.06	0.83	2.38
34.0	187.81	187.85	186.25	186.87	187.74	188.42	189.18	-0.61	-0.57	189.62	1.81	1.77
34.5	204.28	197.86	190.53	191.08	191.97	192.73	193.65	11.55	5.12	193.93	-10.35	-3.92
35.0	193.16	199.85	192.72	193.14	193.77	194.37	194.94	-1.21	5.48	195.57	2.41	-4.28
35.5	204.46	213.40	197.08	197.37	197.95	198.32	199.11	6.14	15.08	199.52	-4.94	-13.88
36.0	199.68	203.21	198.46	198.93	199.45	199.82	200.33	-0.14	3.40	201.02	1.34	-2.20
36.5	202.82	220.00	201.35	202.03	202.60	203.04	203.44	-0.22	16.96	204.24	1.42	-15.76
37.0	205.50	213.29	204.10	204.56	205.15	205.60	206.16	-0.10	7.69	206.80	1.30	-6.49
37.5	208.96	224.00	208.38	208.76	209.31	209.78	210.32	-0.82	14.22	210.98	2.02	-13.02
38.0	222.38	225.00	212.89	213.13	213.62	214.08	214.63	8.30	10.92	215.28	-7.10	-9.72
38.5	232.41	216.82	215.12	215.50	216.01	216.42	217.00	15.99	0.40	217.62	-14.79	0.80
39.0	225.78	224.00	219.58	219.81	220.20	220.59	220.73	5.19	3.41	221.79	-4.00	-2.22
39.5	222.90	224.90	221.62	221.89	222.27	222.59	222.95	0.31	2.31	223.79	0.89	-1.11
40.0	231.24	254.46	226.45	226.51	226.76	227.05	227.39	4.19	27.41	228.25	-2.99	-26.21

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

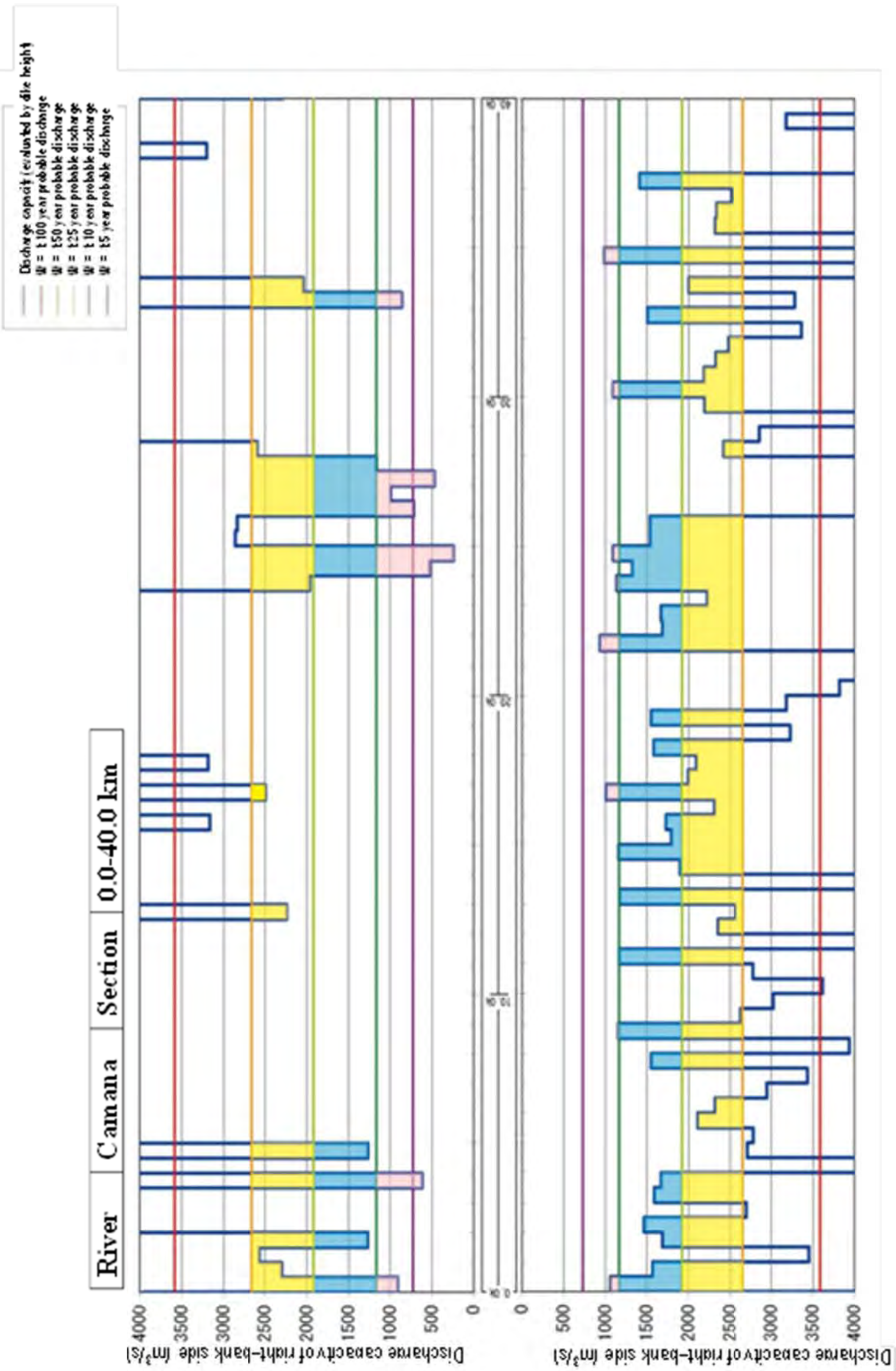

Figure 2.31 **Discharge Capacity in the Camana River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

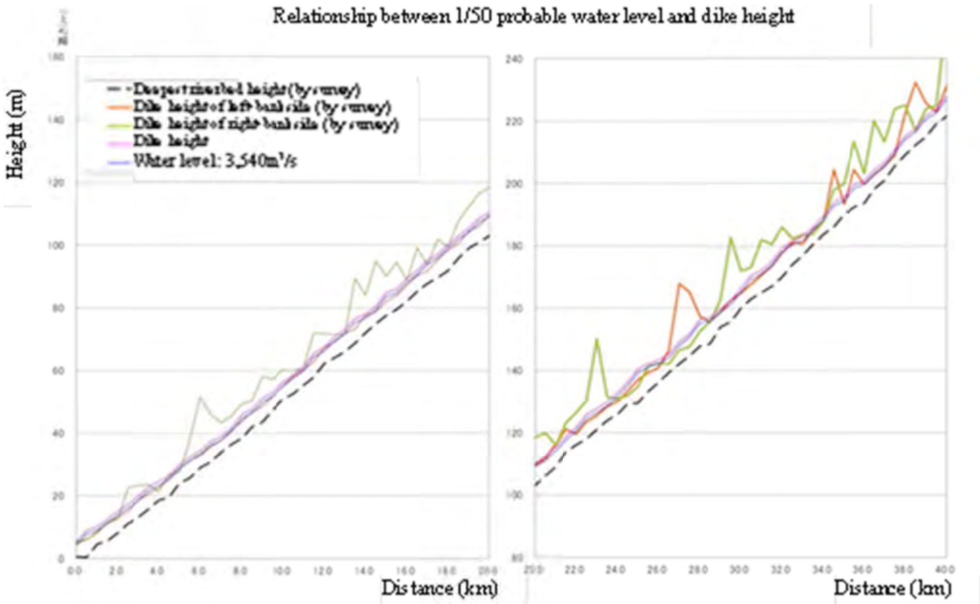

Figure-2.32 **Relation of Water Level of 1/50 Year Discharge and Dike Height in the Camana River**

2) Chanel Width

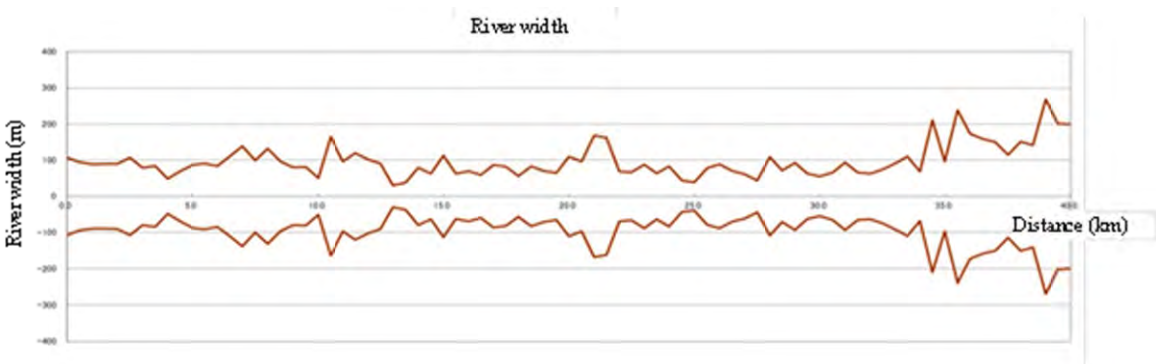

Figure 2.33 **Change of Chanel Width in the Camana River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)

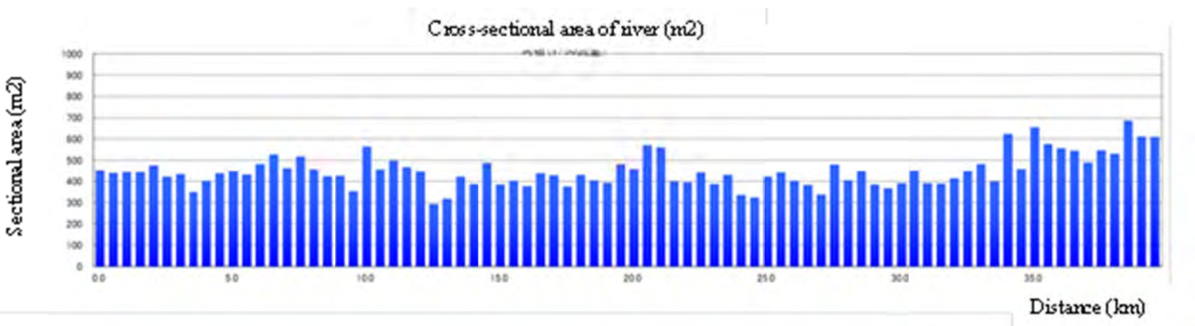

Figure 2.34 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Camana River**

Table 2.8 Calculated Water Level and Necessary Dike Height at the Time of River Flow with Probable Discharge Scale in the Majes River

Majes

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
40.5	238.75	229.19	228.23	228.61	229.14	229.35	230.00	9.40	−0.15	230.55	−8.20	1.35
41.0	243.35	232.04	231.34	231.61	231.98	233.61	232.62	9.74	−1.57	234.81	−8.54	2.77
41.5	244.83	235.47	235.27	235.59	236.02	236.17	236.78	8.65	−0.71	237.37	−7.45	1.91
42.0	250.73	239.16	237.56	238.22	239.23	240.59	240.09	10.15	−1.43	241.79	−8.95	2.63
42.5	255.17	244.44	242.35	242.65	243.01	243.10	243.61	12.07	1.34	244.30	−10.87	−0.14
43.0	259.78	246.46	246.05	246.41	246.91	247.87	247.78	11.91	−1.41	249.07	−10.71	2.61
43.5	260.99	249.74	249.52	250.01	250.70	251.10	251.91	9.90	−1.36	252.30	−8.70	2.56
44.0	254.07	255.56	252.80	253.29	254.04	255.65	255.18	−1.59	−0.10	256.85	2.79	1.30
44.5	256.54	355.37	256.30	256.75	257.39	257.91	258.53	−1.37	97.47	259.11	2.57	−96.27
45.0	260.61	413.49	259.45	259.99	260.77	261.81	262.06	−1.20	151.68	263.01	2.40	−150.48
45.5	263.51	369.98	262.81	263.22	263.80	264.91	264.83	−1.40	105.07	266.11	2.60	−103.87
46.0	266.25	315.14	265.92	266.24	266.71	267.49	267.52	−1.24	47.65	268.69	2.44	−46.45
46.5	269.88	270.01	268.34	269.14	269.68	270.31	270.59	−0.43	−0.30	271.51	1.63	1.50
47.0	275.60	274.95	273.10	273.61	274.29	274.67	275.49	0.93	0.28	275.87	0.27	0.92
47.5	289.11	286.44	276.21	276.53	276.87	278.93	277.45	10.18	7.51	280.13	−8.98	−6.31
48.0	286.18	312.30	279.77	280.03	280.37	280.72	280.96	5.47	31.59	281.92	−4.27	−30.39
48.5	283.73	291.87	283.80	284.16	284.66	284.88	285.54	−1.15	6.99	286.08	2.35	−5.79
49.0	287.36	292.03	286.72	287.15	287.76	289.26	288.83	−1.89	2.77	290.46	3.09	−1.57
49.5	290.36	292.12	290.33	290.67	291.18	291.76	292.02	−1.40	0.36	292.96	2.60	0.84
50.0	295.18	298.86	295.21	295.59	296.13	296.38	297.08	−1.20	2.48	297.58	2.40	−1.28
50.5	299.70	307.87	299.56	299.99	300.60	301.31	301.68	−1.61	6.56	302.51	2.81	−5.36
51.0	305.12	310.49	303.31	303.72	304.28	304.99	305.27	0.13	5.50	306.19	1.07	−4.30
51.5	308.74	309.00	306.95	307.41	308.06	308.59	309.19	0.14	0.41	309.79	1.06	0.79
52.0	312.36	312.50	310.82	311.31	312.01	312.78	313.23	−0.42	−0.28	313.98	1.62	1.48
52.5	313.91	347.19	314.24	314.84	315.69	316.42	317.21	−2.51	30.77	317.62	3.71	−29.57
53.0	319.46	324.98	317.50	317.97	318.54	320.46	319.51	−1.00	4.52	321.66	2.20	−3.32
53.5	322.86	324.29	320.97	321.47	321.98	322.51	322.87	0.35	1.78	323.71	0.85	−0.58
54.0	325.34	339.40	325.31	325.77	326.41	326.77	327.55	−1.42	12.64	327.97	2.62	−11.44
54.5	329.86	346.99	328.62	329.48	330.73	331.67	332.82	−1.81	15.31	332.87	3.01	−14.11
55.0	332.90	372.91	332.05	332.38	332.85	336.39	333.68	−3.49	36.52	337.59	4.69	−35.32
55.5	336.67	369.23	336.86	337.15	337.52	337.95	338.17	−1.28	31.28	339.15	2.48	−30.08
56.0	344.01	388.32	341.93	342.43	343.12	343.53	344.37	0.49	44.79	344.73	0.71	−43.59
56.5	348.44	371.67	345.55	346.06	346.77	348.10	347.98	0.34	23.57	349.30	0.86	−22.37
57.0	353.00	356.86	350.35	350.82	351.37	351.62	352.31	1.39	5.25	352.82	−0.19	−4.05
57.5	357.06	360.00	355.19	355.54	356.03	356.68	356.90	0.38	3.32	357.88	0.82	−2.12
58.0	362.04	369.90	358.97	359.32	359.73	360.22	360.42	1.82	9.68	361.42	−0.62	−8.48
58.5	365.00	366.31	363.65	364.16	364.87	365.30	366.12	−0.30	1.01	366.50	1.50	0.19
59.0	370.06	390.29	367.76	368.21	368.84	369.95	369.94	0.11	20.35	371.15	1.09	−19.15
59.5	374.33	371.96	372.32	372.72	373.31	373.58	374.30	0.75	−1.62	374.78	0.45	2.82
60.0	378.14	374.96	375.89	376.26	376.72	378.01	377.46	0.13	−3.05	379.21	1.07	4.25
60.5	382.86	381.01	380.99	381.34	381.78	381.95	382.56	0.92	−0.94	383.15	0.28	2.14
61.0	385.73	387.67	384.73	385.17	385.59	386.53	386.19	−0.79	1.15	387.73	1.99	0.05
61.5	389.13	390.16	389.73	390.18	390.59	390.72	391.30	−1.59	−0.56	391.92	2.79	1.76
62.0	395.20	395.05	395.10	395.39	395.80	396.22	396.53	−1.02	−1.17	397.42	2.22	2.37
62.5	402.87	400.16	399.69	400.00	400.43	400.58	401.17	2.29	−0.41	401.78	−1.09	1.61
63.0	406.88	405.88	404.21	404.49	404.84	405.50	405.45	1.38	0.38	406.70	−0.19	0.82
63.5	411.27	411.54	409.88	410.34	410.99	411.32	412.08	−0.05	0.22	412.52	1.25	0.98
64.0	416.36	416.12	413.20	414.32	415.05	416.04	416.24	0.32	0.08	417.24	0.88	1.12
64.5	420.47	420.33	418.60	419.08	419.75	420.13	420.92	0.34	0.20	421.33	0.86	1.00
65.0	422.49	425.54	423.28	423.75	424.42	425.12	425.60	−2.63	0.42	426.32	3.83	0.78
65.5	429.42	428.00	427.33	427.70	428.09	428.89	428.78	0.52	−0.90	430.09	0.68	2.10
66.0	437.95	432.88	432.72	432.99	433.38	433.51	434.07	4.44	−0.63	434.71	−3.24	1.83
66.5	437.32	439.27	438.13	438.53	439.09	439.37	440.08	−2.05	−0.10	440.57	3.25	1.30
67.0	445.23	444.37	442.96	443.43	444.09	444.62	445.25	0.61	−0.24	445.82	0.59	1.44
67.5	449.17	449.58	447.45	447.92	448.57	449.19	449.74	−0.02	0.38	450.39	1.22	0.82
68.0	454.82	454.48	452.04	452.61	453.25	453.69	454.37	1.13	0.79	454.89	0.06	0.41
68.5	457.23	459.54	456.15	456.73	457.54	458.20	458.93	−0.96	1.35	459.40	2.16	−0.15
69.0	461.75	463.52	459.62	460.07	460.67	462.22	461.72	−0.47	1.30	463.42	1.67	−0.10
69.5	466.00	465.64	464.95	465.45	466.16	466.58	467.42	−0.58	−0.95	467.78	1.78	2.15
70.0	475.66	469.12	468.67	469.21	469.96	471.13	471.28	4.53	−2.02	472.33	−3.33	3.22
70.5	476.00	475.57	474.19	474.54	475.00	475.18	475.80	0.82	0.39	476.38	0.38	0.81
71.0	480.07	480.00	478.90	479.30	479.79	480.37	480.63	−0.30	−0.37	481.57	1.50	1.57
71.5	484.80	484.00	483.43	483.77	484.24	484.45	485.07	0.35	−0.45	485.65	0.85	1.65
72.0	487.93	494.51	487.56	487.95	488.44	489.26	489.31	−1.33	5.25	490.46	2.53	−4.05
72.5	492.57	492.89	492.63	493.06	493.67	493.99	494.75	−1.43	−1.10	495.19	2.63	2.30
73.0	497.47	496.99	497.06	497.36	497.78	498.70	498.52	−1.23	−1.70	499.90	2.43	2.90
73.5	504.05	504.44	502.99	503.46	504.12	504.51	505.29	−0.46	−0.07	505.71	1.66	1.27
74.0	508.89	509.79	508.84	509.30	509.96	510.32	511.11	−1.43	−0.53	511.52	2.63	1.73
74.5	515.17	514.14	512.79	513.27	513.94	514.97	515.11	0.19	−0.84	516.17	1.01	2.04
75.0	520.15	520.23	517.64	518.18	518.83	519.20	519.98	0.95	1.03	520.40	0.25	0.17
75.5	524.58	524.75	522.52	523.00	523.67	524.29	524.84	0.29	0.47	525.49	0.91	0.73
76.0	528.22	529.44	527.16	527.61	528.23	528.76	529.27	−0.54	0.67	529.96	1.74	0.53
76.5	531.64	534.26	531.53	531.94	532.52	533.07	533.55	−1.43	1.20	534.27	2.63	0.00
77.0	535.15	535.13	535.62	536.13	536.86	537.31	538.15	−2.16	−2.18	538.51	3.36	3.38
77.5	540.28	542.37	540.11	540.45	540.91	541.97	541.72	−1.70	0.39	543.17	2.90	0.81
78.0	545.08	546.72	545.73	546.09	546.59	546.82	547.49	−1.75	−0.10	548.02	2.95	1.30
78.5	552.44	551.73	550.65	551.11	551.76	552.19	552.89	0.26	−0.45	553.39	0.94	1.65
79.0	557.05	556.80	555.02	555.61	556.27	556.93	557.43	0.12	−0.12	558.13	1.08	1.32
79.5	562.51	562.79	559.14	560.42	561.07	561.48	562.14	1.03	1.31	562.68	0.17	−0.11
80.0	563.91	567.45	564.14	564.51	565.02	565.88	565.93	−1.97	1.57	567.08	3.17	−0.37
80.5	571.02	572.31	569.40	569.81	570.32	570.54	571.21	0.48	1.76	571.74	0.72	−0.56
81.0	574.60	574.68	574.72	575.06	575.55	575.99	576.41	−1.39	−1.31	577.19	2.60	2.51
81.5	581.23	581.25	580.33	580.81	581.35	581.59	582.27	−0.36	−0.34	582.79	1.56	1.54
82.0	587.36	585.34	585.62	586.07	586.71	587.06	587.84	0.30	−1.73	588.26	0.90	2.93
82.5	593.38	607.08	590.90	591.37	592.04	592.47	593.21	0.91	14.61	593.67	0.29	−13.41
83.0	598.15	595.22	595.12	595.49	595.96	596.95	596.79	1.20	−1.74	598.15	0.00	2.94
83.5	603.56	601.15	600.93	601.38	602.02	602.36	603.13	1.20	−1.21	603.56	0.00	2.41
84.0	606.51	607.41	604.72	605.26	606.10	607.08	607.35	−0.58	0.33	608.28	1.78	0.87
84.5	609.11	610.58	609.37	609.77	610.33	610.85	611.32	−1.74	−0.27	612.05	2.94	1.47
85.0	622.61	615.37	614.04	614.43	614.92	615.34	615.78	7.27	0.03	616.54	−6.07	1.17

Majes

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
85.5	628.43	620.06	619.83	620.10	620.47	620.58	621.12	7.85	−0.52	621.78	−6.65	1.72
86.0	645.54	627.56	626.30	626.74	627.36	627.69	628.45	17.85	−0.13	628.89	−16.65	1.33
86.5	632.65	633.82	629.79	630.40	630.97	632.21	631.97	0.44	1.61	633.41	0.76	−0.41
87.0	635.86	636.22	633.92	634.43	635.14	635.40	636.12	0.46	0.82	636.60	0.74	0.38
87.5	641.45	639.17	638.53	638.91	639.40	640.25	640.23	1.20	−1.08	641.45	0.00	2.28
88.0	644.21	650.70	643.52	643.95	644.51	644.68	645.28	−0.46	6.03	645.88	1.66	−4.83
88.5	657.62	650.10	650.66	651.03	651.56	651.81	652.50	5.81	−1.71	653.01	−4.61	2.91
89.0	667.85	656.55	654.65	655.27	656.14	656.71	657.64	11.14	−0.16	657.91	−9.94	1.36
89.5	668.63	660.78	658.68	659.17	659.97	661.37	661.03	7.26	−0.59	662.57	−6.06	1.79
90.0	673.44	664.19	662.95	663.31	663.83	664.26	664.73	9.18	−0.07	665.46	−7.98	1.27
90.5	697.69	670.28	667.19	667.58	668.14	668.63	669.12	29.06	1.65	669.83	−27.86	−0.45
91.0	686.00	671.51	670.82	671.18	671.68	672.51	672.55	13.49	−1.00	673.71	−12.29	2.20
91.5	685.08	675.39	674.52	675.32	676.30	677.01	678.02	8.07	−1.62	678.21	−6.87	2.82
92.0	682.72	695.65	679.88	680.80	682.06	683.07	684.21	−0.35	12.58	684.27	1.55	−11.38
92.5	687.29	685.90	684.74	685.87	686.66	688.09	687.87	−0.80	−2.19	689.29	2.00	3.39
93.0	696.78	693.52	689.52	690.05	690.79	691.23	692.07	5.55	2.29	692.43	−4.35	−1.09
93.5	697.53	698.07	694.20	694.76	695.58	696.25	696.89	1.28	1.82	697.45	−0.08	−0.62
94.0	704.83	723.65	698.78	699.50	700.51	701.34	702.38	3.49	22.31	702.54	−2.29	−21.11
94.5	717.41	715.23	702.54	703.27	704.34	706.23	706.47	11.18	9.00	707.43	−9.98	−7.80
95.0	714.48	711.75	705.88	706.41	707.16	708.95	708.49	5.53	2.80	710.15	−4.33	−1.60
95.5	709.48	710.99	709.71	710.32	711.18	711.77	712.71	−2.29	−0.78	712.97	3.49	1.98
96.0	713.23	720.86	712.78	713.42	714.32	716.22	715.82	−2.99	4.64	717.42	4.19	−3.44
96.5	718.39	724.80	717.84	718.43	719.22	719.72	720.59	−1.33	5.08	720.92	2.53	−3.88
97.0	724.98	723.32	722.21	722.61	723.12	724.35	724.00	0.63	−1.03	725.55	0.57	2.23
97.5	726.65	730.79	726.97	727.43	728.09	728.45	729.24	−1.80	2.34	729.65	3.00	−1.14
98.0	731.07	735.05	730.21	731.34	731.98	733.09	733.11	−2.02	1.96	734.29	3.22	−0.76
98.5	744.51	735.62	735.00	735.60	736.35	736.80	737.65	7.71	−1.18	738.00	−6.51	2.38
99.0	748.48	740.07	740.89	741.26	741.75	742.25	742.60	6.23	−2.18	743.45	−5.03	3.38
99.5	746.53	746.62	745.90	746.34	746.85	747.03	747.66	−0.50	−0.41	748.23	1.70	1.61
100.0	765.13	752.28	750.885	751.269	751.64	752.213	752.312	12.92	0.07	753.41	−11.72	1.13
100.5	757.25	757.09	757.166	757.405	757.738	757.82	758.323	−0.57	−0.73	759.02	1.77	1.93
101.0	773.81	762.97	762.995	763.257	763.576	763.648	764.134	10.16	−0.68	764.85	−8.96	1.88
101.5	772	770.41	769.198	769.825	770.726	771.246	772.15	0.75	−0.84	772.45	0.45	2.04
102.0	787.47	774.78	773.713	774.298	775.123	776.01	776.538	11.46	−1.23	777.21	−10.26	2.43
102.5	789.63	788.67	777.953	778.656	779.657	780.393	781.432	9.24	8.28	781.59	−8.04	−7.08
103.0	797.97	785.87	783.246	783.947	784.774	785.729	785.952	12.24	0.14	786.93	−11.04	1.06
103.5	790	788.37	788.877	789.396	790.123	790.536	791.359	−0.54	−2.17	791.74	1.74	3.37
104.0	794	792.84	793.362	793.721	794.205	795.243	795.047	−1.24	−2.40	796.44	2.44	3.60
104.5	807.88	799.11	797.784	798.304	798.948	799.222	799.938	8.66	−0.11	800.42	−7.46	1.31
105.0	813.04	803.88	802.953	803.674	804.261	804.691	805.256	8.35	−0.81	805.89	−7.15	2.01
105.5	817.72	811.8	809.977	810.398	810.954	811.2	811.892	6.52	0.60	812.40	−5.32	0.60
106.0	821.32	822.8	816.71	817.565	818.767	819.718	820.843	1.60	3.08	820.92	−0.40	−1.88
106.5	836	838.53	823.205	823.641	824.257	825.102	825.335	10.90	13.43	826.30	−9.70	−12.23
107.0	838.79	865.15	827.857	828.385	828.899	829.127	829.801	9.66	36.02	830.33	−8.46	−34.82
107.5	833.74	837.9	832.755	833.294	834.076	834.512	835.155	−0.77	3.39	835.71	1.97	−2.19
108.0	839.44	840.38	838.703	839.126	839.807	840.057	840.729	−0.62	0.32	841.26	1.82	0.88
108.5	856.86	850.08	844.468	844.902	845.508	845.819	846.568	11.04	4.26	847.02	−9.84	−3.06
109.0	864.52	849.96	849.078	849.604	850.327	850.915	851.519	13.61	−0.95	852.12	−12.41	2.15
109.5	872.07	859.31	855.554	856.29	856.872	857.144	857.861	14.93	2.17	858.34	−13.73	−0.97
110.0	866.43	865.82	862.209	862.93	863.801	864.316	865.209	2.11	1.50	865.52	−0.91	−0.30
110.5	881.45	872.36	868.983	870.011	870.766	871.097	871.948	10.35	1.26	872.30	−9.15	−0.06
111.0	881.73	878.24	874.948	876.211	877.461	877.931	878.808	3.80	0.31	879.13	−2.60	0.89
111.5	949.26	892.01	883.904	884.988	886.459	887.564	888.736	61.70	4.45	888.76	−60.50	−3.25
112.0	912.4	904.94	890.161	891.346	892.877	894.82	896.103	17.58	10.12	896.02	−16.38	−8.92
112.5	904.46	911.05	891.742	892.668	893.944	896.88	896.185	7.58	14.17	898.08	−6.38	−12.97
113.0	907.55	912.94	898.906	899.753	900.927	901.812	903.232	5.74	11.13	903.01	−4.54	−9.93
113.5	916.04	920.44	901.707	902.419	903.427	906.242	905.173	9.80	14.20	907.44	−8.60	−13.00
114.0	923.28	921.43	907.802	908.898	910.453	911.836	913.447	11.44	9.59	913.04	−10.24	−8.39
114.5	929.36	925.09	912.327	913.587	915.34	916.945	918.643	12.42	8.14	918.15	−11.21	−6.94
115.0	929.96	929.64	914.315	915.451	916.992	921.711	919.509	8.25	7.93	922.91	−7.05	−6.73
115.5	933.64	931.67	918.064	919.407	921.218	922.757	924.151	10.88	8.91	923.96	−9.68	−7.71

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

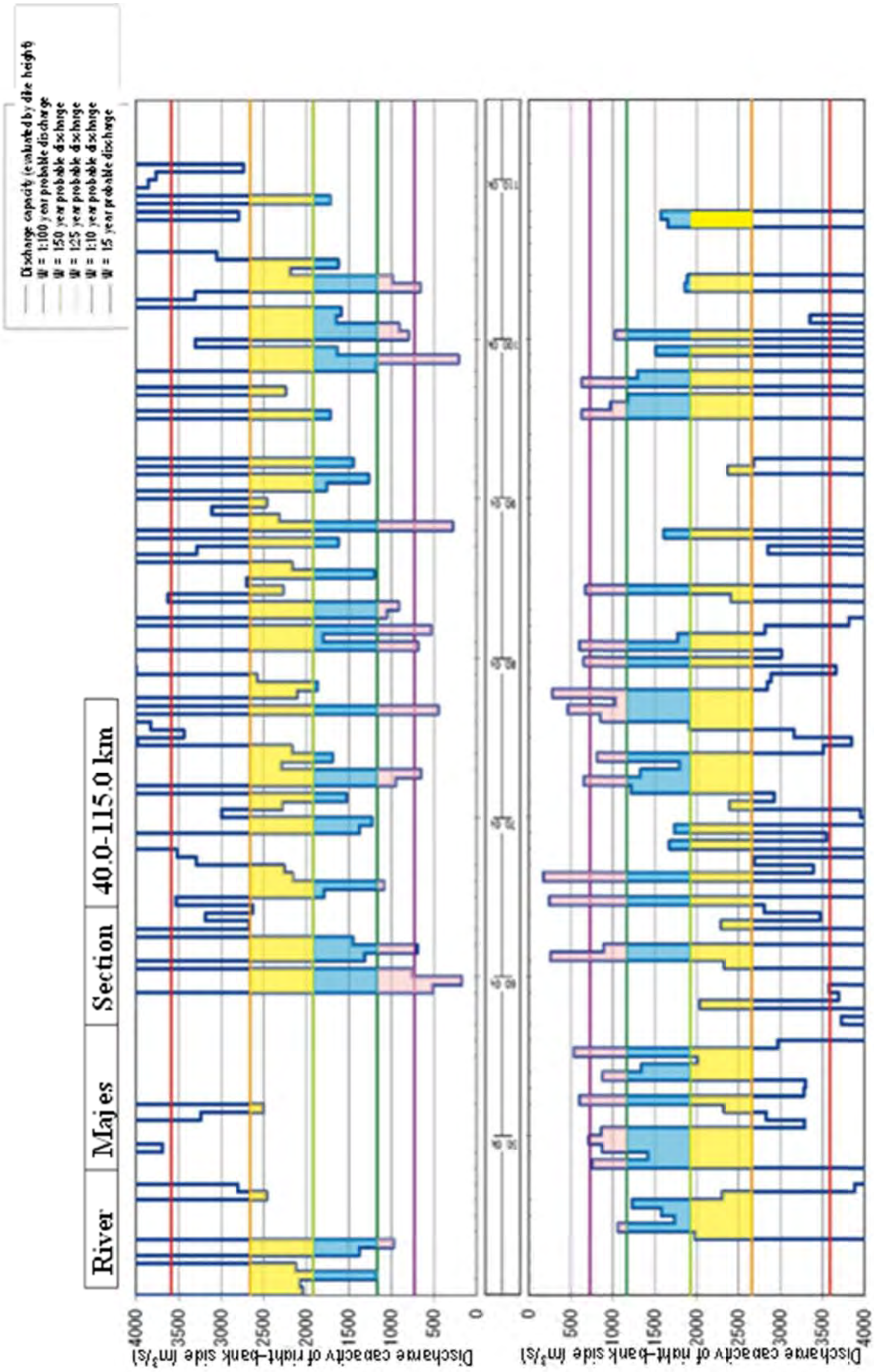

Figure 2.35 **Discharge Capacity in the Majes River**

1) Relation of Water Level of 1/50 Year Discharge and Dike Height

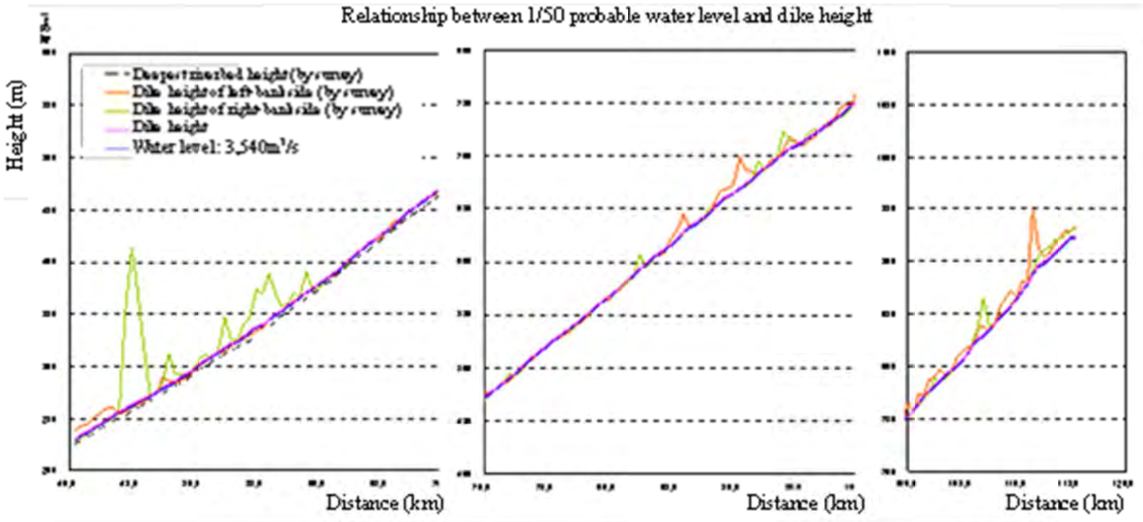

Figure 2.36 **Relation of Water Level of 1/50 Year Discharge and Dike Height in the Majes River**

2) Chanel Width

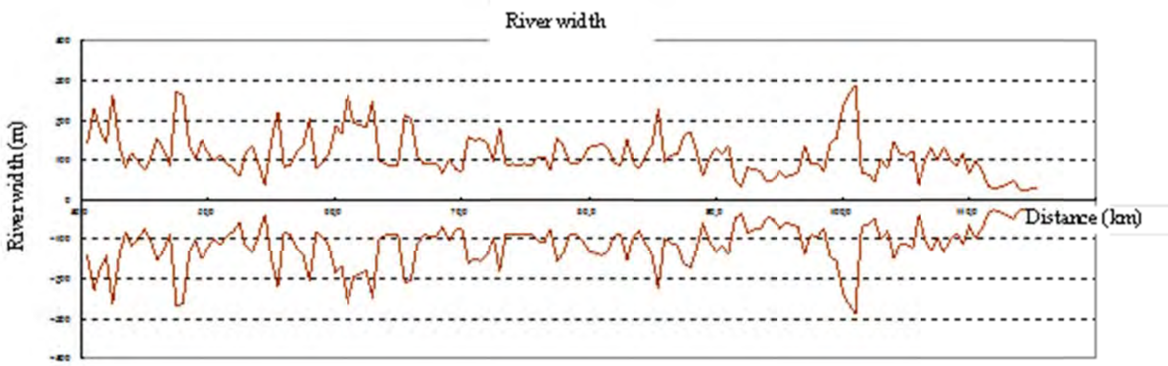

Figure 2.37 **Change of Chanel Width in the Majes River**

3) Cross Sectional Area by Non-Uniform-Flow-Calculation (1/50 Year Discharge)

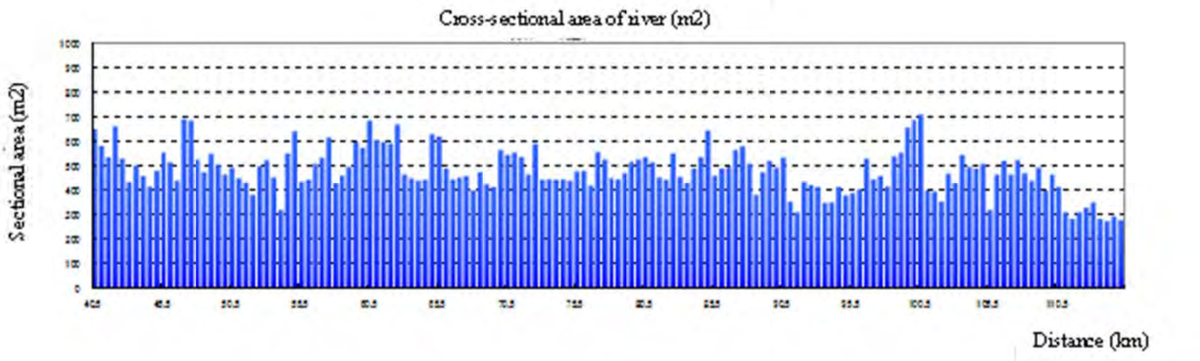

Figure 2.38 **Cross Sectional Area by Non-Uniform- Flow- Calculation (1/50 Year Discharge) in the Majes River**

2.2 Inundation Characteristic

Inundation analysis (1/50 year probable flood scale) for each river was carried out, the flood characteristics arranged are shown in the following tables. Moreover, the flood analysis outputs are shown from the next page.

Table 2.9 **Flood Characteristics for Each River**

River name		Flood characteristics
Chira River		Since the discharge capacity is insufficient in the whole, it overflows at all the points and flood flow spreads in the low flat plain along the river.
Canete River		In the upstream area from 10km (distance mark) from the river mouth, although it overflows due to the shortage of discharge capacity, it remains in the influence of the farmland on the circumference of the channel. However, in downstream area from 10km from the river mouth, the flood flow spreads greatly just in the right-bank side, and the damage becomes large.
Chincha River	Chico	At the vicinities of 15km and 4km from the river mouth, overflows occur, and flood flows spread greatly in the left-bank side.
	Matagente	At the vicinities of 10km and 4km from the river mouth, overflows occur, and flood flows spread greatly in the right-bank side.
Pisco River		In the upstream area from 7km from the river mouth, although it overflows around the channel by the shortage of discharge capacity, the flood flow does not spread widely. However, if it overflows in the downstream area from 7km, the flood flow will spread greatly in the left-bank side, and serious damage will be occurred in the Pisco City.
Yauca River		It overflows in downstream part from the vicinity of 7km from the river mouth, and the flood flow spreads in the farmland of the right-bank side.
Majes- Camana River		It overflows at the vicinity of 5km from the river mouth, and the flood flow spreads greatly in the left-bank side. In middle stream and upstream areas, It overflows in lowland plain, and flood flow stagnates by the surrounded hills and mountains.

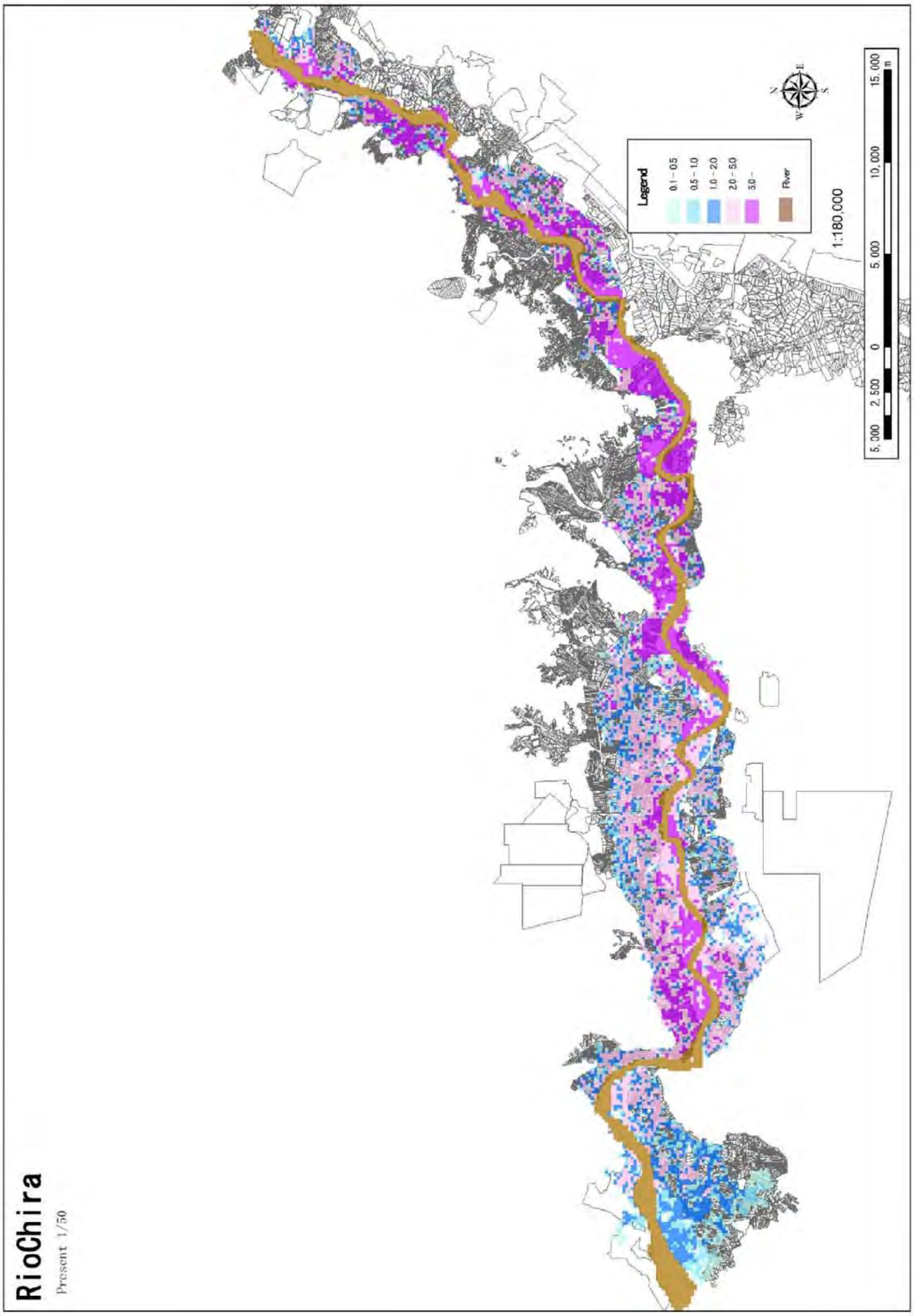

Figure 2.39 **Result of Flood Analysis in the Chira River (1/50 Year Probable Flood)**

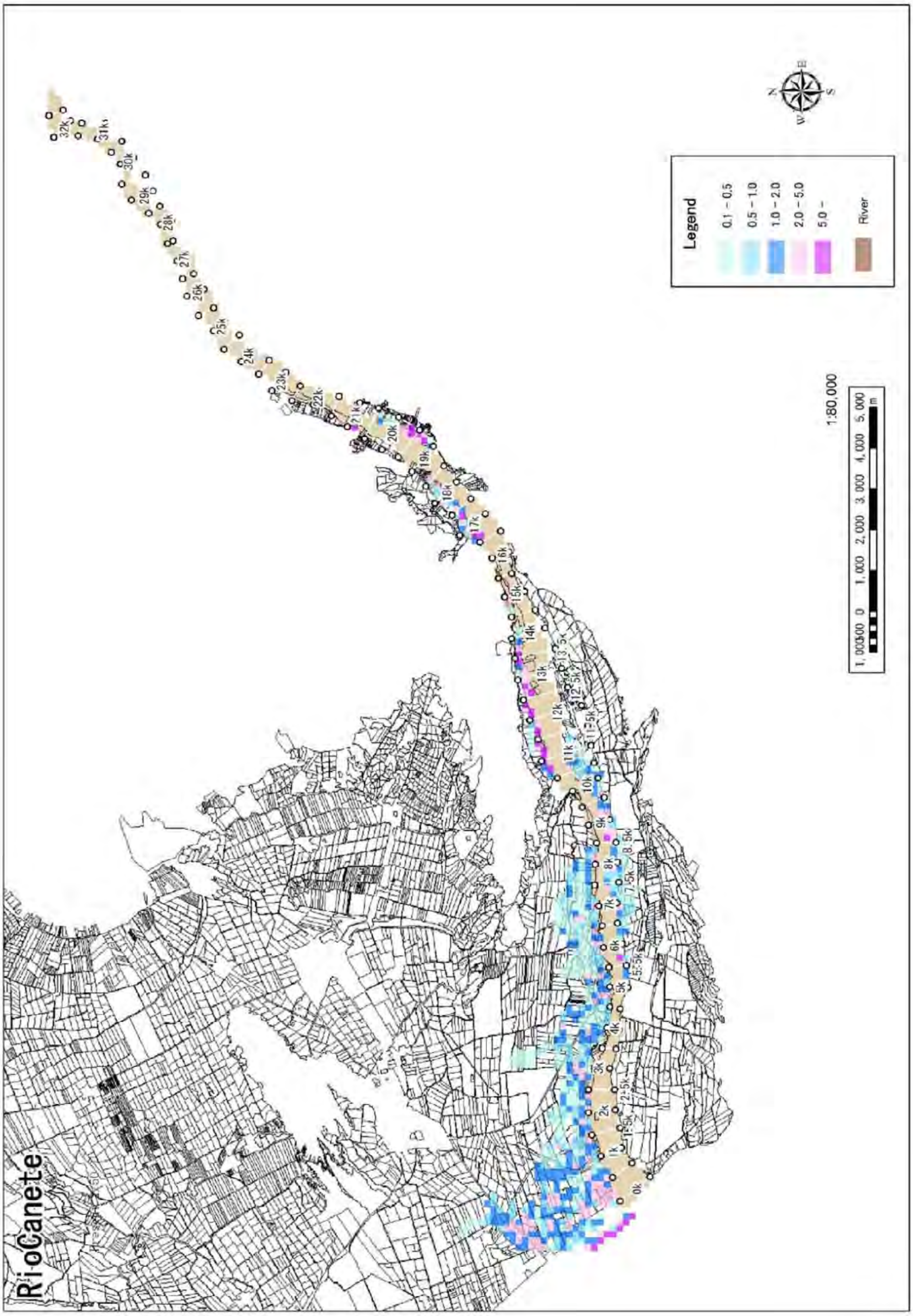

Figure 2.40 **Result of Flood Analysis in the Canete River (1/50 Year Probable Flood)**

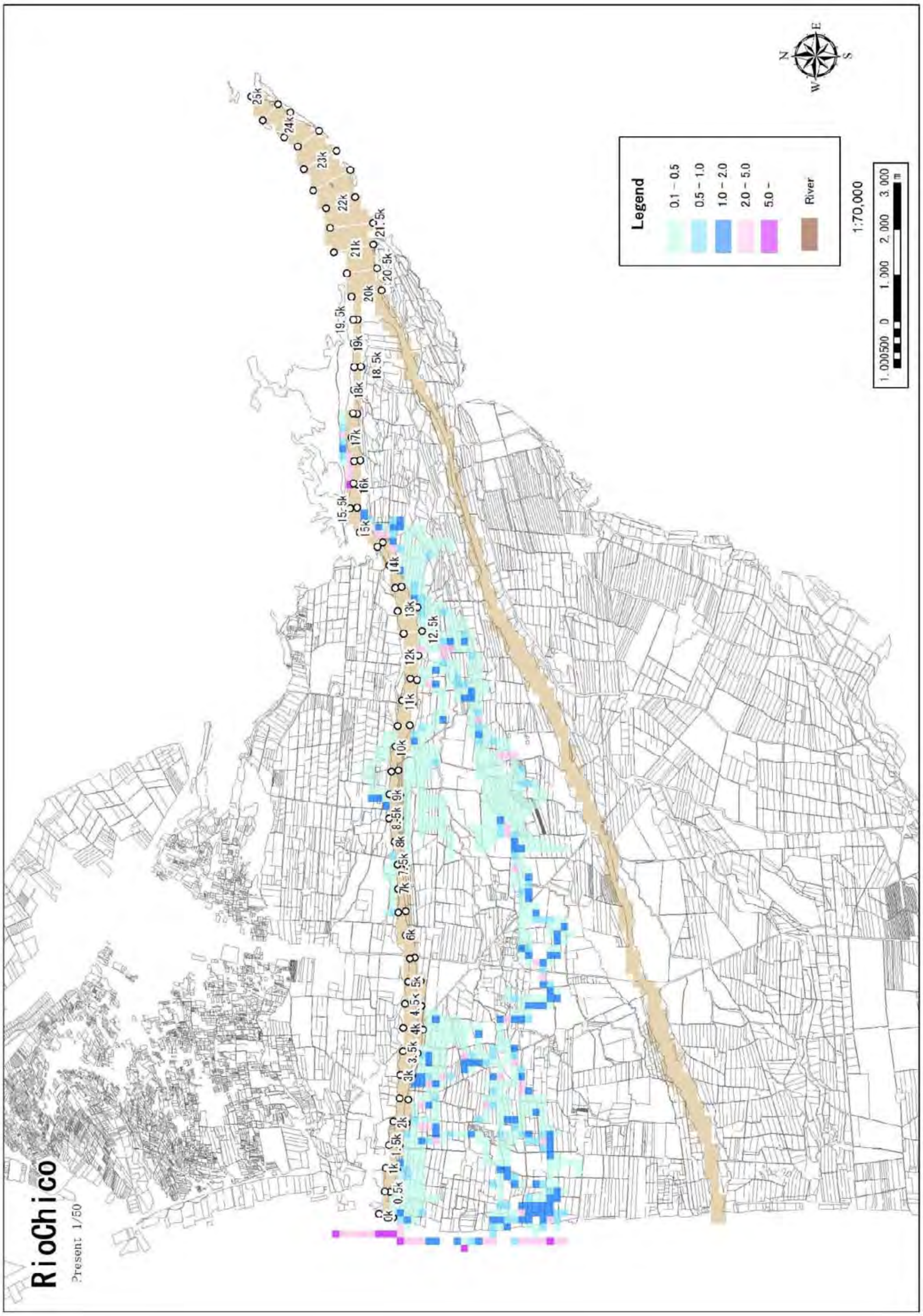

Figure 2.41 **Result of Flood Analysis in the Chico River (1/50 Year Probable Flood)**

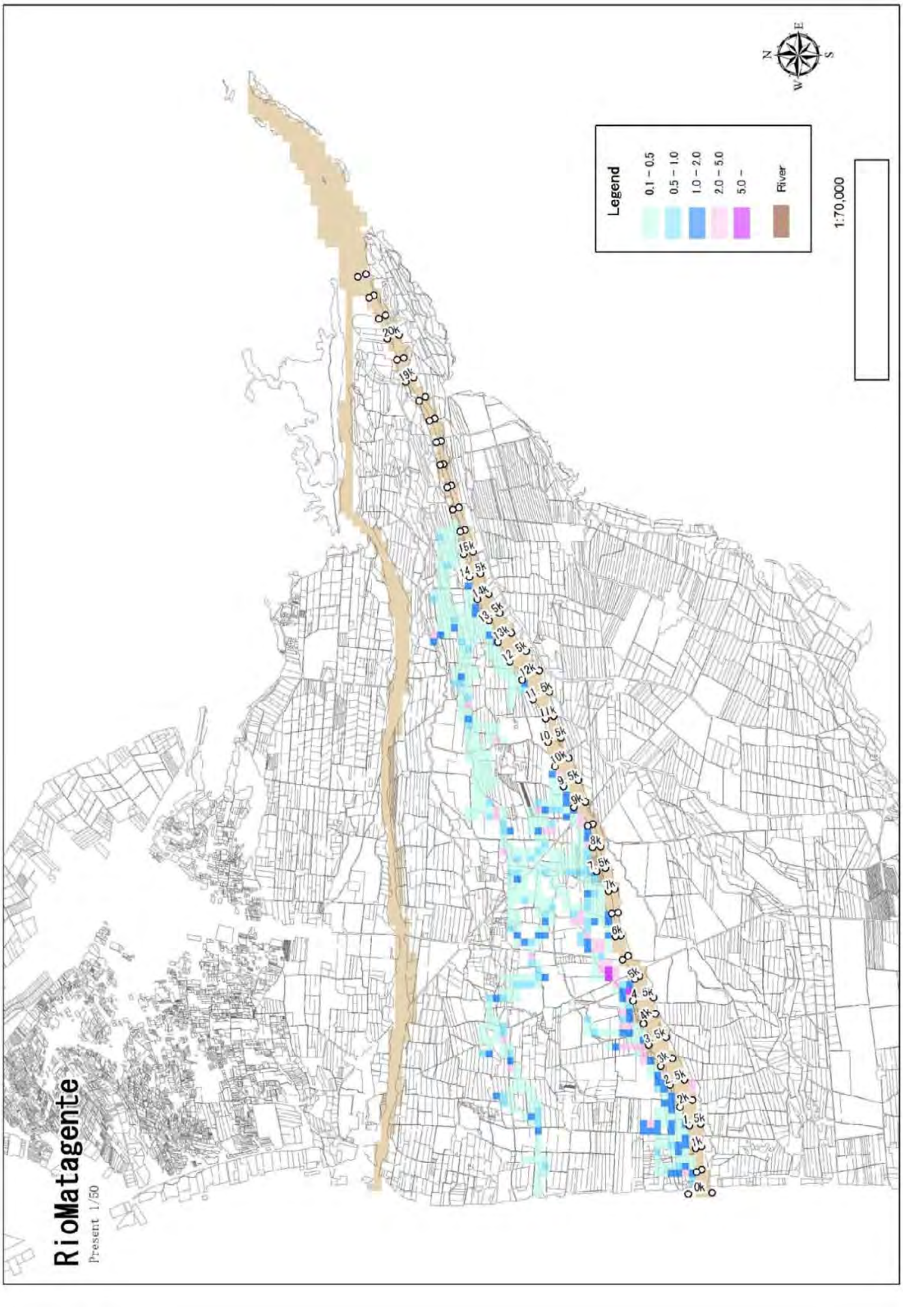

Figure 2.42 **Result of Flood Analysis in the Matagente River (1/50 Year Probable Flood)**

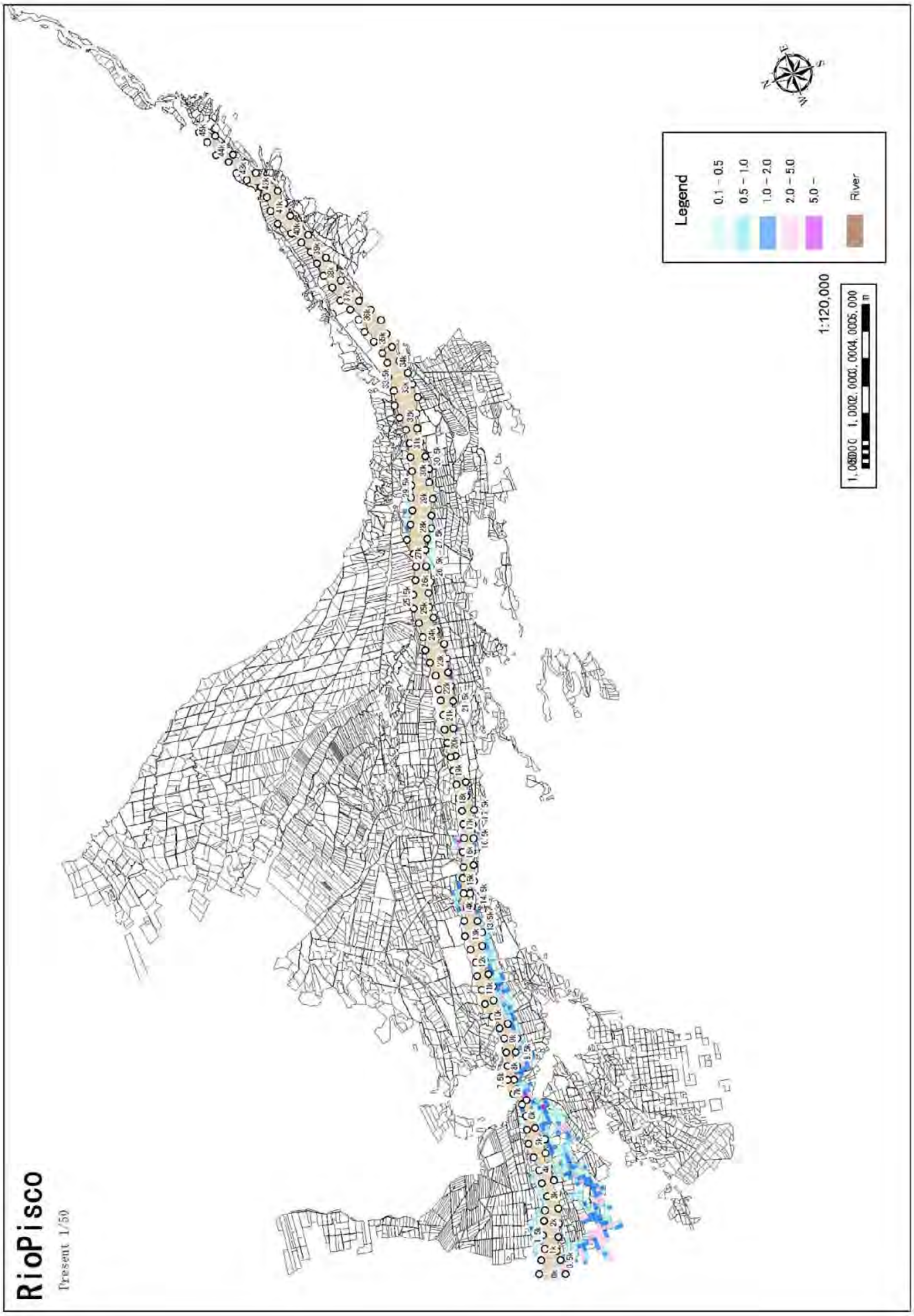

Figure 2.43 **Result of Flood Analysis in the Pisco River (1/50 Year Probable Flood)**

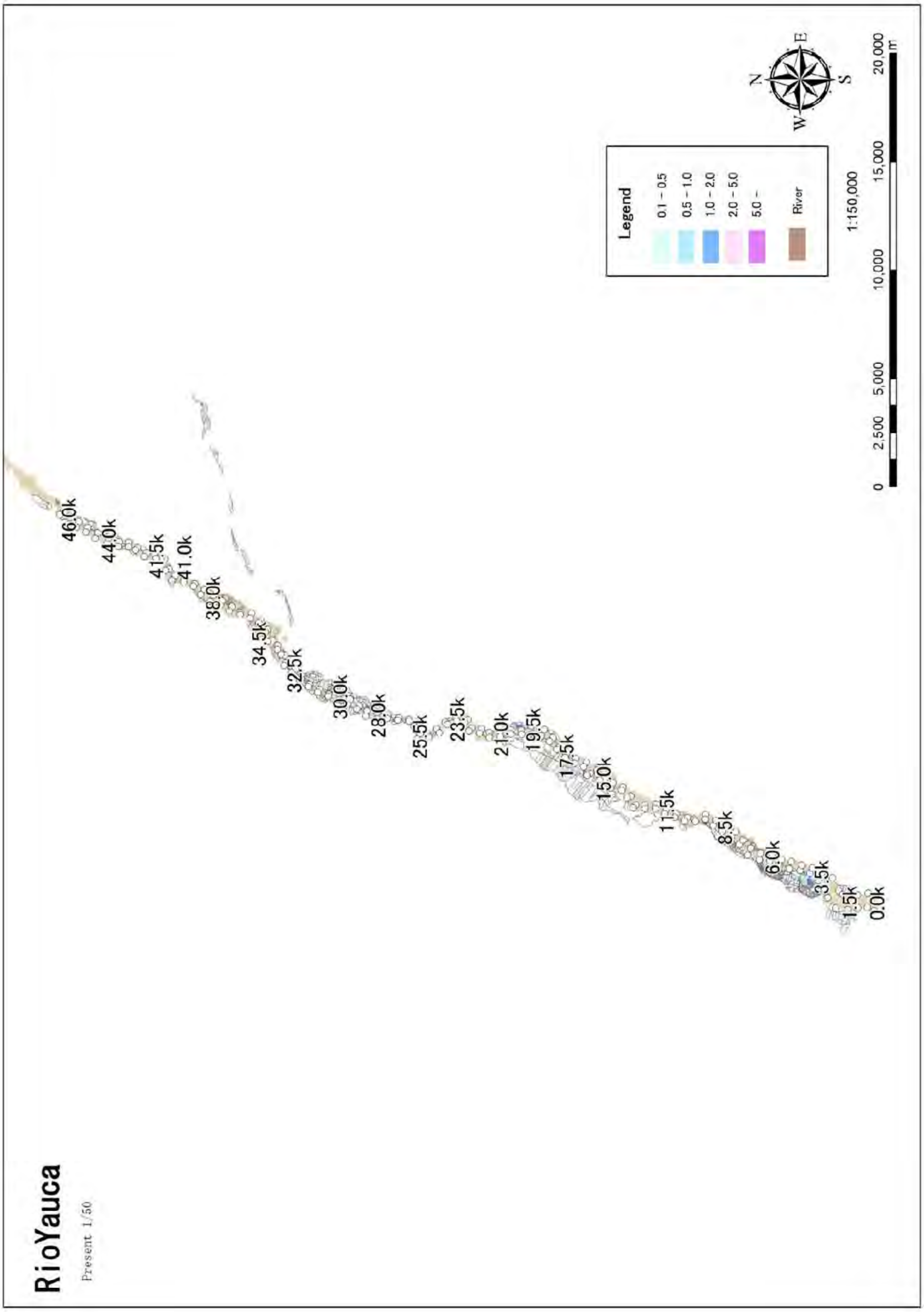

Figure 2.44 **Result of Flood Analysis in the Yauca River (1/50 Year Probable Flood)**

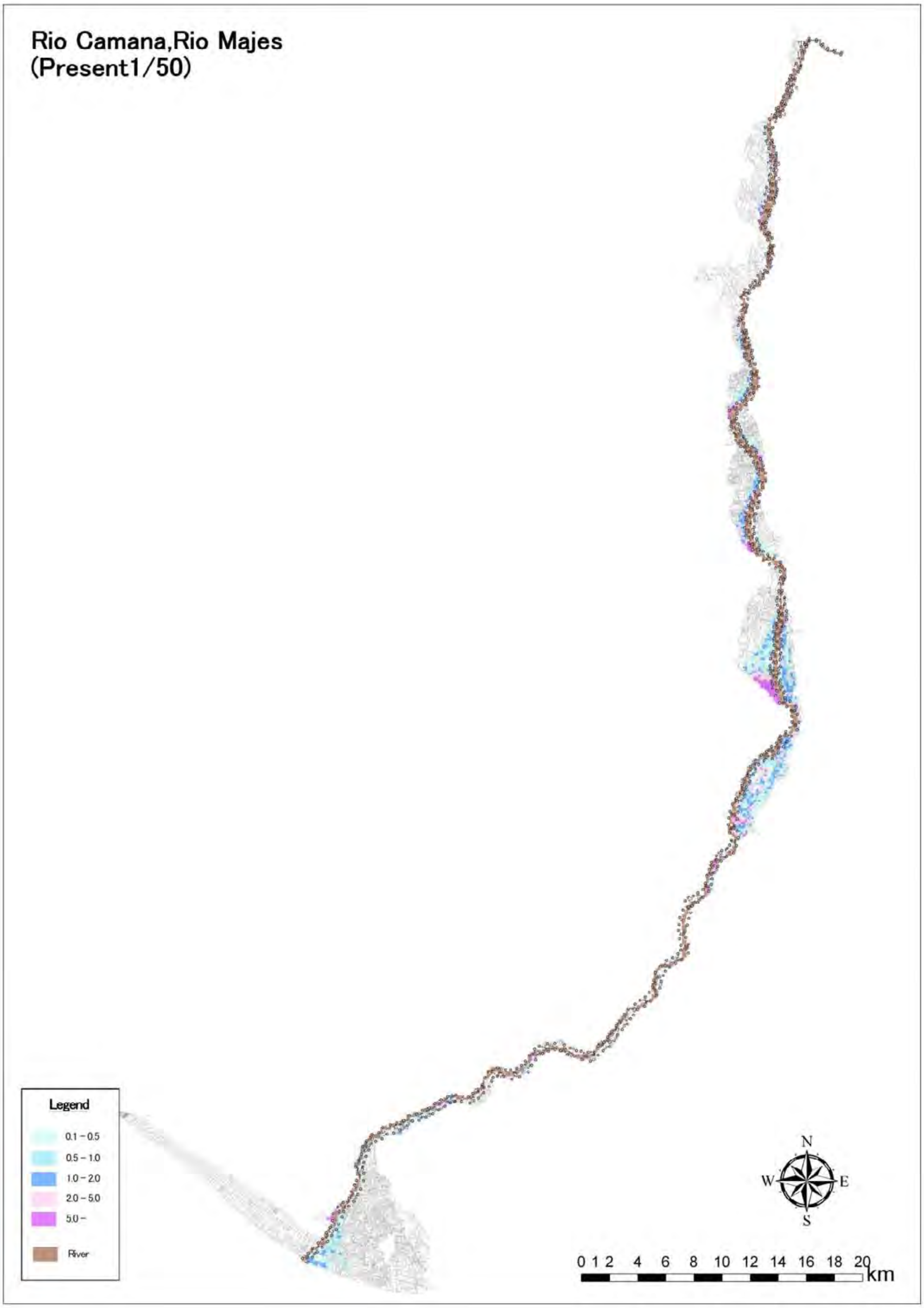

Figure 2.45 **Result of Flood Analysis in the Majes-Canama River (1/50 Year Probable Flood)**

2.3 Riverbed-Fluctuation Characteristic

The results of riverbed fluctuation analysis are arranged as follows.

River name	Riverbed-fluctuation characteristics
Chira River	➢ Since the outflow of sediment is intercepted by the Poechos dam in the Chira river, the degradation of riverbed is remarkable in the just downstream of the dam. ➢ On the other hand, in the Sullana Weir located in the middle stream part, since the sediment moving from the upstream channel and tributaries accumulates, and then the riverbed aggrades. ➢ In case of carrying out no maintenance for sediment excavation, the discharge capacity will be insufficient in the future. ➢ Large riverbed fluctuation does not produce fundamentally in most of sections in the downstream area. ➢ The riverbed degradation occurs at several sections immediately after large-scale flood.
Canete River	➢ The average riverbed aggradation is calculated about 20cm in average in the Canete River in case of 50 years for the future. ➢ However, since the channel width is narrow in 28-30km (distance mark) section in the upstream, the riverbed aggradation with 1-2m occurs locally. ➢ The periodical excavation (maintenance) is required in this section. ➢ Also at the just downstream point (4km) of Ca-1 and Ca-2 which show critical points, the riverbed aggradation with about 1m may arise at the maximum. Continuous monitoring is required in order to grasp the influence of the sediment discharge capacity at the implementation sections of measures.
Chincha River	➢ In the Chincha River, when the diversion Weir is repaired and the flow rate and sediment discharge can be allocated to 1:1 in the future, the riverbed aggradation of the average of 20 -30 cm produces in case of 50 years later. ➢ On the other hand, when the diversion weir has not been repaired, and if the flow rate and sediment discharge incline toward either, the riverbed aggradation in case of 50 years becomes more twice compared with the repaired case. Through the comparison on “with improvement” and without improvement” for weir, the riverbed aggradation control effect by improvement of the diversion weir can be checked. ➢ Taking into account the critical points and the riverbed fluctuation tendency, sediment accumulates in the section just downstream of C-1 and C-2 points of the Chico River, and the risk of the flood occurrences is high in the upstream. ➢ On the other hand, sediment deposition has occurred at M-3 and M-4 points in the Matagente River, and the risk of flood occurrences is also high. ➢ As for the measures on sedimentation, periodical excavation (maintenance) is required.
Rio Pisco	➢ The riverbed aggradation with 20 cm in average will be assumed in the Pisco River in case of 50 years after. ➢ Aggradation rate is relatively small in average, however, the section just upstream the narrow areas with about 1m has possibility for aggradation, and the inundation risk is high. ➢ In those narrow sections, periodical excavation for maintenance is required.
Yauca River	➢ The riverbed aggradation with 10cm in average will be expected in the Yauca River in case of 50 years after. ➢ Although riverbed fluctuation will occur partially in the river mouth section and the upstream section, the riverbed will show a stable inclination on the whole. ➢ This main reason on stable condition is due to low river discharge to carry sediment. ➢ Although sediment deposition will occur in the most downstream section, since there are no critical places in the part, even if it will deposit, for the

	moment, adverse problems will not occur.
Majes − Camana River	➢ The riverbed aggradation with 20cm in average will be predicted in the Majes-Camana River in case of 50 years after. ➢ Although there is low possibility that adverse problems will arise on flood control, in the vicinities of 13km and 101km distance mark, the riverbed aggradation with 0.8m and 1m will be predicted, respectively. ➢ It is analyzed that sedimentation will occur in the channel section which just downstream of the narrow section near 13km distance mark causing by expansion to the upstream. There is a diversion weir at 12.8km distance mark and trouble for taking water may arise, and excavation for maintenance in the river will be required. ➢ Moreover, the 101km mark is a wide channel section which just downstream of narrow section, and also overflowed point in the past, excavation for maintenance is required from the viewpoint on flood control. ➢ The riverbed aggradation is seen in the sections other than the above-mentioned section at 13km and 101km mark. It is not serious situation, the necessity of excavation for maintenance is low. ➢ In the Majes-Camana River, the sections of the excavation for maintenance are the vicinities of 13km and 101km points, from the viewpoint of flood control and water use such as irrigation.

2.4 Local Scouring for Each River

The local scouring sections (Erosion) for each river are arranged based on the field reconnaissance result and the survey result. In the future, the measures against local scouring sections also become an important subject.

Table 2.10 **Main Partial Scour (Erosion) Parts in the Object Rivers**

Object river	Erosion Sections	Erosion situation
Chira River	① 11.5 km～12.5 km Right Bank	Bank erosion has advanced, and the possibility that erosion will reach the road along the right bank is high.
	② 73 km Right Bank	Damage of farmland with 5km by bank erosion
	③ 98 km Right Bank	Bank erosion has advanced, and the agricultural channel along the right bank may suffer damage.
	④ 99.5 km	By the influence of dam discharge, the riverbank of downstream of the dam has suffered damage by erosion.
Canete River	① 7.5 km Right Bank	Bank collapsed by local scouring at the time of the flood occurred five years ago, and flood flow overflowed.
	② 24 km～25 km Right Bank	Bank erosion has advanced, and possibility that damage will reach the road along the right bank is high.
Chincha River	Remarkable erosion part was not identified.	
Pisco River	Remarkable erosion part was not identified.	
Yauca River	① 7.0 km Right Bank	Farmland along riverbank has suffered the damage of washing away by floods.
Majes－Camana River	① 12 km～13 km Left Bank	Damage may reach the urban water supply waterway constructed along the riverbank.
	② 26 km	The circumference of the bridge piers has eroded several meters by the flood of one year ago, and may suffer damage from now on.
	③ 55 km～56.5 km Left Bank	Farmland suffers damage by erosion caused by flood water every year.
	④ 84.5 km Right Bank	Bank erosion has advanced gradually every year. In case that the erosion is expanded downstream, the influence may reach the bridge located in the downstream.
	⑤ 88.5 km Right Bank	Caused by the flood in February, 2011, large-scale bank erosion arose and parts of houses were washed away.