SECTOR 3 SEDIMENT AND EROSION

INTERIM REPORT

SECTOR 3 SEDIMENT AND EROSION

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SECTOR 3. SEDIMENT AND EROSION

3.1 FEATURE OF PYANJ RIVER BASIN

3.1.1 Topology of Pyanj River Basin

The Pyanj River's basin can be classified into three discriminative zones; the upstream zone, the middle-stream zone, and the downstream zone.

1) Upstream Zone

This zone is located in the section of the east side to the line connecting from Qarakul Lake, through Sarez Lake, to Yashilkul Lake.

There are mountains higher than 5000m elevations at their summits and a number of basins, and plains ranged along the river. The elevation of bottom of valleys is around 3500m, so the relative relief (difference of the summits and bottoms) is around 1500m, which means this zone relatively flat comparing to the middle stream zone. The Widths of the basins or valleys are 4~10 km in wider length. The north side of this zone has bottom of basin or valleys where combined alluvial funs and floodplains while the south side has vast moraine.

The slopes of the mountains and combined alluvial funs areas are suggesting characteristics of semi-arid. Regardless of the higher elevation, glacier is not developed at the mountain range in this zone at present because of this characteristic. However, thick moraine suggests that glacier had developed in this zone. The ends of the moraine are found at the elevation of 3800m.

Vegetation is poor in this zone so that freeze-thaw and wet-dry repetitions promote weathering of rocks, even hard rocks, and sediment production has been in considerably high level. Found are wetland plants along the meandering river that suggests the particle side of the sediment material is fine. Alluvial terraces are not developed in the basins and floodplains that suggest the riverbed in this zone generally has an inclination to deposit.

2) Middle Stream Zone

This zone is delineated from the upstream zone to Khirmanjo where there are steep mountainous areas with higher than 6000m elevation at their summits. Highest is located at Revolyttzya with 6940 m elevation. Difference between summits and bottom of valleys is 4000 m elevation at the maximum and almost 3000 m elevation at average. The biggest glaciers are located in the Revolyttzya where Yangulom River and Vanj River are originated and length and width of glaciers are respectively 30 km and 25 km.

Slopes of the mountains in this zone are very steep and widths of the valleys are relatively narrower than the upstream area's. U-shapes are formed by glacier actions so that small valley connecting to the glacier has extreme steep slopes. There is sediment in the bottom of the U-shape valleys with mostly moraine, and debris and small alluvial corn. The small branches of the Pyanj River in this zone form the alluvial corns ranging in the mountain foot. Especially, the alluvial corns in the Pyanj River are found with fresh colored sediments that suggest that the sedimentation in this zone is on going.

The mainstream in this zone has relatively narrow riverbed with around 3 km at maximum comparing to the upstream, so that mostly floodplains are not formed in the river course. One of the tributaries, Bartang River as the major, and the most of tributaries in Afghanistan have small floodplains showing the nature of non-floodplain-valley. In those sections have small alluvial corns, debris and narrow-short floodplains in the tributaries at the conjunctions of the mainstream.

Middle part of this zone has many traces of rockslide formation and big-scale landslide. One of the biggest landslide traces is 5 km in width and 8 km in length, and 2 km in slide-body length. There is Sares Lake formed by rockslide in 1911.

There are some other rockslide-blockage lakes found from the traces of rockslides.

In this zone there are high mountains so that freeze-thaw reaction and scrape of glacier is a primal sediment production and erosion of moraines, alluvial terraces and debris is a secondary.

There are several basins to store the sediments, where traces of alluvial terraces are not found. It means that generally the riverbed in this zone has an accumulating inclination. The Sarez Lake and Yashilkul Lake has no overflowing outlet so that sediments are stored in the lakes.

3) Downstream Zone

This zone is sectioned from Khirmanjo and the Chubek Intake point at the top of the Hamadoni alluvial fan. The Pyanj River is running down through narrow valley.

This zone is laying lower than 4000 m elevation, has a little of glacier, and is characterized with existence of many traces of landslide and land-collapse, explored rock with small valleys and steep slope with thin gullies.

Afghanistan side in this zone has a topographical feature of semi-circle shape, and is left from the re-erosion of flat mountains up-thrust. Steep slopes formed by scouring of the mainstream and the tributaries are bordered to the flat areas in the top with transition array, where the land is unstable and has many traces of landslide and big-scale land-collapse suggesting on production of much sediment discharge. In addition, exposed rocks in the steep slopes has well developed gullies and small valleys suggesting weathered by freeze-thaw and wet-dry repetition to produce much sediment discharge.

The narrow channel of the mainstream, without wide floodplains development, suggests that produced sediment discharge in this zone is spread out over the Hamadoni Alluvial Fan

3.1.2 Feature of Study Area

1) Hamadoni Alluvial Fan

The Pyanj River is breaking out of the Pamir Highland to a basin surrounded by hilly terrains with 1000 to 1500m in elevation, forming an alluvial fan at Chubek, Hamadoni. The alluvial fan area is around 470 square kilometer in area, confined in fan shape, opening toward to the west in a circular arc with around 68 degree. The summit of the fan is located at nearly the Chubek Intake.

It is know that the Pyanj River runs in several branches, none of which has not drained in the territory of Tajikistan for long time; according to the residents, the river has flown in there a hundred years ago. Presently, the river is running through in two ways; one is to Afghanistan – Darkad River – and the other is along the dike in parallel to the border.

The fan changes its characteristics in 470~480 m in elevation where the towns of Pakhtakor, Davlatobod, and Metintugay are located.

The upper section from this zone has slope steeper, ranging 1 to 250 and 300 than the lower section; topographic units are small holms in fish scale shape and cancellous-wise. Therefore, the river channels have not been fixed and the river courses are unclear.

The lower section has slope ranging 1 to 300 and 600, where the main streams are fixed and the clear old rivers are traceable.

2) Floodplain of Kizilsu River

The Kizilsu River flows down from north to south along the base of mountain situated in the west of Study Area and forms floodplain with the width of 1 to 5 km as well as crescent lake and former riverbed. The gradient of floodplain is gentle with the slope of 1/2000.

3) Mountainous Area and Hillock

Aspect of mountainous area and hillock area is explained as follows:

(a) There is geological structure stretching north to south at the attitude between 1,000 and 1,400 meters in the east of the Study Area,

(b) The isolated ridge founded on halite at the North part of the Study Area with the attitude of 1,334 meters, which look like the rounded shape of hat with brim,

(c) Between (a) and (b), the general slope surface can be seen at bottom of mountain at the altitude 600 to 700 m,

(d) There is small hilly surface with thick レス around the summit of mountains with the attitude of 1,100 meters at the east and south part of the Study Area, and

(e) Generally the denuded land is few at the mountainous area, but some part at the left bank of slope of mountain at top of the fan and salt mountain has the denuded area.

4) Terrace

Terrace that has several platform of geomorphic surface is appeared in alluvial fan. Generally, the terrace is sometimes formed at tributaries in left bank of the Pyanj River.

5) Land formed by Valley

This alluvial fan is appeared in tributaries of the left bank of Pyanj River.

3.2 GEOLOGY

The study area is located at the end of mountain ranges of Pamir to form wide alluvial fan covered with loose sand-gravel layers. Along the river in the basin is covered with deposit of floodplain. The study area is belonged to the Tajik Depression Zone and the river basin of Pyanj River ranging over Pamir Highland. In the Tajik Depression Zone is spread over the deposits of Cainozoic Tertiary Era and Quaternary Era.

The depression zone has two major faults, Peter the first and Darvaz-Karakul, and is formed in hilly topography with unconsolidated conglomerate, partly with halite dome of Jurassic Era and weathered rock of Paleozoic Era. Over those rocks, loess accumulates in the north side of Pyanj River. Over the Pamir Highland is covered by rocks ranged from Palaeozoic Era to Palaeogene Era. Conceptual geological map is shown as follows;

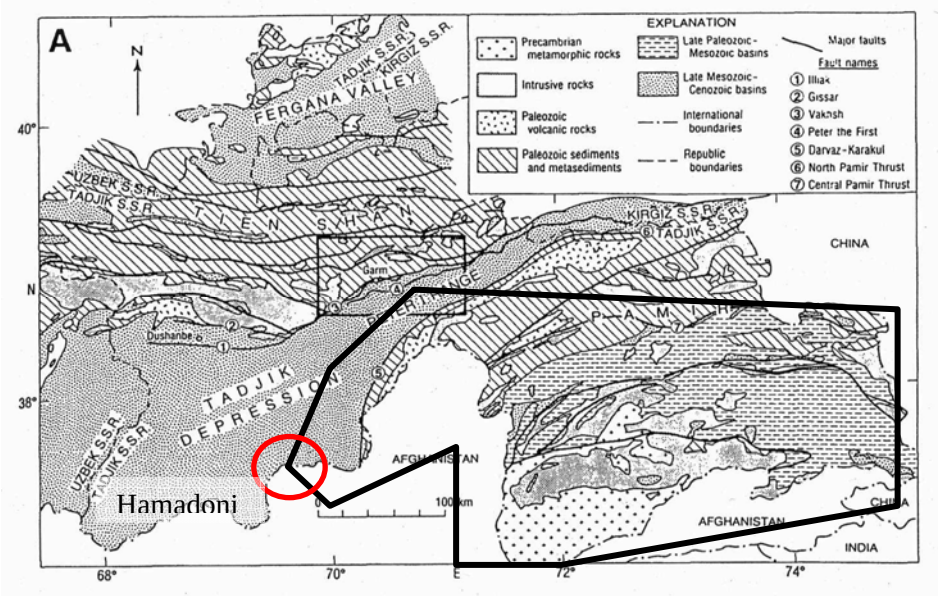


Fig. R 3.2.1 Conceptual Geological

3.3 TRANSITION OF RIVER COURSE

Comparing the satellite images taken in 1970s to 2005 suggests that the main stream of the Pyanj River in the fan area has been transited from the south to north or from Afghanistan side to Tajikistan side. The transition of the river course is described as follows;

· The images from 1972 and 82 shows that there are more than five branches running over the Afghanistan side;

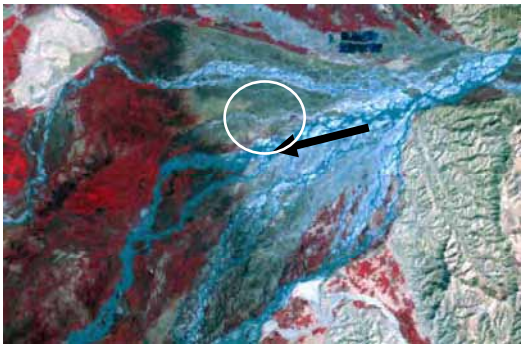
· Those images show that the mainstream has been mostly dominated by Darkad River shown with black arrows in the satellite images of 1971 to 2005.

· During this period, a wild plant-grown area has been maintained in the north of the mainstream shown with circles in the images while the plant-grown area is eroded in a part of it in the image of 1986.

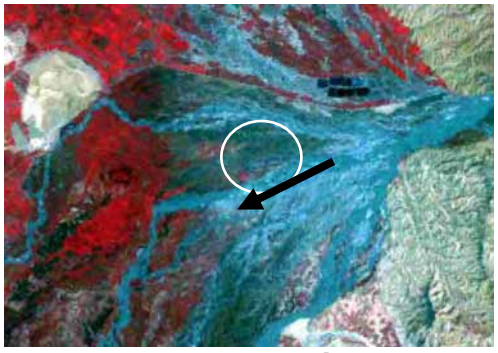
· After the image of 1995, the plant-grown area is completely disappeared remaining the trace of holms without plants.

· The mainstream is found along the Darkad River in the images from 1972 to 2005 June, which is the image taken just before the 2005 flood.

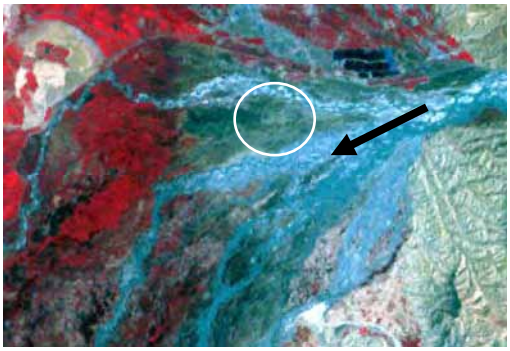
· The mainstream is found to change its trace from black arrow of June 2005, before 2005 flood, to white arrow of July 2005, after 2005 flood.



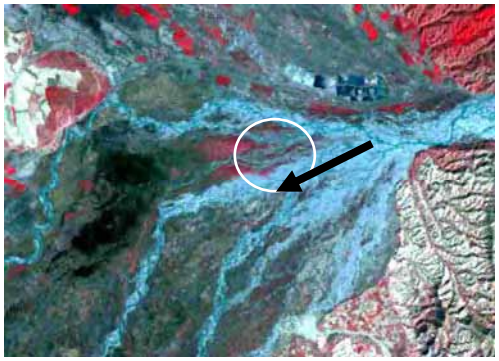
LANDSAT: Spet.10, 1972



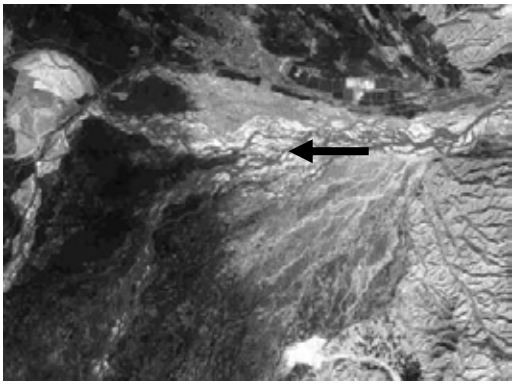
LANDSAT: Jul. 1975



LANDSAT: July 21, 1982

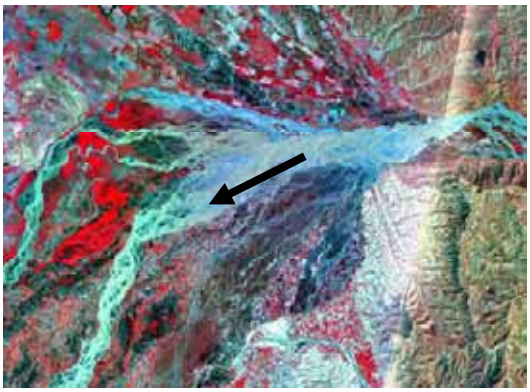


LANDSAT:Apr. 1986

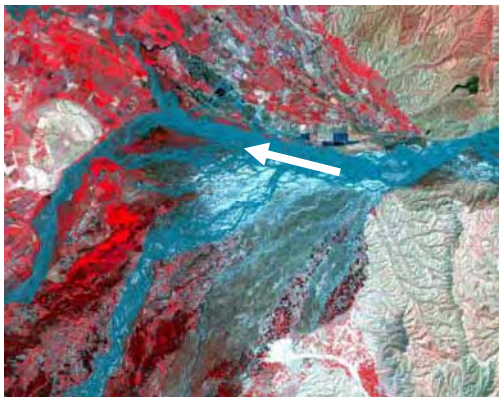


SPOT: Spet.10, 1995

LANDSAT: Oct.7, 1999



SPOT: June 17, 2005



ASTER: July 19, 2005

Fig. R 3.3.1 Transition of River course

3.4 LAND CLASSIFICATION

3.4.1 Elaboration of Land classification Map

Land classification map was elaborated about Hamadoni alluvial fan and Pyanj River Basin. The methodology of elaboration is described below.

1) Around Hamadoni Alluvial Fan

The land classification map was elaborated to identify the condition of topography and landform in the Study Area by topographic interpretation of the ASTER satellite maps that was taken in July 2005 to be utilized for stereoscope. Thus, the time of topographic interpretation is July 2005. Incidentally, for the topographic interpretation, other satellite maps (SPOT: June 2006 taken) and result of field survey was leveraged because the low resolution and difficulty of stereoscope due to small scale (1/25,000) of ASTER satellite map. Finally, the result of topographic interpretation was overlaid on the SPOT satellite map, which is recognized as the land classification map for Hamadoni Alluvial Fan.

2) Pyanj River Basin

The land classification map was elaborated to investigate the condition of dilapidation of the Pyanj River Basin by topographic interpretation of the ASTER satellite maps above mentioned to utilize for stereoscope. Incidentally, for the topographic interpretation, other satellite maps (LANDSAT: 1/200,000) were also utilized even if the resolution is low compared with ASTER because there is the lack of ASTER satellite maps at some place of the basin. Finally, the result of topographic interpretation was overlaid on the LANDSAT satellite map, which is recognized as the land classification map for Pyanj River Basin.

3.4.2 Legend of Land Classification Map

The elaborated land classification map was scanned and saved in GIS database as described in Chapter 4 in the Supporting Report. The legend of land classification map is itemized as follows:

Table R. 3.4.1 Itemization of Land Classification for Hamadoni Alluvial Fan

Main Item	Sub items
(A) Riverbed or Sedimentation Accumulated Area	A.1 Water part A.2 Sand/Gravel area A.3 Vegetation area
(B) Alluvial Fan (Upstream Part)	B.1 General surface B.2 Riverbed and flooded area until late years B.3 Relatively higher and well drained lowland B.4 Accumulated area of aged sedimentation
(C) Alluvial Fan (Downstream Part)	C.1 General surface C.2 Relatively higher and well drained lowland C.3 Relatively lower land
(D) Other Alluvial Fan	D.1 Relatively Terraced alluvial fan D.2 Alluvial fan of tributary and alluvial cone
(E) Valley Bottom Plain or Floodplain	E.1 Major tributary E.2 Relatively lower land E.3 Small tributary
(F) Former River Bed	F.1 Former river bed
(G) Piedmont Aggraded Area	G.1 Talus G.2 Piedmont general slope surface
(H) Terrace	H.1 Lower terrace H.2 Medium terrace H.3 Higher terrace
(I) Culmina or Mountainside General Slope Area	I.1 Culmina or mountainside general slope area
(J) Others	J.1 Denuded land J.2 Landslide configuration J.3 Dent J.4 Photolineament

Table R. 3.4.2 Itemization of Land Classification for Pyanj River Basin

Main Item	Sub items
(A) Slope Failure/Collapse (Large Scale)	A.1 Slope Failure A.2 Bare Land (Steep Slope) A.3 Landslide Scarp A.4 Landslide A.5 Collapse Scarp (Large Scale) A.6 Collapse Debris (Large Scale)
(B) Riverbed	B.1 Riverbed (Floor Area): Remain unchanged B.2 Riverbed (Floor Area): Trend of Expansion B.2 Riverbed (Floor Area): Contractive tendency
(C) Valley Bottom Plain/Colluvial Slope)	C.1 Floodplain/valley bottom plain/lake plain C.2 Alluvial Fan, Alluvial Cone C.3 Composite Fan/Colluvial Slope/Pediment C.4 Steep Slope Valley Bottom Deposit C.5 Talus C.6 Lower Terrace C.7 Higher Terrace
(D) Glacier/Glaciated Landform	D.1 Glacier D.2 Moraine/Other Glacial Deposit
(E) Others	E.1 Peneplain/Uplifted Erosion Surface E.2 Lake

3.5 SEDIMENT BALANCE

3.5.1 Mechanism of Sediment Balance

The sedimentation production at the small tributaries and slope surface at upper and middle Pyanj River Basin was conveyed through flood or debris flow, of which the coarse grinded materials are reserved in composite fans, alluvial cone up to middle river basin. In addition, the portion of the sedimentation which does not reserved up to middle basin might accumulate in riverbed of relatively widen valley or small flood plain. Furthermore, Lakes such as Sarez, Yashikul and Zorkul Lake are also impounding the sedimentation from upstream and the sedimentation is collected in widen part of riverbed in the main course of Pyanj River or main tributaries

As described above, the sedimentation is caught as variable way and temporarily stored at upstream and middle part of the basin. Hence, the presumable theory of transportation of sediment yield is that the sedimentation yield generated from lower part of Pyanj River Basin and conveyed from the narrow way through the Khirmanjo make a contribution to accumulation of sediment yield in Hamadoni alluvial fan.

Part of sedimentation conveyed through the narrow valley accumulates on the alluvial fan or flow past further to downstream. To confirm the balance of sedimentation, the competency of transportation of sedimentation was calculated at the top of fan and at the edge of fan. As the result of the calculation, the amount of deposit on alluvial fan can be estimated at about 5 mil. m^3 per year, all of which is equivalent to the sedimentation with the depth of two (2) to four (3) cm per year.

The process of conveyance of sedimentation from upstream to alluvial fan is described in Figure below.

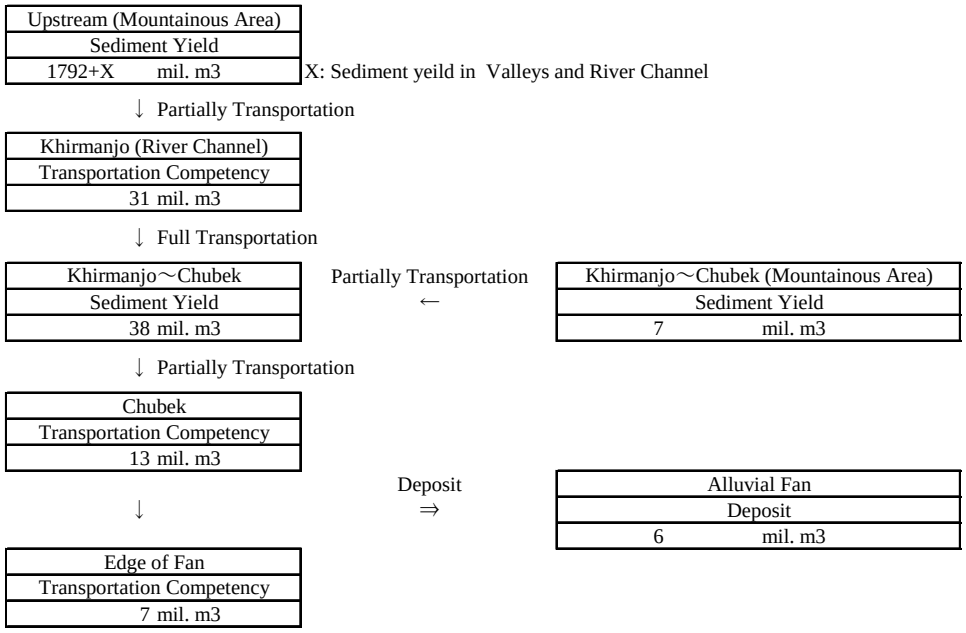


Fig. R 3.5.1 Sediment Balance of Pyanj River Basin

The explanation regarding estimation of sediment balance in Pyanj River Basin is described in Subsection 3.5.2 to 3.5.3

3.5.2 Sediment Source

There are considered three (3) type of the sediment source at the up-middle stream of Pyanj River, namely, the slope failure, the surface erosion and sediment deposit of riverbed. In this section, the amount of sediment source in the up-middle stream basin is estimated as follows:

1) Existing Unstable Sediment and Sediment Yield of Upstream Zone

The amount of unstable sediment at the basin upstream of Khirmanjo is estimated in this item.

a) Existing Unstable Sediment Yield by Slope Failure

As a result of photographic interpretation, there are 6,300 numbers of slope failures and the each single slope failure has an area of around 15,000 m^2. Total area of failures is therefore estimated at about 95 km^2. The unstable sediment by slope failures (V_{sf}) is calculated multiplying area of slope failure (A_{sf}) by depth of that (D_{sf}). Incidentally, the depth of failure was decided in reference to relationship between failure depth and that area, which was examined in Republic of China through JICA Study as follows:

Table R. 3.5.1 Depth of Slope Failure in accordance with Area

Area per One Slope Failure (m^2)	Less than 500	1,000	5,000	10,000	20,000	More than 60,000
Depth of Slope Failure (m)	3	5	10	15	20	35

In addition, the 85 % of sediment yield from slope failure is also determined in the JICA Study. Therefore, on assumption that there is a number of comparable size of slope failures, the unstable sediment of slope failures (V_{sf}) can be estimated as follows:

$$\sum_{n=1}^{N} V_{sf} = \sum_{n=1}^{N} (A_{sf} \times D_{sf}) \fallingdotseq \overline{A_{sf}} \times \overline{D_{sf}} \times N = 15{,}000 m^2 \times 17.5 m \times 6{,}300 \fallingdotseq 1{,}650 \times 10^6 m^3$$

$$1{,}650 \times 10^6 m^3 \times 0.85 = 1{,}402 \times 10^6 m^3 \text{ (Bed Load)}$$

b) Sediment Yield from Surface Erosion

Sediment yield from surface erosion should be estimated by land classification specifications of which are different respectively.

i) Specific Sediment Yield

Specific sediment yield from surface erosion corresponding to land classification is set as Table R.3.5.2, which was defined considering Chinese and Japanese experimental result in JICA study.

Table R. 3.5.2 Specific Sediment Yield from Surface Erosion

No.	Category	Land Classification	Specific Sediment Yield (m^3/ Year/ km^2)	
			Total	Bed Load
1	A	Slope Failure	252	214
2	B	Cultivated Area	1,195	418
3	C	Grassland/Wasteland	761	457
4	D	Shrub Area	67	24
5	E	Arbor Area	3	1

ii) Sediment Yield per Year

Land classification of Pyanj River basin at the upstream of Khirmanjo is analyzed by satellite map analysis (as to details refer to “Satellite Image Analysis”, Supporting Report). Using the land classification result and specific sediment

descried in previous section, the sediment yield by land classification is calculated multiplying each classified area and specific sediment yield and summarized in Table 3.5.3.

Table R. 3.5.3 Sediment Yield by Land Classification

No.	Classification	Area (km^2)	Category	Sediment Yield (m^3/Year)
1	Build-Up Area	5.1	-	
2	Irrigated Agricultural Area	692,2	B	280,287
3	Rainfed Agricultural Area (on Flat land)	178.1	B	3,517
4	Rainfed Agricultural Area (on Sloppy Land)	2,743.1	B	276,450
5	Mixed Rainfed Agri. (on Sloppy land) & Grassland	15,023.4	B	2,183,944
6	Grassland/Shrub land	39,926.9	C	16,831,581
7	Marshland	35.7	C	12,187
8	Snow & Cloud	26,448.5	C	11,321,985
9	Slope Failure	5,250.0	A	20,242
Total				30,930,194

c) Deposit of Riverbed

Deposit of riverbed cannot be estimated without cross-sectional or longitudinal profile information in plural age. Unfortunately, that information at upstream Pyanj River does not exist as far as the Study Team tries to find through the CoES. However, as described in section 3.1.1, there is obviously huge sediment deposit in main river of Pyanj and tributaries on the ground of photographic interpretation in this study.

2) Existing Unstable Sediment and Sediment Yield of Middle Stream Zone

The Middle stream zone, where many slope failures can be discovered in satellite map, is the basin situated between Khirmanjo and Chubek. The land classification of Middle stream zone is shown as Fig. R.3.5.2.

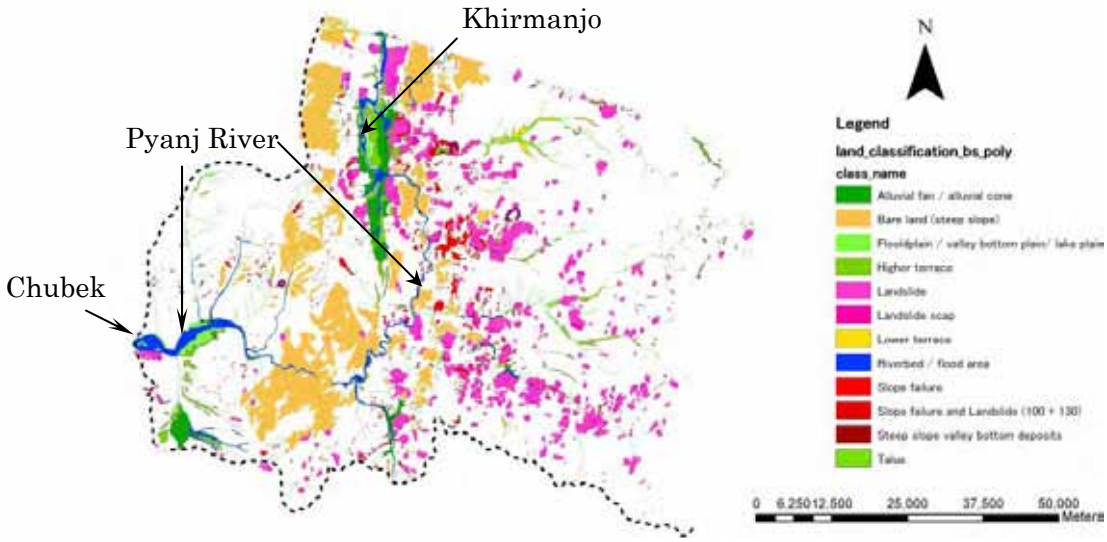


Fig. R 3.5.2 Land Classification of Middle Stream Zone

a) Existing Unstable Sediment by Slope Failure

As a result of photographic interpretation, there are of slope failures with the area of 79 km^2. Thus, the amount of existing unstable sedimentation can be estimated at 1,385 m^3 of which 1,177m^3 is defined as bed load sediment.

b) Sediment Yield from Surface Erosion

The sediment yield by land classification is calculated multiplying each classified area and specific sediment yield and summarized in Table 3.5.4 as explained item 1).

Table R. 3.5.4 Sediment Yield by Land Classification

No.	Classification	Area (km^2)	Sediment Yield (m^3/Year)
1	Build-Up Area	0	0
2	Irrigated Agricultural Area	22	9,218
3	Rainfed Agricultural Area (on Flat land)	170	70,983
4	Rainfed Agricultural Area (on Sloppy Land)	2,082	870,840
5	Mixed Rainfed Agri. (on Sloppy land) & Grassland	9,802	4,099,587
6	Grassland/Shrub land	3,064	1,399,055
7	Marshland	9	4,094
8	Snow & Cloud	1,652	754,395
9	Slope Failure	79	16,888
Total		-	7,225,060

3.5.3 Sediment Transportation Competency

1) Method and Condition for Calculation of Competency

The sediment transportation competency at points listed below should be computed to estimate the sediment balance in Hamadoni alluvial fan.

- Khirmanjo hydrological observatory
- Top of Alluvial Fan (around Chubek intake weir)
- Edge of Alluvial Fan

The competency was computed in accordance with ATM (Ashida, Takahashi and Mizuyama) formula under the hydraulic condition described below. The ATM formula is appropriate method for calculation for sediment transportation in steep slope river.

Table R. 3.5.5 Condition for Calculation of Transportation Competency

No.	Item	Place		
		Khirmanjo	Top of Fan	Edge of Fan
1	River Width	150 m	1,000 m	2,000 m
2	River Slope	1/200	1/320	1/400
3	Manning's Roughness Coefficient	0.040	0.035	0.030
4	Regime Ratio	1.0	1.0	1.0

2) Computing Result

The sediment transportation competency of Khirmanjo, the top of fan, the edge of fan is calculated at relatively, 31, 13, 7 mil. m^3/year.

3.5.4 Sediment Movement of Alluvial Fan

From the result achieved up to Subsection, the explanatory diagram for transportation of sediment is described as shown in Fig .3.5.1. According to the figure, the deference of sedimentation between the inflow at Chubek and the outflow at the edge of fan is 6 mil. m^3 per year, i.e., the deposit of sedimentation would be accumulated on alluvial fan with 2, 3 cm per year.

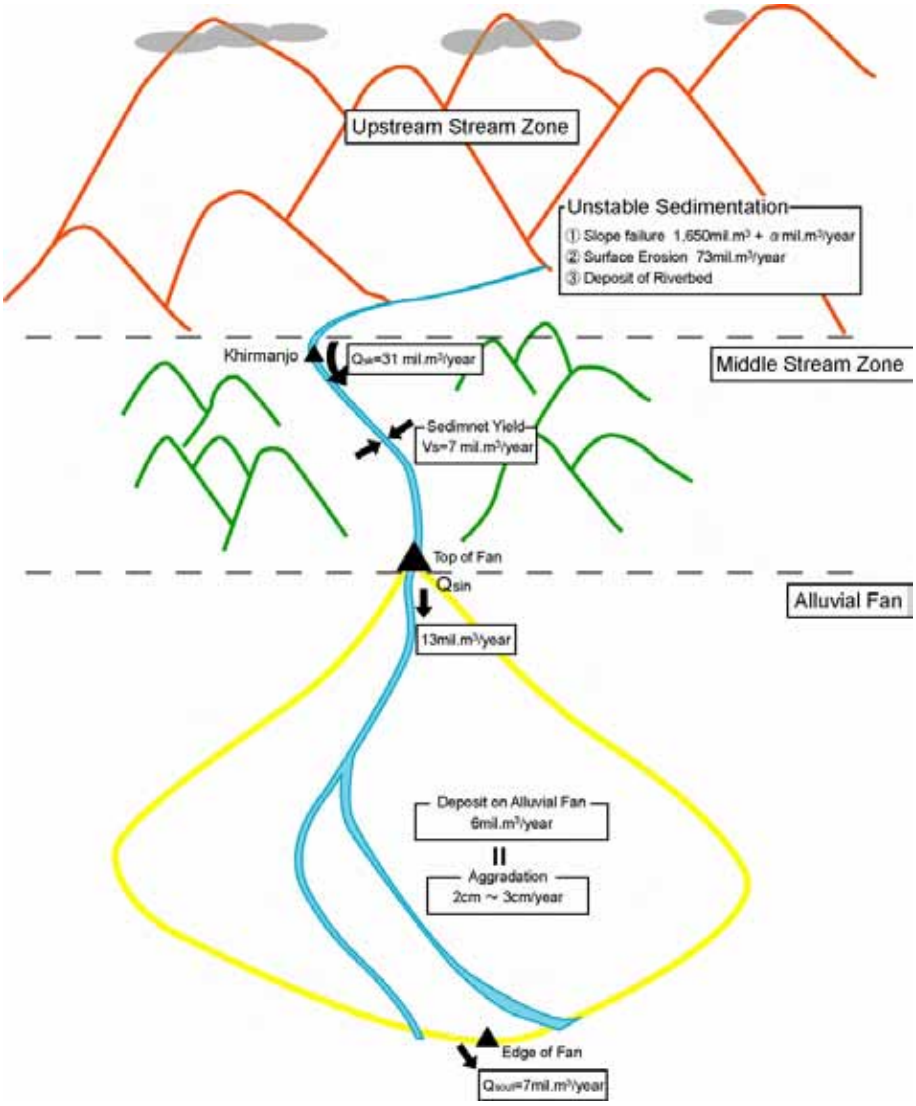


Fig. R 3.5.3 Sediment Balance of Alluvial Fan

SECTOR 4 SATELLITE IMAGE ANALYSIS

SUPPORTING REPORT

SECTOR 4 SATELLITE IMAGE ANALYSIS

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SECTOR 4. SATELLITE IMAGE ANALYSIS

4.1 SELECTED SATELLITE IMAGES

4.1.1 Remote Sensing Technology

Satellite provides Images of areas relatively in a faster and cost-efficient manner, and attempts to demonstrate the real time phenomenon, that is, "what is happening right now". This is the prime advantage over air photos and fieldwork, which take great deal of both cost and time to carry out and sometimes making not feasible for the study. Satellite and digital imagery acquired these days, provide more overall detail to assist in extracting the required spatial information. Moreover, if available in the archive, the satellite data provides opportunity to look at the condition of features in the past (as back as 1973 when the 1st satellite was launched). This multi-temporal data facilitates to analyze the successive change over the longer period.

Considering these points, Satellite Images were decided to be used for this Project, which was to be completed in about one year.

4.1.2 Satellite Images Selected for this Project

The extensive search was made both through Internet and through the providing agencies for getting suitable Satellite Images for this Project. And, out the available list, the Images were selected based on mainly following two criteria:

1) Acquisition Date of Satellite Image

The satellite data had to be used for various purposes such as; analysis of River Course Change (during Rising Water Period and Decreasing Water Period), extraction of Land Use/Land Cover, Landform, Landslide area, and others. Thus, due consideration was given to the acquisition date of the available Satellite Images in order judge their usefulness for the Project work.

2) Cloud Cover

As far as possible, Satellite Images with no or minimum cloud were selected for this Project.

The Satellite Images acquired from Landsat (MSS, TM, and ETM+ sensors), SPOT (Pansharpened Color and Panchromatic), and ASTER satellites were used in this Project. Also, the used Digital Elevation Model (DEM) data are those derived from these Satellite Images.

An area of 1,600km^2 (40km * 40km) covering the Alluvial Fan area of Hamadoni district and part of Afghanistan was designated as The Pilot area. This is the main vulnerable area for flooding. The Satellite Images and DEM data used covering the Pilot area are listed in Table R 4.1.1. Most of these Image scenes have very less cloud cover (less than 10% of total scene area).

Table R 4.1.1 Selected Satellite Images Covering the Pilot Area

Work Item	Satellite Images/DEM Data	Number of Scenes / Km^2	Satellite Image Acquisition Date	Representing Season	
				Rising Water Period	Decreasing Water Period
For River Course Analysis and Land Use Extraction	Landsat（MSS)	1 scene	1972/9/10	○	
	Landsat（MSS)	1 scene	1975/7/13	○	
	Landsat （MSS)	1 scene	1979/2/16		○
	Landsat（MSS)	1 scene	1980/6/7	○	
	Landsat （MSS)	1 scene	1981/12/17		○
	Landsat（MSS)	1 scene	1982/7/21	○	
	Landsat （MSS)	1 scene	1986/4/2		○
	SPOT	1 scene	1995/9/28		
	Landsat (TM)	1 scene	1999/1/16		○
	Landsat (ETM+)	1 scene	1999/10/7	○	
	Landsat (ETM+)	1 scene	2002/8/28	○	
	Landsat (ETM+)	1 scene	2003/1/3		○
	ASTER	2 scenes	2005/7/19	◯	
For Geographic features and Land Use Extraction	SPOT (Pansharpened Color)	2 scenes	2005/6/17 (Left) & 2005/7/7 (Right)	◯	
	SPOT DEM Data	1600 Km^2	DEM prepared from SPOT HRS Pairs of dated February to September 2003		

The Pansharpened Color Image of SPOT Satellite was also used for Land Use Extraction. Similarly, covering the Pyanj Basin, two types of satellite data were used; Landsat (MSS) and ASTER. The lists of these two Satellite Images are presented in the Table R 4.1.2 and Table R 4.1.3 and their locational coverage is presented in Fig. R 4.1.1 and Fig. R 4.1.2. The ASTER Satellite data could not found covering whole Pyanj Basin and thus, these Images cover only for part of Basin area.

Table R 4.1.2 Selected Landsat (MSS) Satellite Images Covering the Pyanj Basin Area

S. N.	Scene ID	Acquisition Date	Path	Row	Image Cloud Cover (%)
1	1163034007319390	1973/07/12	163	034	< 10
2	1162034007225290	1972/09/08	162	034	< 20
3	1162033007227090	1972/09/26	162	033	< 10
4	2163033007512090	1975/04/30	163	033	< 20
5	1164033007225490	1972/09/10	164	033	< 20
6	1163035007319390	1973/07/12	163	035	< 20
7	1163035007319390	1973/07/12	163	035	< 20
8	1161033007225190	1972/09/07	161	033	< 20
9	1161034007225190	1972/09/07	161	034	< 30

Table R 4.1.3 Selected ASTER Satellite Images Covering the Pyanj Basin Area

SN	File code	Scene ID	Acquisition Date	Scene Center Latitude	Scene Center Longitude	Scene Cloud Cover (%)
1	002	ASTL1A 0507190616350507240062	2005/7/19	37.343300	69.431999	0
2	001	ASTL1A 0507190616260507240061	2005/7/20	37.872799	69.590500	0
3	043	ASTL1A 0509210615530509240507	2005/9/21	38.214699	70.990601	19
4	042	ASTL1A 0509140610070509180224	2005/9/14	36.917198	70.092697	0
5	041	ASTL1A 0509140609580509180223	2005/9/14	37.447601	70.244003	0
6	039	ASTL1A 0509140609490509180222	2005/9/14	37.977901	70.396896	5
7	038	ASTL1A 0509140609400509180221	2005/9/14	38.507999	70.551300	5
8	037	ASTL1A 0509140609320509180220	2005/9/14	39.037998	70.707397	12
9	036	ASTL1A 0509090551300509130006	2005/9/9	37.504299	74.465500	20
10	035	ASTL1A 0509090551220509130005	2005/9/9	38.034901	74.615402	12
11	034	ASTL1A 0508220603470508250174	2005/8/22	38.341599	73.252197	19
12	033	ASTL1A 0508220603380508250173	2005/8/22	38.870201	73.417099	16
13	032	ASTL1A 0507190616440507240063	2005/7/19	36.813702	69.275200	0
14	025	ASTL1A 0407250611010408110506	2004/7/25	36.232201	71.015701	11
15	031	ASTL1A 0410040616150410150413	2004/10/4	37.704800	70.707001	17
16	029	ASTL1A 0409110610300409230269	2004/9/11	36.763500	71.161797	9
17	028	ASTL1A 0409110610220409230268	2004/9/11	37.292801	71.321098	8
18	027	ASTL1A 0409110610130409230267	2004/9/11	37.821899	71.482201	13
19	026	ASTL1A 0409110610040409230266	2004/9/11	38.350800	71.644997	12
20	024	ASTL1A 0406300616540407250136	2004/6/30	37.164299	70.618500	0
21	023	ASTL1A 0309110557380309280321	2003/9/11	38.381199	74.529800	14
22	022	ASTL1A 0308170604140309081192	2003/8/17	36.743099	72.844101	14
23	021	ASTL1A 0308170604050309081191	2003/8/17	37.272202	73.003899	8
24	019	ASTL1A 0308170603560309081190	2003/8/17	37.801300	73.165398	7
25	018	ASTL1A 0307250557520308080170	2003/7/25	36.910099	73.235497	13
26	017	ASTL1A 0307250557440308080169	2003/7/25	37.440498	73.386597	4
27	016	ASTL1A 0307250557350308080168	2003/7/25	37.970798	73.539299	1
28	015	ASTL1A 0307250557260308080167	2003/7/25	38.500900	73.693497	2
29	014	ASTL1A 0303170611510304290492	2003/3/17	36.977501	69.652199	0
30	013	ASTL1A 0303170611420304290491	2003/3/17	37.508301	69.800697	0
31	011	ASTL1A 0008310626110301030420	2000/8/31	36.666500	71.803398	10
32	012	ASTL1A 0209220612270210150795	2002/9/22	37.173698	72.103401	14

Note: "File code" *is the code number as mentioned in the originally purchased Image file.*

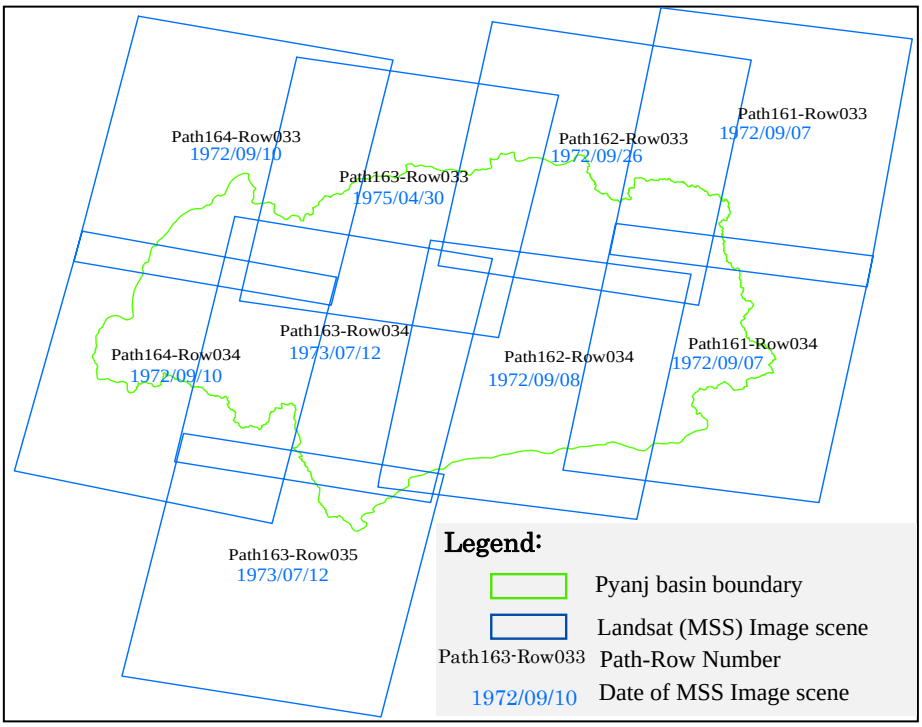


Fig. R 4.1.1 Location of Landsat (MSS) Satellite Image Scenes in the Pyanj Basin

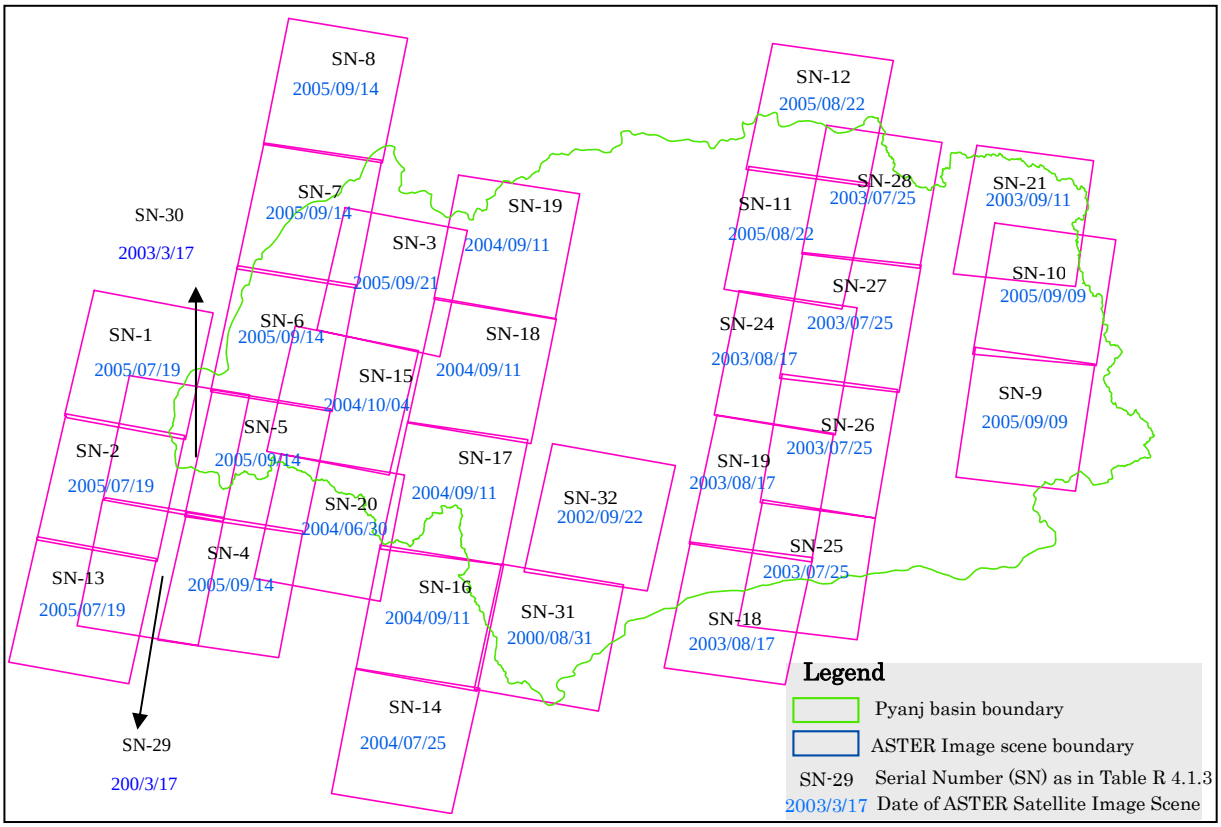


Fig. R 4.1.2 Location of ASTER Satellite Image Scenes in the Pyanj Basin

4.1.3 Brief Description of Used Satellite Images / DEM

1) SPOT Image

After launched in 1986, SPOT (Système Pour l'Observation de la Terre) satellite has been providing continuous Images (revisit cycle, meaning the satellite flies over the same points on the ground, is 26 days). SPOT5 is the latest series of SPOT satellite put into orbit. The used two types of SPOT Satellite Images are Pansharpened color Image of SPOT5 with spatial resolution 2.5m, and Panchromatic Image of SPOT4 with 10m spatial resolution.

2) ASTER Image

The ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) satellite is an advanced multispectral imager (launched in 1999, revisit cycle 16 days) that covers a wide spectral region with 14 bands; three VNIR (Visible and Near Infrared Radiometer) bands with a spatial resolution of 15m, six SWIR (Short Wave Infrared Radiometer) bands with a spatial resolution of 30m and five TIR (Thermal Infrared Radiometer) bands with a spatial resolution of 90m. In addition, one more telescope is used to see backward in the near infrared spectral band (band 3B) to give the stereoscopic capability.

Out of these, VNIR band Images and band 3B have been used for the Project works. The Images were purchased as ortho-rectified, which also had DEM included.

3) Landsat Image

With the first launched in 1972, Landsat has the latest Landsat7 of its series in the orbit. Up to Landsat5 both sensors MSS (Multi Spectral Scanner) and TM (Thematic Mapper) have been included while Landsat7 has only ETM+ (Enhanced Thematic Mapper plus) sensor. MSS has 4 bands data in VNIR (resolution of 80m), and TM has 7 bands; 4 in VNIR, 2 in SWIR, 1 in TIR (resolution of 30m for VNIR & SWIR and 120m for TIR), and ETM+ has all bands of TM plus a Panchromatic band (resolution 15m). Revisit cycle up to Landsat3 is 18days and that of Landsat4 to Landsat7 is 16 days.

4) SPOT DEM

SPOT DEMs are produced by automatic correlation of stereopairs acquired by HRS (High Resolution Stereoscopic) imaging instrument flown on SPOT5 satellite. This instrument provides simultaneous stereopairs in panchromatic (black and white) mode with a spatial resolution of 10m and a telescope viewing angle of ± 20°.

The used SPOT DEM data covering the Pilot area has been prepared from the HRS stereopair Images of various dates from February to September 2003. Horizontal and vertical projection system of DEM data is UTM WGS84 and EGM96, respectively. Its accuracy description is as follows:

- Absolute planimetric accuracy;

Circular error with respect to WGS84 (confidence level 90%)……..15m to 30m

- Absolute elevation accuracy:

Linear error with respect to EGM96 (confidence level 90%)

flat or rolling terrain (slope <= 20%)…….10m to 20m

The above mentioned accuracy specifications are valid for a full square degree (1° X 1°).

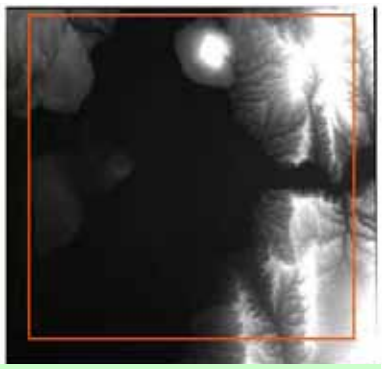
4.2 SATELLITE IMAGE ANALYSIS

4.2.1 General

Using the Erdas Imagine Software, the above Satellite Images and DEM data were processed for geo-referencing, color balancing, mosaicking, and then clipping into map sheet. The nature of used various satellite data being different, the processing was carried out as per requirement.

4.2.2 DEM Data Analysis

The SPOT DEM data was directly used for the ortho-rectification of SPOT satellite data. All the 32 scenes of ASTER DEM data were mosaicked into one (Fig. R 4.2.1). The height information from these DEM data was used for flood and other analysis.



SPOT DEM covering Pilot Area

ASTER DEM Covering Part of Pyanj Basin

Fig. R 4.2.1 SPOT DEM and ASTER DEM

4.2.3 SPOT Image Analysis

The SPOT Satellite Images, having wider viewing angles, were orthorectified to make their use more accurately. For this, first the Ground Control Points (GCPs) were collected by conducting the field survey. Then, using these GCPs and SPOT DEM, all the SPOT Images (two scenes of 2005 and one scene of 1995) were ortho-rectified. The two scenes of 2005 (Left and Right) were mosaicked into one. The Pansharpened color SPOT Image covering the Pilot area is presented in Fig. R 4.2.2.

4.2.4 ASTER Image Analysis

Although the purchased ASTER Images were ortho-rectified, little bit distortion was still present at the edge of the scenes, which was corrected resulting well edge matched with the adjacent Image scenes. After that, all 32 ASTER Image scenes were mosaicked into one and then clipped into map sheets (Fig. R 4.2.3).

4.2.5 Landsat Image Analysis

With the help of ortho-rectified SPOT Satellite Image of 2005, all the Landsat Images (MSS, TM and ETM+) covering the Pilot area were geo-referenced.

Similarly all the Landsat (MSS) Images covering the whole Pyanj Basin were geo-referenced using the coordinates from ASTER Image. All the nine MSS scenes were mosaicked and then clipped into 18 map sheets. The Landsat (MSS) Image covering the whole Pyanj Basin is presented in Fig. R 4.2.3.

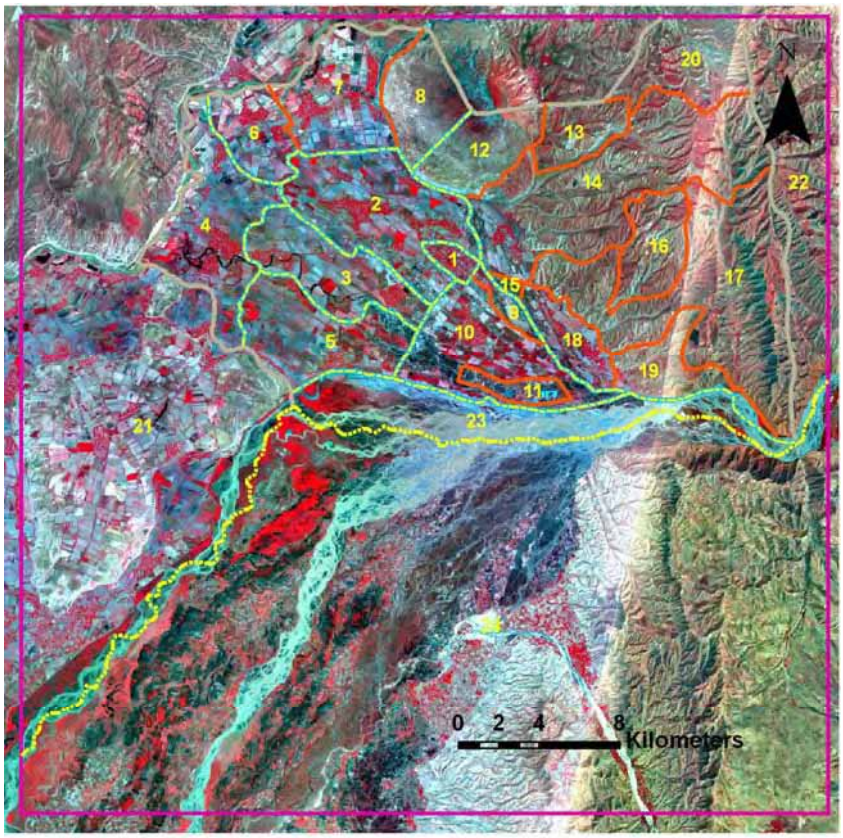


Fig. R 4.2.2 SPOT Satellite Image (Pansharpened Color) Covering the Pilot Area

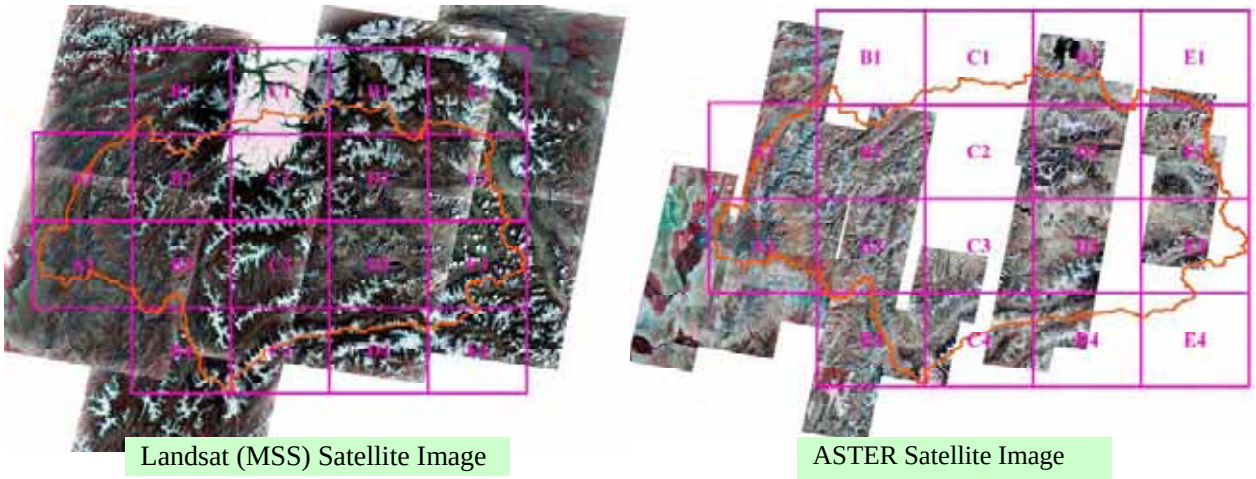


Fig. R 4.2.3 Landsat (MSS) and ASTER Satellite Image Covering the Pyanj Basin Area.

4.2.6 Projection System

The same Projection System was maintained for all the processed Satellite Images as well as DEM data, which is as follows:

Projection:	UTM
Spheroid:	WGS84
Datum:	WGS84
UTM Zone:	42
Unit:	Meters

The data from this Projection System can be smoothly converted to other designated Projection System.

4.3 PREPARATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

4.3.1 Preparation of GIS Data for Pilot Area

List of prepared various GIS data covering the Pilot area is presented in Table R 4.3.1. The Data layers such as Contour, River and Canal network, Road and Railway, and one time series Land use were extracted from latest Pansharpened SPOT Satellite Image (2005), which has spatial resolution 2.5m. Thus, the extracted information was relatively in detail.

Table R 4.3.1 List of GIS Data Prepared Covering the Pilot Area

S.N.	Name of GIS Data Layer	Used Source Data	Contents of Work	Applicable Analysis
1	Land Use	SPOT & Landsat (MSS)	Land use prepared from two date satellite data (1975 MSS & 2005 SPOT). With 12 categories (Delineated at the scale of 1:50,000)	for Runoff analysis
2	Contour	SPOT DEM	Delineated with Principal contour: 100m interval; Intermediate contour: 20m interval; Supplementary contour: 10m interval (as in 1:50,000 TOPO maps)	for displaying and analysis
3	Road and Railroad	SPOT 2005	Delineated at scale of 1:50,000.	for analysing their distribution
4	River and Canal	SPOT 2005	Delineated at scale of 1:50,000.	for analysing their distribution
5	Administration Boundary	Existing Maps	With boundary code for National, District, Jamoat, and Lower level of Jamoat. Also for each Administrative units code was assigned.	for Jamoat wise Land Use analysis
6	River Course change and Sand Dune variation	ASTER and Landsat (MSS)	Interpreted information (1:100,000) of all 14-time series data (from 1972 to 2005) was digitalized to Raster format and geocoded. Out of these, information of 3 dates (25th Sep 1982, 1995, and 19th July 2005), was converted to Vector format.	River change, flood analysis, and others.
7	Landform Classification	ASTER	Interpreted information (1:100,000) was digitalized to Raster format.	Runoff analysis, outflow earth-and-sand analysis

1) Land Use

To analyze the Land Use/Land Cover change over the period of time, two-time series Satellite Images were used. Moreover, to keep the wider gap between the first and second time of land use, the Landsat (MSS) Satellite Image of 2nd September 1975 and SPOT Satellite Image of June-July 2005 were used for this purpose, making the time difference of 30 years. These two Satellite Images were free from Cloud or Snow.

Out of these two Images, the Pansharpened color SPOT, having the higher spatial resolution (2.5m), was first analysed to extract the land use information. For this, at first, field survey was conducted whereupon the color in the SPOT Image was compared with the current land use pattern. Also, the existing Topographic map (1:100,000 scale) was used during the survey. Thus, after becoming familiar with the land use pattern in the Project area, the Interpretation key for the land use categories was established; refer to Fig. R 4.3.1 below:

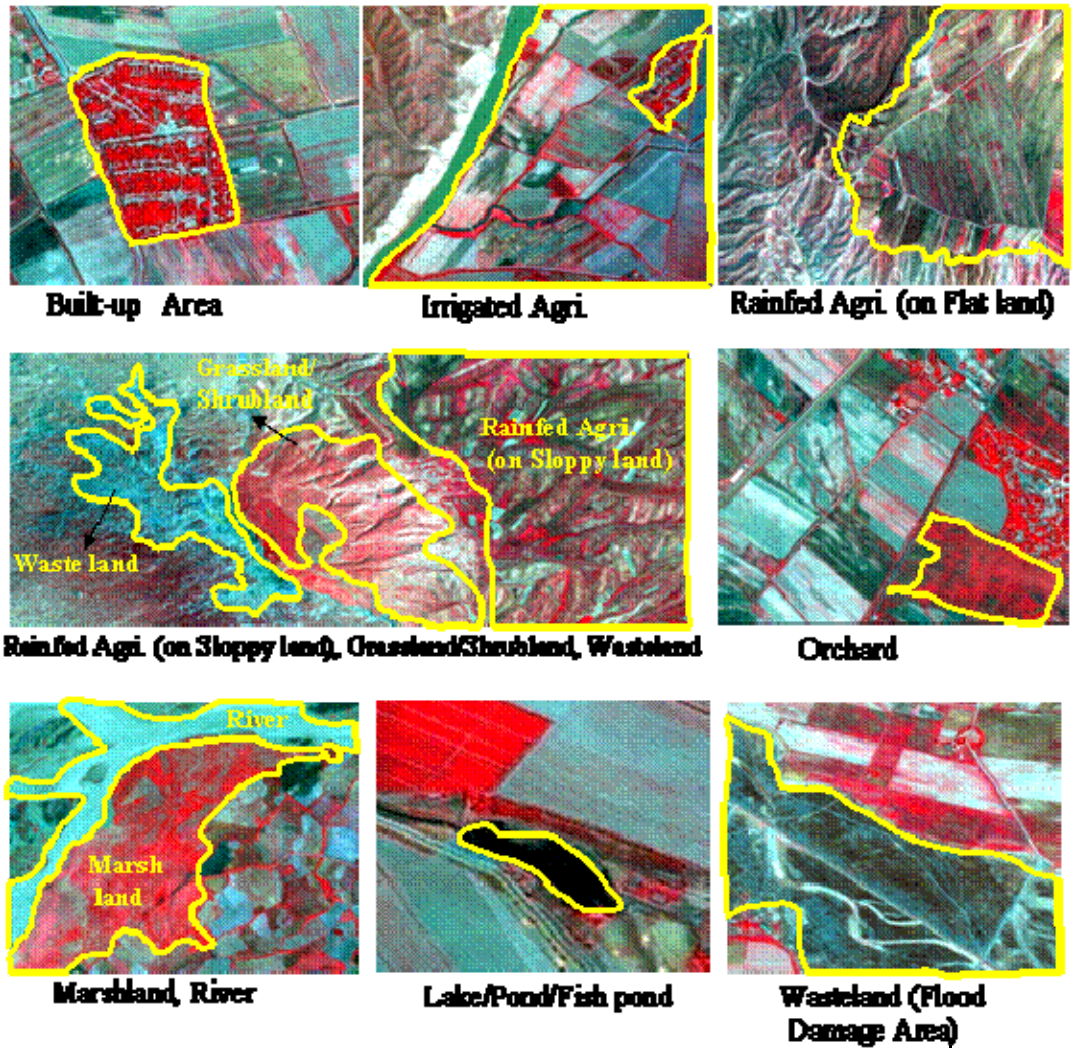


Fig. R 3.1 Interpretation Keys for Various Land Use Categories in the Pilot Area

All of the above-presented samples of SPOT Image are with the combination3, 2, 1 as Red, Green Blue. The Built-up area, for instance, could be clearly recognized as a mix pattern of grey and Red (resulted from building and vegetation around, respectively) and had clear demarcation of roads and streets as light grey line. Similarly, the irrigated agricultural land had regular lines of its bunds/channels and roads. In the mountain area, agriculture land was

found mixed with grassland. Thus, such area was categorized as “Mixed Rainfed Agriculture and Grassland”.

The screen digitization method was used to delineate the boundary and each polygon was assigned with code and category name. Same land use categories were kept for the both time data (1975 and 2005); however, some of the categories could not be found in the 1975 data. The included land use categories along with their area are presented in Table R 4.3.2. Furthermore, the table indicates that over the last thirty years, there is significant decrease in grassland and more area has been brought under cultivation.

Table R 4.3.2 Area of Various Land Use Types in 1975 and 2005

Land Use Code	LU Class Name	Area in 1975 (Km^2)	Area in 2005 (Km^2)
1	Built-up Area	44.53	61.10
2	Irrigated Agri.	465.35	529.80
3	Rainfed Agri. (on Flat land)	146.14	78.72
4	Rainfed Agri. (on Sloppy land)	52.71	80.38
5	Mixed Rainfed Agri (on Sloppy land) & Grassland	233.58	316.70
6	Grassland	332.37	222.83
7	Orchard	0.00	0.68
8	Marshland	153.26	158.90
9	River	144.39	120.26
10	Lake/Pond/Fish pond	1.75	0.78
11	Wasteland	8.81	12.34
12	Wasteland (Flood Damage Area)	17.11	17.50
Total Area		**1,600.00**	**1,600.00**

The distribution of land use types in 2005 is presented in Fig. R 4.3.2.

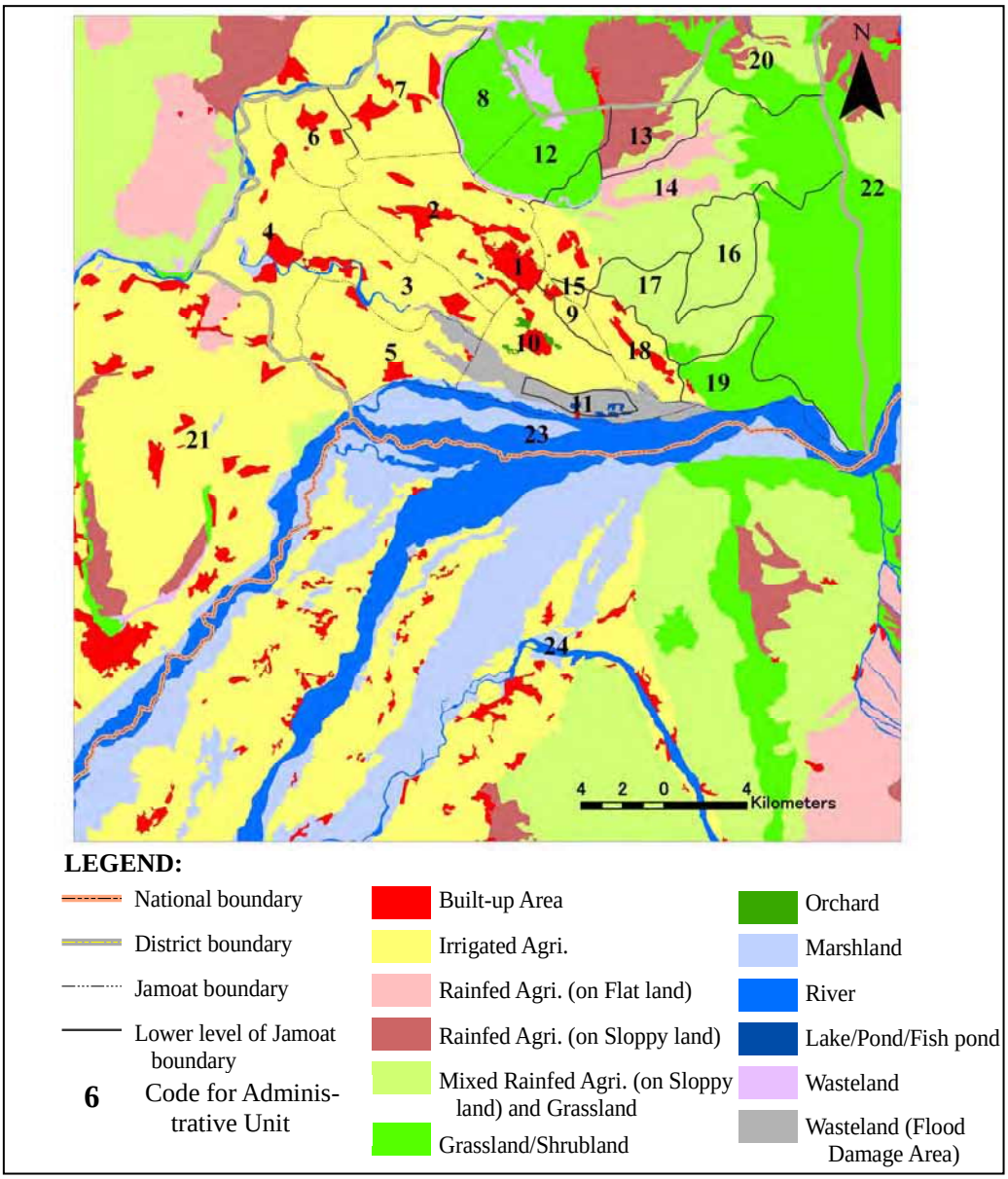


Fig. R 4.3.2 Land Use in the Pilot Area (in 2005)

2) River Course Change and Sand Dune Variation

All the 14-time series interpreted data of River Course Change and Sand Dune Variation were rasterized and geocoded. Thus, these can be overlaid with other GIS or Satellite Image whenever needed. And, out of these 14-time series data, the information of three dates (25th Sep 1982, 1995, and 19th July 2005 was vectorized to prepare GIS data. The classes of these datasets are presented below:

- River Course Change:

Code	*Class name*
1.	Water course
2.	Riverbed / flooded area
3.	Riverbed / flooded area (covered by vegetation)

- Sand Dune Variation:

Code	*Class Name*
4.	Boundary not changed (compared with previous date)

5. Boundary changed (compared with previous date)
6. Boundary of big scale sedimentation

3) Landform Classification

The interpreted information of landform classes was digitalized to Raster format and geocoded. Thus, it can be overlaid with other GIS or Satellite data. The included classes are presented in table R 4.3.3

Table R 4.3.3 Categories of Landform Classification data

Main category	Symbol	Category name
Riverbed / floooded area	1	Water surface
	2	Riverbed / flooded area
	3	Riverbed / flooded area (covered by vegetatior
Upper alluvial fan (Pyanj River)	f_1	Upper alluvial fan
	f_{11}	Riverbed and flooded area until late years
	f_{12}	Relatively higher and well drained lowland
	f_{13}	Accumulated area of aged sedimentation
Lower alluvial fan (Pyanj River)	f_2	Lower alluvial fan
	f_{21}	Relatively lower land
	f_{22}	Relatively higher and well drained lowland
Alluvial fan / alluvial cone (tribuaries	f_3	Dissected fan
	f_4	Alluvial fan / alluvial cone (tributaries)
Floodplain / valley bottom plain	A1	Floodplain (Kizilus River)
	A2	Relatively lower land
	A3	Valley bottom plain (tributaries)
Old river course	O	Old river course
Colluvial slope	D	Talus
	G	Colluvial slope
Terrace	T_1	Lower terrace
	T_2	Middle terrace
	T_3	Upper terrace
Loess topography /uplifted erosion surface	P	Loess topography / uplifted erosion surface
		Slope failure
		Landslide
		Sinkhole
		Photo lineament

4.3.2 Preparation of GIS Data for Pyanj Basin

The list of included various GIS data layers covering the Pyanj Basin area is presented in the Table R 4.3.4. The national boundary of Tajikistan was delineated from the existing 1:100,000 Topographic maps. And, for this, all the existing 1:100,000 Topographic maps were first geocoded. The GIS layers such as Land Use, River network, Sub-basin boundaries, and Land Classification were delineated at the scale of 1:200,000. The lines of the river network were then adjusted using the 1:100,000 Topographic maps. Such adjustment was also made for sub-basin boundaries that were along the national boundary.

Table R 4.3.4 List of GIS Data Prepared Covering the Pyanj Basin

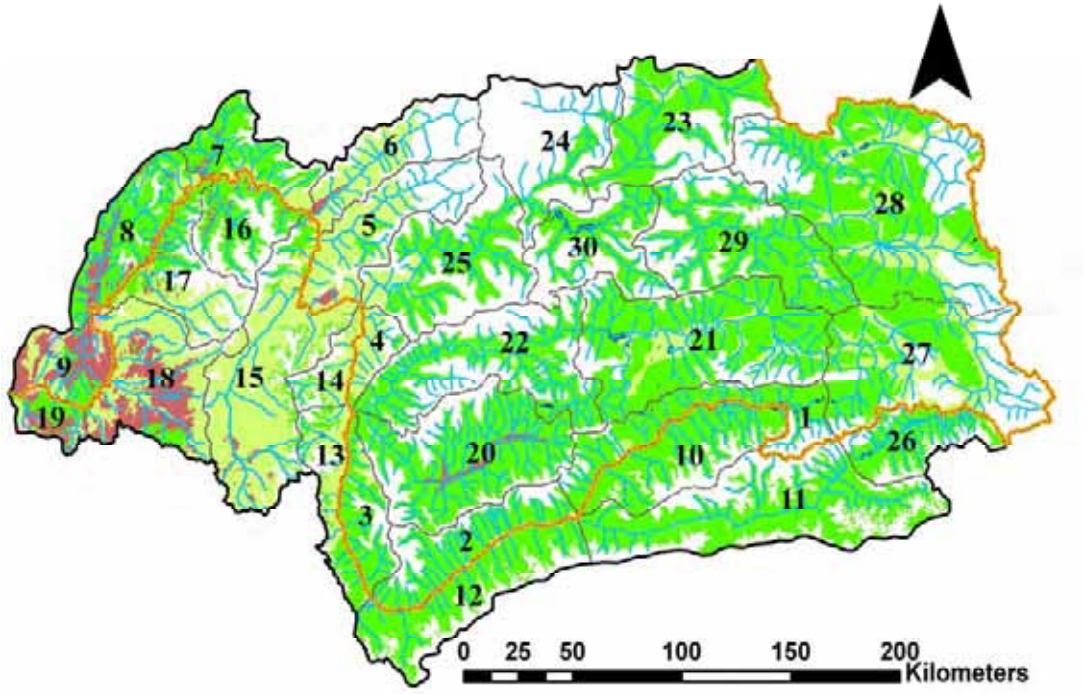
S.N.	Name of GIS Data Layer	Used Source Data	Contents of Work	Applicable Analysis
1	Land Use	ASTER and Landsat (MSS)	Latest Land use prepared covering whole watershed (at scale 1:200,000) with categories are similar to that in Pilot Area.	for Runoff analysis
2	National Boundary	Existing 1:100,000 Topographic maps	National boundary of Tajikistan located within the Pyanj basin delineated from 1:100,000 Topographic maps.	for analysing their distribution
3	River Network	ASTER and Landsat (MSS)	Delineated at scale of 1:200,000 and then adjusted using existing 1:100,000 Topographic maps	for analysing their distribution
4	Sub-basin Boundary	ASTER, Landsat (MSS), River Network	Delineated at scale of 1:200,000. Boundary along the national boundary was adjusted.	for analysing their distribution
5	Hydrological Satation	Data from CounterPart	Location of 20 Hydrological stations with name	for analysing their distribution
6	Meteorological Satation	Data from CounterPart	Location of 21 Meteorological stations with name	for analysing their distribution
7	Land Classification	ASTER and Landsat (MSS)	Interpreted information (scale 1:200,000) covering whole Pyanj basin area was digitalized to Raster format and geocoded. Out of these, the data covering part of area was converted to Vector format.	Runoff analysis, outflow earth-and-sand analysis,

1) Land Use

Using ASTER and Landsat (MSS) Satellite Images, the land use of whole Pyanj Basin was delineated at the scale of 1:200,000.Land use categories were kept similar to that for Pilot area. However, some of categories were not found in the Pyanj Basin. Moreover, Snow and cloud covered area was categorized in separate category. The area of various land use categories is presented in Table R 4.3.4. Most of the area is covered by grassland, and mixed grassland. The Pyanj River (wherever possible at 1:200,000 scale) was drawn as polygon.

Table R 4.3.5 Area of Various Land Use Types in Whole Pyanj Basin

Land Use Code	LU Class Name	Area (in Km^2)
1	Built-up Area	5.38
2	Irrigated Agri.	692.18
3	Rainfed Agri. (on Flat land)	178.12
4	Rainfed Agri. (on Sloppy land)	2,742.96
5	Mixed Rainfed Agri (on Sloppy land) & Grassland	14,155.49
6	Grassland	39,229.96
7	Orchard	0.00
8	Marshland	35.66
9	River	83.22
10	Lake/Pond/Fish pond	266.48
11	Wasteland	0.00
12	Wasteland (Flood Damage Area)	0.00
13	Snow / Cloud	25,174.43
Total Area		**82,563.90**



Legend:

- Built-up Area
- Irrigated Agriculture
- Rainfed Agriculture (on Flat land)
- Rainfed Agriculture (on Sloppy Land)
- Mixed Rainfed Agriculture and Grassland
- Grassland/Shrubland
- Marshland
- River
- Lake/Pond/Fish pond
- Snow / Cloud
- River Network
- Pyanj Basin Boundary
- Sub-basin Boundary
- **10** Sub-basin Number
- National Boundary

Fig. R 4.3.3 Land Use and River Network in the Pyanj Basin Area

2) River Network and Sub-basins Boundary.

For the network analysis, the river lines were delineated. The whole Pyanj Basin was divided into smaller sub-basins. Altogether, 30 sub-basins (both Tajikistan and Afghanistan sides) were delineated. Both data were delineated at the scale of 1:200,000. The lines of the river network were then adjusted using the existing 1:100,000 Topographic maps. Such adjustment was also made for sub-basin boundary that was along the national boundary.

3) Hydrological and Meteorological Station

Obtaining the coordinates data from the Hydro-meteorological department, the location of Hydrological and Meteorological stations was input to GIS. Altogether it includes 41 stations; 20 Hydrological stations and 21 Meteorological stations. Out of these some are located outside (but nearer to) Pyanj Basin. Similarly, some of the hydrological and meteorological stations are located at the same place.

4) Land Classification

This data contains various information regarding landform and soil condition in the Pyanj Basin. All the interpreted information (at the scale 1:200,000) of Land Classification covering the whole Pyanj Basin area was digitalized to Raster format and geocoded. Out of these, the data covering a part of area was converted to Vector format, which has following categories

Code	*Class name*
100	Slope failure
110	Bare land (steep slope)
120	Landslide scarp
130	Landslide
200	Riverbed / flood area
210	Riverbed / flood area
220	Riverbed / flood area
300	Floodplain / valley bottom plain/ lake plain
310	Alluvial fan / alluvial cone
320	Composite fan/ colluvial slope / pediment
330	Steep slope valley bottom deposits
340	Talus
350	Lower terrace
360	Higher terrace
370	Glacier
380	Moraine / other glacial deposits
390	Peneplaine/uplifted erosion surface
500	Basin boundary
105	Slope failure and Landslide (100 + 130)
106	Slope failure and Bare land (steep slope) (100 + 110)
115	Bare land (steep slope) and Landslide (110 + 130)

As mentioned above, the categories with codes 105, 106, and 115 contain the characteristics of two categories, thus these are only in Vector format data.

4.4 TECHNOLOGY TRANSFER OF GIS DATA

Arranging all the GIS (Vector and Raster), Satellite Image, DEM, and Rasterized existing Topographic maps (1:100,000) data into separate folders, display system was created in ArcMap of ArcGIS as Project file (*.mxd*). All these data are arranged in folders are equipped with “ReadMe file” containing the organization of files and content of the data. Then, all these

data were transferred to Counterpart Staff. During this, along with displaying the Project file the content of all data were described and discussed one by one in detail.

Fig. R 4.4.1 Displaying and Describing the GIS and Related Data to Counterpart

REFERENCES

1. GIS data of Afghanistan as Shape files. From Internet site of Afghanistan Information Management Service (AIMS). http://www.aims.org.af/

SECTOR 5 RIVER FACILITY DESIGN

SUPPORTING REPORT

SECTOR 5 RIVER FACILITY DESIGN

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SECTOR 5. RIVER FACILITY DESIGN

5.1 EXISTING RIVER FACILITY

Existing river facilities along the Pyanj River and irrigation cannel in Hamadoni Rayon are listed in Table R 5.1.1. Spur Dike constructed on main dike is counted 18 locations, 4 locations are concrete block type and 14 locations are concrete block with gabion mattress. These 14 locations which constructed in ADB Fund portion was designed with round head.

Table R 5.1.1 Existing Structures along Pyanj River and Hamodoni Rayon

Existing River Facility			Type	General Description
Dike	Main Dike	CoES	Embankment	Length about 5.0km
		MMWR	Embankment	Length about 7.5km (Including ADB Portion 4.5km)
	Intake Canal Guide Dike		Embankment	Length about 1.1km
	Spillway Guide Dike		Embankment	Length about 1.4km
Spur Dike	Main Dike		Concrete Block	4 locations, Length from 23.0m to 31.6m Width from 2.0m to 2.6m
			Round Head (ADB portion)	14 locations, Length from 26.7m to 47.5m Width from 12.4m to 42.0m
	Intake Canal Guide Dike		Concrete Block	7 locations Length from 19.8m to 110.0m Width from 2.0m to 20.0m
			Round Head	1 location Length 19.9m Width 2.5m
	Spillway Guide Dike		Concrete Block	12 locations Length from 10.0m to 27.3m Width from 2.0m to 2.5m
Chubek Weir	Intake Weir		Sluice Gate	4 Sluice Gates
	Spillway Gate		Radial Gate	5 Radial Gates
Irrigation			Chubek main canal	Length about 15.0km
			Dehkonobod canal	Length about 25.0km
			New Dehkonobod canal	Length about 12.0km
			Other canal	More than 400 small canals in Hamadoni rayon.

5.2 DESIGN CONDITIONS

5.2.1 Design Description

1) General Layout of Structures

As discussed in the previous sector, the following flood control facilities and other related structures have been preliminarily designed as the proposed structural measures for flood mitigation and improvement in the project Area

2) Basic Design Requirements

Hydraulic design for this project requires that existing riverbank elevations along the Pyanj River. The raising or widening of dikes shall be done with the construction of Revetment, Foot Protection and Spur Dikes

The following basic design concepts were applied to the study of project structures:

(a) Proposed structures are designed based on design flood for the project scale of a 100-year return period for Master Plan of river systems.

(b) Based on the urgency and budget limitation, Master Plan will be separated to Short Term Plan (hereinafter called “STP”) and Medium /Long Plan (hereinafter called “MLP”).

(c) STP will be a partial duration plan of MLP, which means STP portion will not repeat construction in the MLP.

(d) In designing the structures, locally based structural materials are used wherever possible.

(e) The following design criteria and standards are applied:

Tajikistan Codes and Standards

(i) “Construction Standard and Riles”; SNIPs, Soviet Unions, 1980’s to 1990’s

Foreign Codes and Standards

(i) Technical Standard for Rivers and Sabo Facilities (Ministry of Construction of Japan)

(ii) Other accepted applicable codes and standards

5.2.2 Summary of Design Conditions

Summary of Design Conditions is shown as follows (TableR 5.2.1);

Table R 5.2.1 Summary of Design Condition

Item of Design Condition	Data Resources	Adopted value
Design Water Level (D.W.L.), 30 Years Return Period Water Level	Non-uniform Flow Calculation (Refer Sector 1)	Refer to Fig 1.9.3
Mean Riverbed Elevation	DEM data	
Existing Dike Elevation, Ground Level, Existing Riverbed	Primary Survey	
Design Velocity	Non-uniform Flow Calculation (Refer Sector 1)	Upstream of BM(9.3km): 5.0(m/s) Downstream of BM(9.3km): 3.0(m/s)

5.3 DESIGN OF DIKE

5.3.1 Components of Dike

Components of dike are shown in below(Fir R 5.3.1). This figure shows a typical cross section of dike facing from upstream side to downstream.

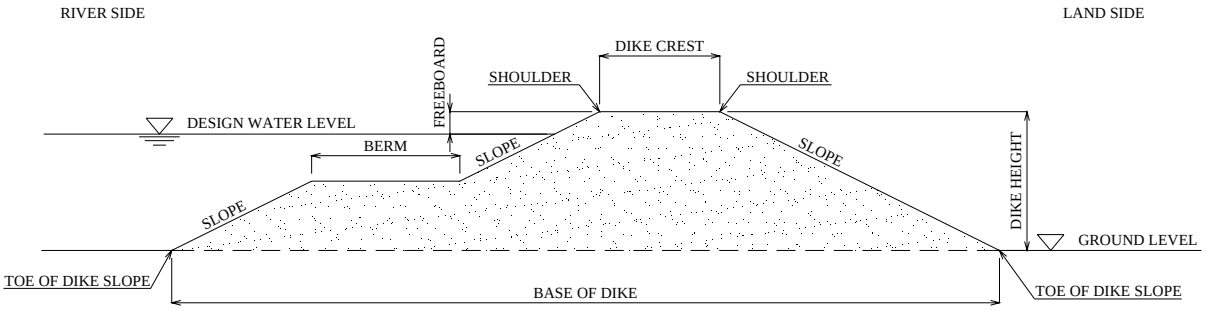


Fig. R 5.3.1 Components of Dike

5.3.2 Dike Crest

Width of dike crest at existing dike is between 4.0m to 10.0m or more. Based on the standard in Japan dike crest width is between 6.0-8.0m. According to SNIP, dike crest width is 8 meters. Thus, in this study 8.0 m is adopted.

5.3.3 Freeboard

Design Crest Level is to be determined with freeboard adding to the design water level. Freeboard consists of all of unknown factors, like wave height. Usually 0.7m is adopted to dike design according to SNIP. Along the dike in this study area, there are many spur dikes existed already and proposed in this study. Spur dike blocks river flow and reduces the river flow velocity so that water level in the upstream side of the spur dike is to be dammed-up with certain height of water level. Dammed up water height is estimated with the formula $V^2/2g$; V is the river flow velocity and g is gravity acceleration, and the velocity is estimated 4 m/sec so that additional height caused by dammed-up of spur dike is calculated with 0.8 meters.

Therefore, total freeboard is proposed with 1.5 meters.

5.3.4 Slope

Slope angle is ranging from 1:1.5 to 1:1.8 in the existing dike according to the site survey that form stable slope embanked with sand and gravel in general. Considering requirement of allowance to bank erosion and loosening due to saturation of water, 1:2.0 is proposed for slope angle of the embanked dike including spur dike.

Provision of berm on the slope with 3m in width is proposed because of the following reasons;

- To provide space for machinery to work there for repairing slope protection or foot protection works
- To increase width of dike for dike body to resist against erosion or filtration

5.3.5 Slope Protection

Conventionally there are some means for slope protection in river engineering; gabion, wet-stone-masonry, concrete block, riprap, etc. In this study area, gabion, concrete block and riprap have been utilized. In comparison of unit cost, riprap is the cheapest, following with gabion, wet-stone-masonry, and concrete block. Considering of convenience of repair works to damaged portion like erosion and appreciation of the actual site practices, riprap, gabion and concrete block is proposed.

Dimensions of the proposed methods are shown as follows;

1) Concrete Blocks

a) Upstream of BM(9.3km)

Size of concrete blocks is determined for the block not to be ridden up by the river flow based on the following calculation;

$$W_W \times \cos\theta \times \ell_b / 2 \geq L \times \ell_L + D \times \ell_d$$

W_W: Weight of concrete block

ℓ_b : Length of the block in up-downstream direction

L: Uplift induced by the river flow acting to the block

ℓ_L : Length from downstream end to action point of L

D: Thrust force induced by the river flow acting to the block

ℓ_d : Length from bottom to action point of D

θ: Angle of slope to horizon

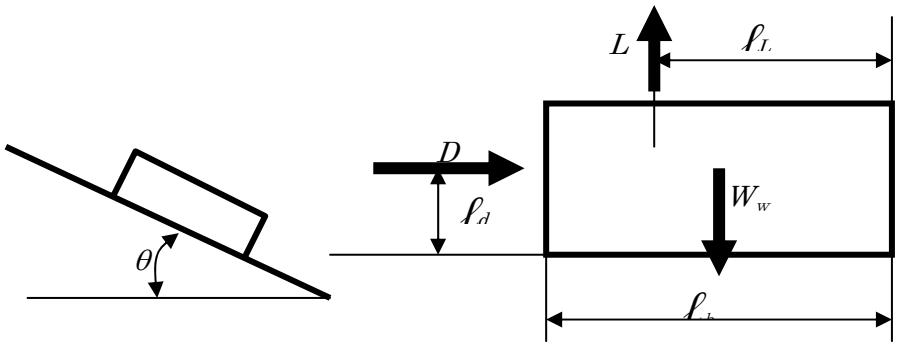
$$L = \frac{\rho_W}{2} C_L A_L V_d^2 \qquad D = \frac{\rho_W}{2} C_D A_D V_d^2$$

ρ_w : Density of water

$C_{L,D}$: Experimental coefficient for uplift or thrust force respectively

$A_{L,D}$: Area for uplift or thrust force respectively

V_d: Flow velocity



Note: Sliding is not considered as design condition because the blocks are connected each other behaving in a mass.

Result of the calculation is shown as below:

Thickness	0.5 m	0.3 m	0.2 m
Result	OK	OK	NG

Therefore, size of concrete blocks placed as slope protection is proposed with 1m x 2m x 0.3 m.

In order to prevent soil washed out through the spaces from the embankment, filter material should be placed underneath.

b) Downstream of BM(9.3km)

As based on the same calculation、the size of concrete blocks placed as slope protection is proposed with 1m x 2m x 0.2 m.

In order to prevent soil washed out through the spaces from the embankment, filter material should be placed underneath.

2) Gabion

a) Upstream of BM(9.3km)

Gabion is composed of iron-wire net and boulders so that diameter of iron-wire and boulders should be determined. Diameter of iron-wire is proposed with 3 mm. Boulder size is determined with the following conditions;

- There is no soil pressure and water pressure underneath.
- Movement of packed boulders induced by the river flow causes critical condition, which make deformation of the wire frame.

Using empirical formula, required boulder size for gabion is determined with more than 0.19 m in average diameter.

In order to prevent soil washed out through the spaces from the embankment, filter material should be placed underneath.

b) Downstream of BM(9.3km)

Gabion is composed of iron-wire net and boulders so that diameter of iron-wire and boulders should be determined. Diameter of iron-wire is proposed with 3 mm. Boulder size is determined with the following conditions;

- There is no soil pressure and water pressure underneath.

- Movement of packed boulders induced by the river flow causes critical condition, which make deformation of the wire frame.

Using empirical formula, required boulder size for gabion is determined with more than 0.10 m in average diameter.

In order to prevent soil washed out through the spaces from the embankment, filter material should be placed underneath.

3) Riprap

Riprap is composed of crashed rocks or boulders in general. Particle size should be designed under the following conditions;

- There is no soil pressure and water pressure underneath.
- Movement of particle is induced when scouring force of the river flow exceeded resistance of the particle.

Using empirical formula, required particle size for riprap is determined with more than 0.45 in average diameter.

In order to prevent soil washed out through the spaces from the embankment, filter material should be placed underneath.

5.3.6 Foot Protection Works

The length of foot protection is to be placed at certain depth to count on farther erosion. The depth of foot protection is determined based on the deepest depth of the riverbed. Considering site conditions and river flow velocity obtained from the hydraulic analysis, concrete block, which has been utilized in the study area, is proposed as material for foot protection works.

1) Design depth

a) Upstream of BM(9.3km)

The design depth of foot protection is determined with the deepest scoured depth from the mean riverbed elevation given from DEM data. The deepest scoured depth is estimated from the following empirical formula, which has been used for river engineering in Japan.(Fig R 5.3.2)

$\Delta Z = 0.8 * H_S$

ΔZ: Depth from the deepest portion to the mean riverbed

Hs: Height from the deepest portion to the top of the holm

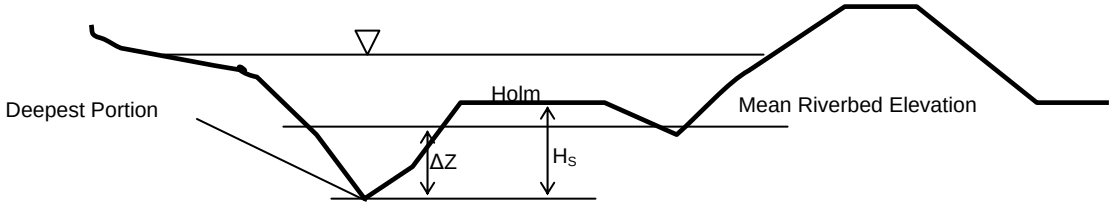


Fig. R 5.3.2 Definition of ΔZ and H_S

The deepest portion has been surveyed in this Study, so that the deepest scoured depth can be estimated with the above-mentioned formula, resulting 6.0 meters in design depth, which is applied to the portion where no spur dikes are provided.

The foot protection of dikes protected with spur dikes is given 1.5 meters in design depth.

b) Downstream of BM(9.3km)

Based on the numerical simulation, flow velocity at downstream of BM(9.3 km) can be seen reducing speed by compare with the upstream. Therefore, erosion behavior in front of toe of dike can be assumed small. The foot protection of dikes protected is given 1.5 meters depth from the existing riverbed.

2) Design dimension of concrete block

Required size of concrete block should be satisfied the condition shown as follows;(Fig R 5.3.3)

$F_D < \mu(W_w - F_L)$

F_D: Thrust caused by the flow

μ: Coefficient for friction; 0.65

W_w: Weight of the block

F_L: Uplift caused by the flow

$F_D * hs < Ww * Ls - F_L * L_b$

hs: Height from the bottom to the action point of the thrust caused by the flow.

Ls: Length from the edge to the center of gravity

L_b: Length from the bottom to the action point of the uplift caused by the flow

(Refer to Fig. R 5.3.3)

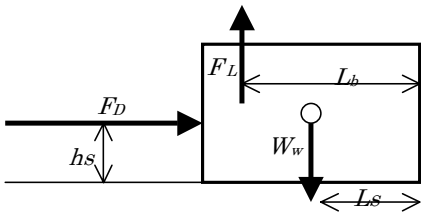


Fig. R 5.3.3 Outer and Inner Forces to action to the concrete block

Result of the calculation with the design flow velocity, 5 m/sec, shows that concrete block with 1m x 1m x 2m is required for stable placement, which has been used in the site already. The longer side of the concrete block should be placed in parallel to the river flow direction.

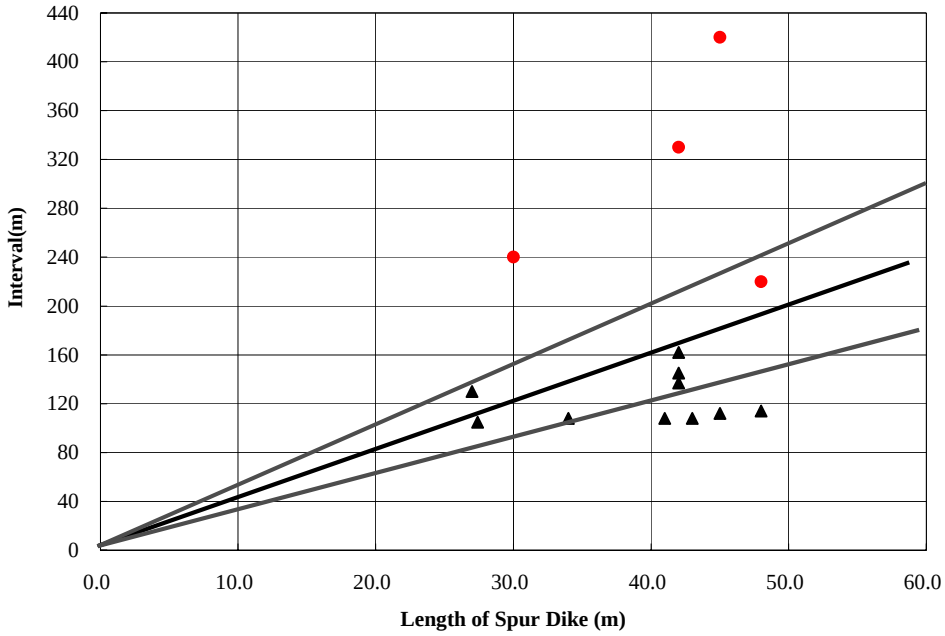
Result of the calculation with the design flow velocity, 2 m/sec, it shows that concrete block with 1m x 1m x 0.4m is required for stable placement. The longer side of the concrete block should be placed in parallel to the river flow direction.

5.4 DESIGN OF SPUR DIKE

For the design of spur dike, two kind of research have been carried out in the Study; one is site survey on the existing spur dikes and other is hydraulic analysis of simulation with numerical model. The items to be determined for spur dike design are examined as follows;

5.4.1 Interval of Spur Dikes

Site survey on the existing spur dikes has been carried out to find effectiveness of spur dike. One of elements to secure the effectiveness is a ratio of length to interval of spur dikes. Some of portions in the existing dike are heavily eroded while some are well protected by spur dikes. Distances to damaged portions from the immediate upstream spur dikes were scaled along the existing dikes constructed in 2006. Result is shown as follows (Fig R 5.4.1) with red points showing damaged portions and with black triangle points showing intervals of spur dikes, which have been well protecting the embankments with no damages.



note: ● is damaged portion, ▲ is no damaged portion

Fig. R 5.4.1 Result of Site Survey on Spur Dike Effect

The above figure shows that damaged portions are located with the distances from the immediate upstream spur dike exceeding the distance more than the four (4) times of the spur dike length, or the dike slopes have no damages and well protection in case the intervals of spur dikes have less than four (4) times to the spur dike lengths.

Therefore, the interval to length of the spur dikes is to be less than 4. Cost analysis results that the less than 4 has the more expensive. Resulting, the ration of interval to length of the spur dikes is proposed with four (4).

5.4.2 Length of Spur Dike

One of purposes of spur dike is to protect the flood protection dike from bank erosion with buffering tolerant and colliding flow against the dike. The main flow of Pyanj River lately has been running along the existing flood protection dike, and colliding against the dike in some portions causing bank erosion. Therefore, the longer spur dike can well protect it with keeping the main flow the farther away from the existing dike.

Meanwhile a primary study shows that in comparison of construction cost per unit of spur dikes and flood protection dikes with fixed the ratio of length-interval of spur dike, the shorter spur dike has the less unit cost of construction of spur dike and flood protection dike. In addition, the

longer spur dike induces the deeper scouring at the toe portion and requires the more construction cost.

In the respect of spur dike design, empirical methods have many lessons and learnt. The existing dike constructed after 2005 flood has many of the expirical works. Result of site survey on spur dike effects is shown as follows (TableR 5.4.1);

Table R 5.4.1 Result of Site Survey on Existing Spur Dike constructed in 2006

Length of spur dike	Damages at toe section	Damages in dike section	Formation of sediment between spur dikes	Depth of scouring at the toe portions
Whole	Damaged 8 spur dikes among 14, 60 %.	No Damages	12 super dikes among 14 formed sedimentation in front of the flood protection dikes. Condition of rest of 2 is unknown because they are still submerged at the time of research.	2.0m-2.6m (2 sample)
Length: longer than 40m shorter than 50m	Damaged 4 among 7, 60%	No Damages	The lengths of sedimentation range 45m-100m, and the widths do 12m-34m	submerged
Length: 40m-30m	Damages 1 among 4, 25%.	No Damages	The lengths range 50m-65m, and the widths do 12m-25m.	2.6m
Length: less than 30m	Damaged 2 among 2, 100%. These portions have strong flow collides.	No Damages	The lengths range 24m-40m, and the widths is around 10m.	2.0m

The result suggests that the spur dikes with length of around forty (40) meters have been working for well protection of the dikes.

Cost analysis results that the longer length of spur dike costs the more expensive cost in case interval-length ration is fixed. Considering economic effects and functional effects of spur dike, length of spur dike is proposed with forty (40) meters.

5.4.3 Type of Spur Dike

There are two types of spur dikes adopted in the site, one is made of soil embankment and the other is made of concrete block. The former type has been introduced in 2006. The latter has been constructed before then. Site survey on the concrete block type was carried out and resulted as follows; (Table R 5.4.2)

Table R 5.4.2 Type of Spur Dike

	Section	Damages	Effect of spur dikes	Depth of scouring at the toe portions
Concrete block type	Flood Protection Dike (4 spur dikes)	Toe sections of all the spur dikes have the concrete blocks being sliding down.	Not much sedimentation is developed at the every spur dike.	2.4m-3.0m (2 sample)
	Intake Guide Dike (8spur dikes)	Stable	No sedimentation observed in 4 cases among 8 but scale of sedimentation is small.	2.0m-5.2m (8samole)
	Spillway Guide Dike (12 spur dikes)	Downstream section of C20 has strong flow collide against the dike, so that the toe portions of the spur dikes have damaged.	Not much sedimentation has been developed because of short length of spur dike and small angle; less than 20m in length and less than 30 degrees in angle. One of them is with 40m in length has sedimentation in small scale.	1.4m-4.0 (7samle)
Embankment type	Flood Protection Dike (14 spur dikes)	8 among 14 have damages at the toe portions.	Almost all spaces between spur dike have formed sediment deposits, which protects well dike slope from bank erosion	2~2.6m

It is found that embankment type is well functioned to protect the main dike with forming sedimentation in the spaces between spur dikes, comparing on spur dike designs in concrete block type and embankment type.

However, embankment type should be closely examined to solve the problem of damages at the toe portion.

5.4.4 Direction of Spur Dike

Hydraulic analysis has been carried out to find optimum arrangement of spur dikes, resulting the acute angle of spur dike has less scouring depth at the toe portion than the right -angle's. The result of the analysis is shown in the followings (Fig. R 5.4.2);

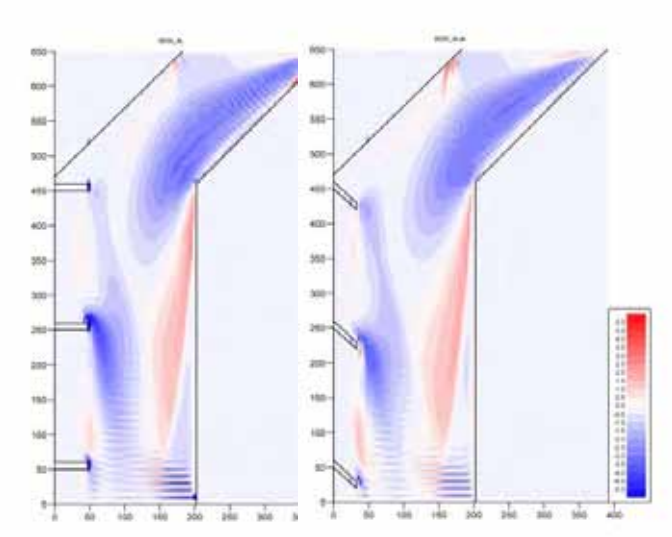


Fig. R 5.4.2 Result of Hydraulic Analysis on Spur Dike in case of Collide Flow

The result shows that if the angle is set in the less angle, the scouring depth is the shallower and the torrential flow is the nearer to the bank.

In case spur dike length is 40 m, scouring depth is obtained with the result of analysis, based on which required foot protection length is calculated as follows (Table R 5.4.3);

Table R 5.4.3 Required Foot Protection Length according to setting angels of Spur Dike

Angle(degree)	Scouring Depth (m)	Foot Protection Length (m)	Perpendicular Length (m)
90	8.1	14	40.0
60	6.9	12	34.6
50	6.5	11	30.6
45	6.3	11	28.3

In the respect of foot protection length, which contributes cost rising, in case of 50° and 45° has the least length, while perpendicular length gets the shorter according to the less degrees of angle that means torrential flow is the nearer to the dike.

According to the site survey on the existing spur dike of embankment type as shown in the following table (Table R 5.4.4),

Table R 5.4.4 Result of Site Survey on Setting Angle of Spur Dikes

No.	Angle of Spur dike (degree)	Damages in the toe portion
R1	59.8	Non
R2	50.1	Damage
R3	49.4	Damage
R4	50.1	Damage
R5	40.7	Damage
R6	55.0	Damage
R7	75.0	Non
R8	50.0	Damage
R9	50.0	Non
R10	50.2	Non
R11	40.5	Damage
R12	40.4	Non
R13	40.5	Non
R14	60.5	Damage
Average	50.9	

Some have damages in the toe portion but there are no evidence showing that setting angle causes the damages, while it is observed that all of the spur dikes listed in the above table have well function to protect the main dike.

Considering those results of the research and analysis, angle of spur dike is proposed with 50°.

5.4.5 Toe Protection

Spur dike usually is severely collided by river flow at the toe portion. The experienced practices suggest that 3 or 6 meters is required for design depth of riverbed at the severely colliding portion.

Hydraulic analysis has been carried out in this study to figure out the design depth for the toe portion protection works, utilizing two-dimensional hydraulic analysis with mesh method. The depth induced by erosion is calculated with flow velocity and critical velocity of bed-load transportation. The analysis is simulated to the river flowing athwart a holm toward the riverbank.

Result of the analysis is shown as follows (Fig. R 5.4.3);

Deepest portion is indicated with 6.5 meters in depth.

There are two ways of countermeasures for foot protection; one is to design the works to place the deepest depth obtained above, the other is to cover the deepest portion with connecting concrete blocks. Considering a difficulty to excavate so deep, connecting concrete blocks method is proposed and shown with conceptual drawing as follows (Fig. R 5.4.4);

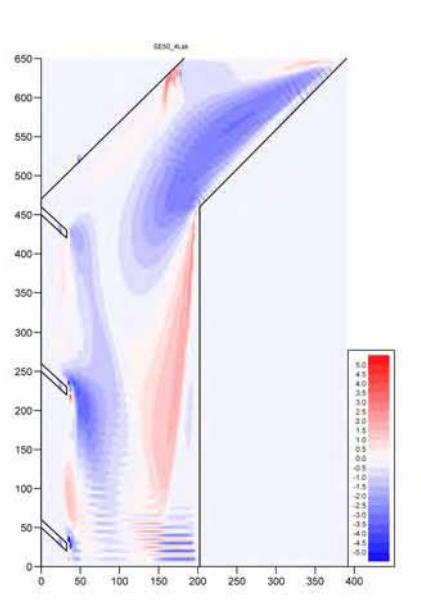


Fig. R 5.4.3 Result of Hydraulic Analysis for Deepest Scouring Depth

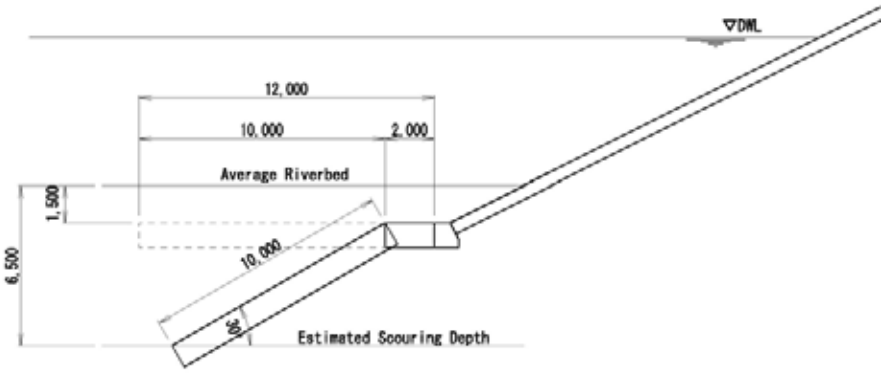


Fig. R 5.4.4 Conceptual Drawing of Toe Protection

In order to cover the deepest scoured portion with inclining the concrete blocks, the series of connected concrete blocks requires ten (10) meters in total length.

5.5 COUNTERMEASURE OF SEEPAGE

Based on the field survey, damaged portions were confirmed six (6) locations in the study area. The damaged phenomenal are seepage in the landside of existing dike.（Fig. R 5.5.1）One of the reason caused seepage is low-land elevation due to the embankment works of Dike.

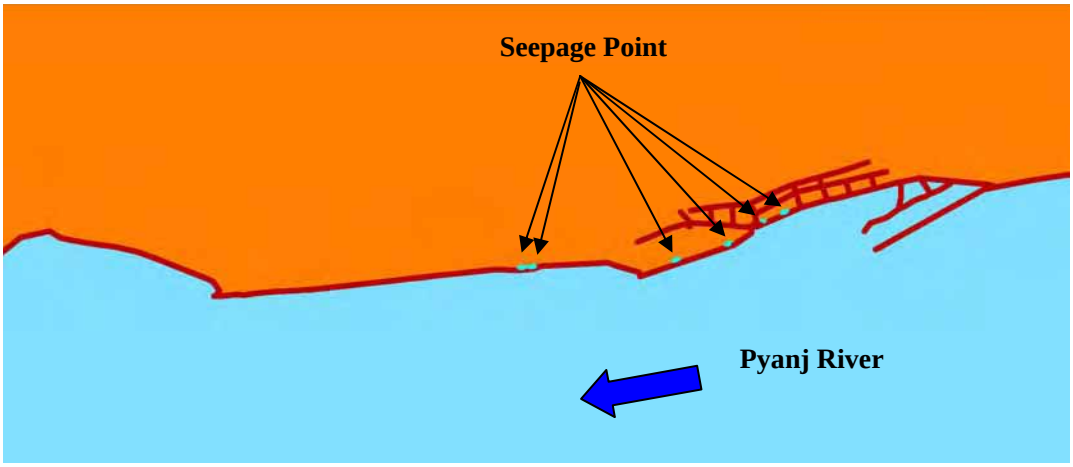


Fig. R 5.5.1 Seepage Point

Seepage portion without rehabilitation works will be enlarged a serious damage to the Main Dike by slide of toe of dike slope.(Fig R 5.5.2)

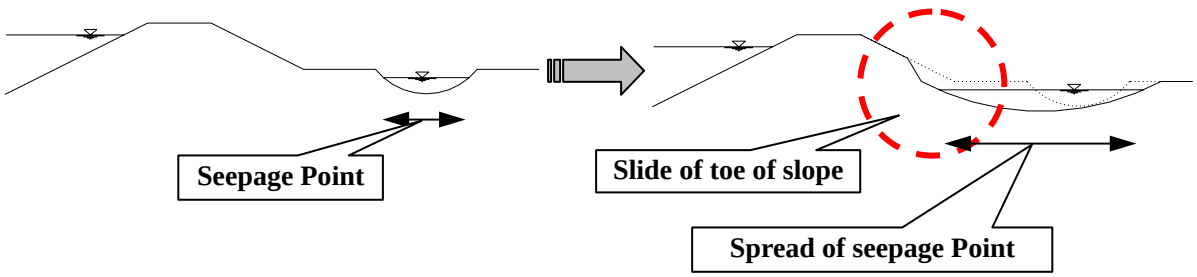


Fig. R 5.5.2 Conceptual Drawing of Damage to Main Dike

Countermeasure for seepage can be identified as following methods (Fig R 5.5.3)

- Backfilling the seepage portion up to the elevation become as same as surrounding area.
- Embankment works for slip preservation, reduction of average hydraulic gradient and extension of creep length.
- In order to prevent additional seepage, materials for backfilling and dike widening shall be taken from the certain distance of the Dike.
- Materials for backfilling and dike widening at land side shall be used gravel in order to drain water easily.

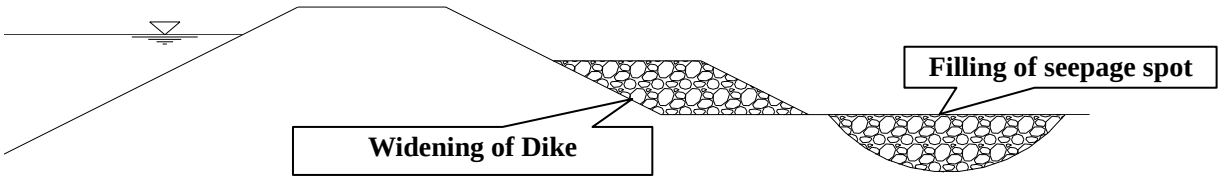


Fig. R 5.5.3 Countermeasure of Seepage

5.6 DESIGN DIFFERENCE BETWEEN EXISTING AND BASIC PLAN

As mentioned above design of dike and spur dike, some changing ideas are proposed and introduced. The difference point between existing design and design of this study are listed in Table R 5.6.1

Table R 5.6.1 Design Difference between Existing and Basic Plan

Facilities		Existing	Basic Plan	Remark
Dike	Freeboard	0.7m	1.5m	
	Berm	None	3m	
	Revetment	・ Concrete Block ・ Gabion Mattress ・ Concrete Block with Gabion Mattress ・ Riprap	・ Concrete Block ・ Gabion Mattress ・ Riprap	
	Couple of block	Tie by wire or no coupling	Steel shackle	
	Slope	River side is from 1:1.5 to 1:1.8 land side is 1:1.5	Both river side and land side is 1:2	
	Foot Protection	Partially existed	・ With spur dike: 2m ・ Without spur dike: 11m (except downstream of 9.3km)	
	Anti-suction sheet	None	Adopt	Geotextile
Spur Dike	Interval	80 ~ 1,000m	160m	
	Length	30 ~ 50m	40m	
	Type	・ Concrete Block type ・ Round Head type	Concrete Block type	
	Couple of block	Tie by wire	Steel shackle and Wire	
	Direction	40 ~ 60 degree	50 degree	
	Anti-suction sheet	None	Adopt	Geotextile
	Foot Protection	None	12.0 m	
	Berm	None	3m	

5.7 URGENCY COUNTERMEASURE

Based on the result of field survey, partial damaged portions can be observed in the Main Dike. Urgent action shall be taken for high risk portions where cannot wait for completion of Master Plan. Urgency of the location will be decided by following conditions.

- Colliding portion of Superelevational Flow
- Damaged in Main Dike
- Attacking by strong water flow at upstream of 9.3 km.

Damaged portion by Superelevational Flow is identified in below Fig. R 5.7.1.

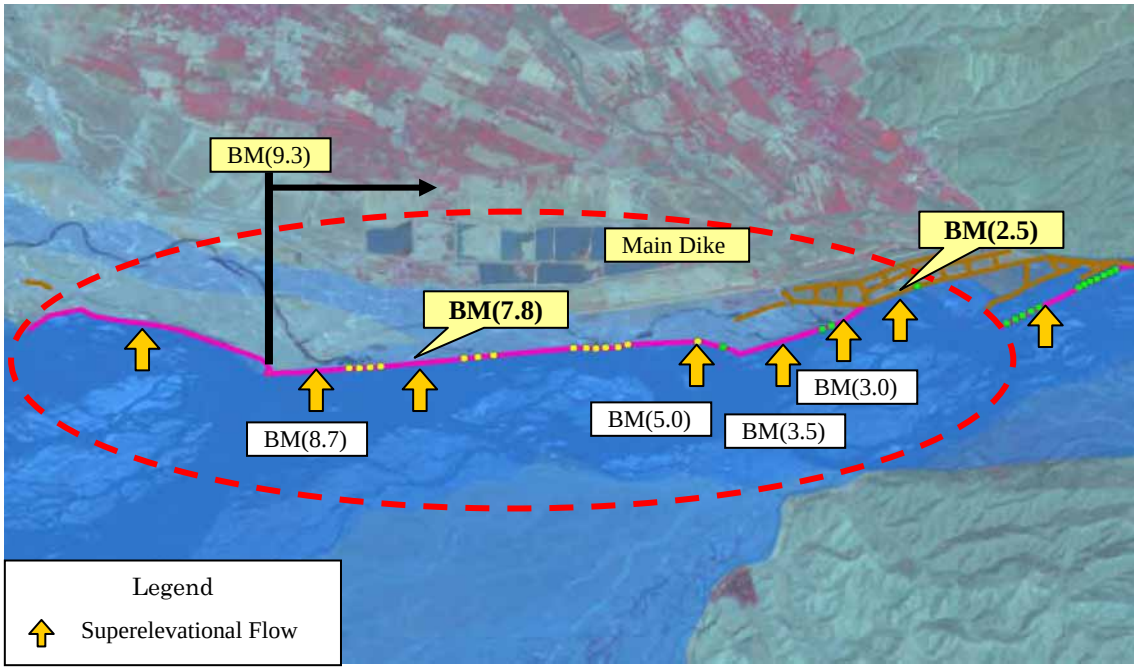


Fig. R 5.7.1 Damaged portion by Superelevational

As above the Fig. R 5.7.1 , there are five (5) locations hitting by superelevational flow at the Main Dike. At the station BM(7.8), there is additional concrete block and embankment works implemented by the concerned office. At the station BM(2.5), there is Spur Dikes and Revetment constructed by Pilot Project of this study.

Therefore, four locations is selected for urgent enforcement works, as the location of BM(3.0)、BM(3.5)、BM(5.0)、BM(8.7).

Countermeasures for urgent repair works are shown in Fig. 5.7.1.

5.8 COMPARISON OF ALTERNATIVE

Considering the effective use of the existing flood control facilities, four alternative plans were proposed shown between Fig.5.8.1 to Fig 5.8.4.

1) Basic Plan; Enforcement the Main Dike with Spur Dike

- Enforcement of Existing Dike by heightening and extension 1.5 km of new main dike.

- Spur Dike with length 40.0m will provide in order along the Main Dike.
- Revetment is constructed by using concrete block type and riprap type. Foot protection of dike is provided with 2.0m width along the Main Dike.
- Improvement works for existing Intake and Guide Dike include construction of heightening dike, additional spur dike, revetment work and foot protection.
- Improvement of Spillway consist of heightening dike, additional spur dike and revetment work and foot protection.

2) Alternative 1; Stabilization of Water Course

- Enforcement of Existing Dike by heightening and extension 1.5 km of main dike. (Same as Basic Plan)
- Additional spur dike will not construct, but revetment and foot protection work will be provided. Width of foot protection will be placed with 11.0m and 2.0m as the length of 7.1 km and 3.7 km, respectively.
- Improvement of Intake Canal and Guide Dike are proposed as same as Basic Plan.
- Spillway dike will be extended forward to riverside about 500m in order to lead discharge to center of waterway.
- River excavation will be conducted in order to stabilized waterway.

3) Alternative 2; Construction of Inland Main Dike

- New Main Dike will be constructed in the behind of existing dike. New main dike will be enlarged existing irrigation canal with total of 13km.
- Improvement of Intake Canal, Guide Dike and Spillway are proposed as same as Basic Plan.
- Groundsill will be provided between existing Dike and New Main Dike in order to maintain the national land conservation.

4) Alternative 3; Enforcement of Main Dike without Spur Dike

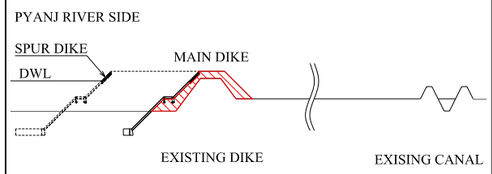
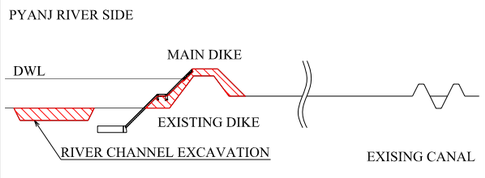
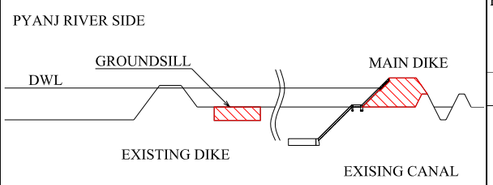
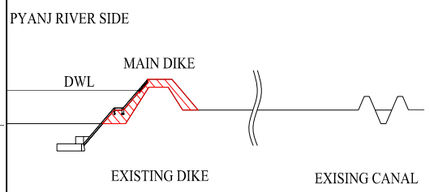
- Improvement work of Main Dike will not adopted Spur Dike Structures. In order to protect toe of main dike from strong flow, additional foot protection is required.
- Improvement of Intake Canal, Guide Dike and Spillway are proposed as same as Basic Plan.

Comparison of Basic Plan and Alternative Plans will be summarized in Table R 5.8.1.

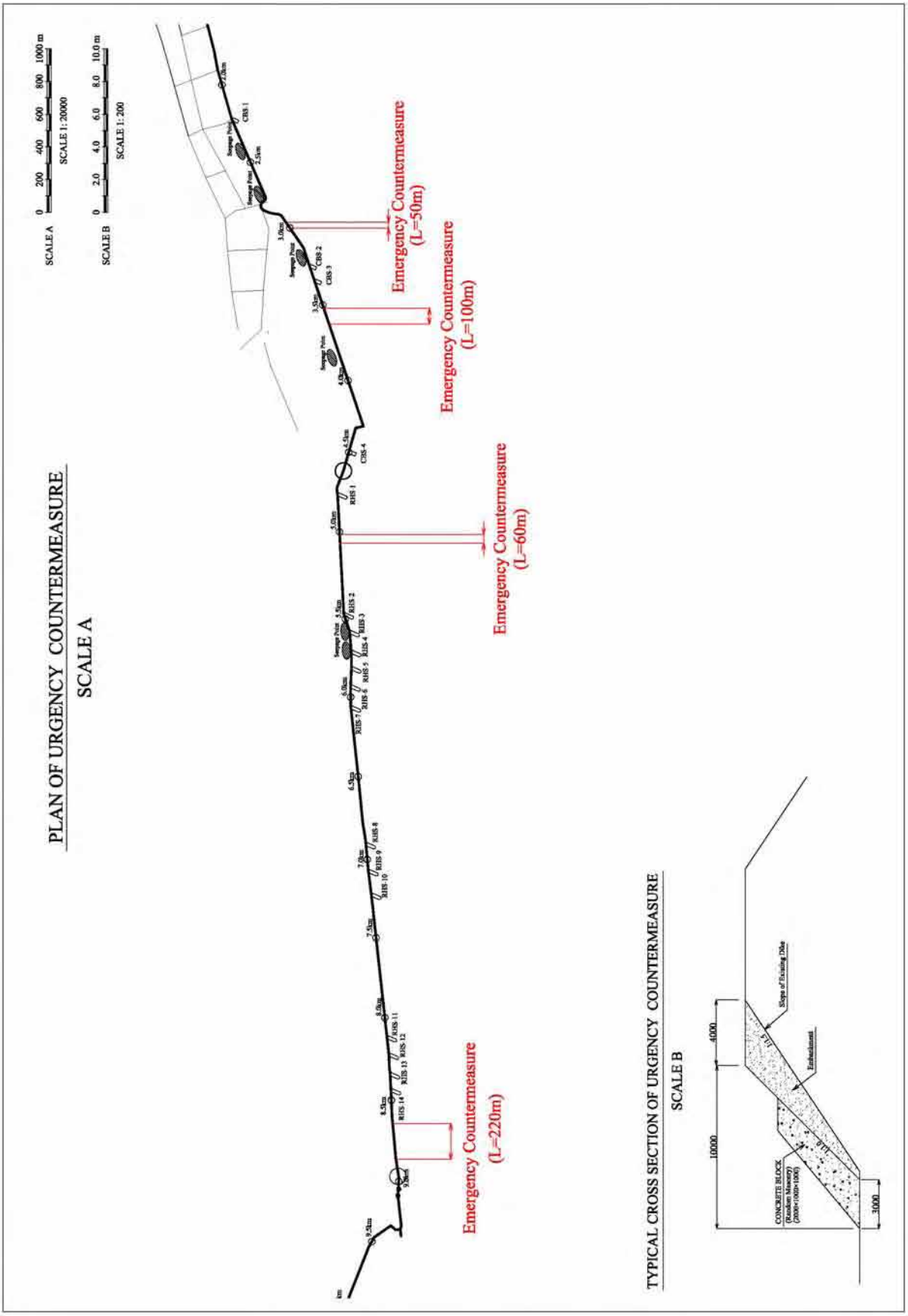
5.9 ADOPTION OF BASIC PLAN

Based on the result of alternative study, basic plan is most effectively and economically plan. Therefore, Basic Plan will be chosen as the proposed Master Plan of this study. The design drawings for Basic Plan (STP and MLP) will be show between Fig. 5.9.1 to Fig. 5.9.12.

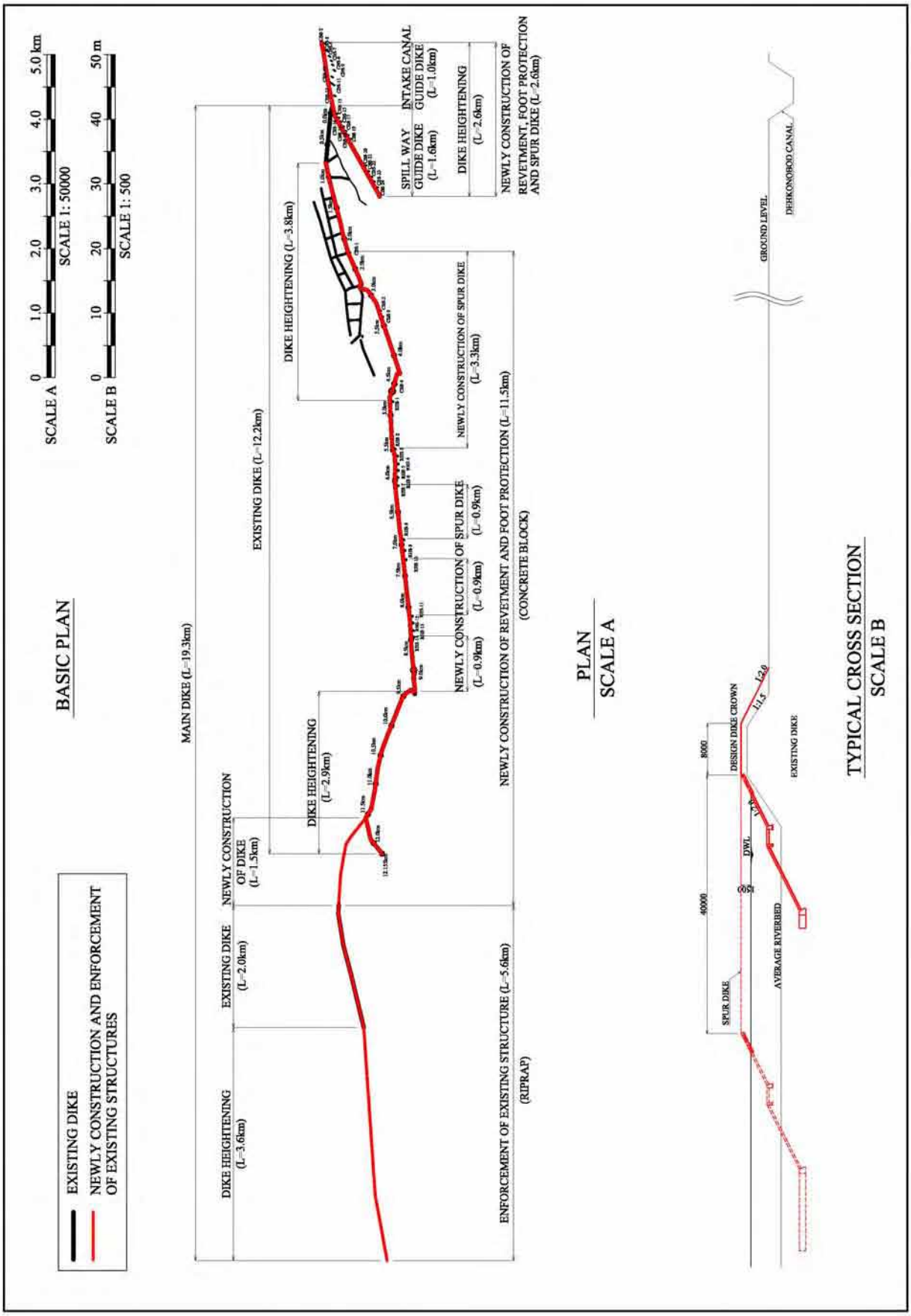
Table R 5.8.1 Comparison of Alternative

Item			Basic Plan: Enforcement the Main Dike with Spur Dike	Alternative1: Stabilization of Water Course	Alternative2: Construction of Inland Main Dike	Alternative3: Enforcement of Main Dike Without Spur Dike
						
	Countermeasure for Dike Erosion		• Provide Spur Dike and Revetment for enforcement of existing Dike. • Extension of Main Dike	• Extend Spillway guide dike. • Conduct river channel excavation in order to mitigate main flow. • Provide Revetment and Foot Protection in Main Dike.	• Construction of New Main Dike in Canal. • Provide Revetment and Foot Protection in main Dike. • Provide groundsill behind of existing dike for national land conservation.	• Provide Revetment and foot protection in Main Dike. • Provide additional foot protection against strong scour force at the toe portion • Removal of existing spur dike
	Countermeasure for Overflow		Heightened up the existing dike to designed dike elevation			
	Countermeasure for Seepage		Widen the crest of Dike to 8.0m and provide additional embankment in landside.			
Newly River Facility	Main Dike	Dike	Dike: 1.5km Heightening of Existing Dike: 10.3km	Same as “Basic Plan”	Dike: 2.1km Heightening of Existing Dike: 13.5km	Same as “Basic Plan”
		Spur Dike	Spur Dike (L=40m): 39 locations	None	None	None
		Revetment	Concrete Block Type: 11.5km Riprap Type: 5.6km	Same as “Basic Plan”	Same as “Basic Plan”	Same as “Basic Plan”
		Foot Protection	Foot Protection (B=2m): 11.5km	Foot Protection (B=11m): 7.1km Foot Protection (B= 2m): 4.4km	Foot Protection (B=11m): 10.8km	Foot Protection (B=11m, B=3m 2layers): 7.1km Foot Protection (B= 2m): 4.4km
	Intake Canal Guide Dike	Dike	Heightening of Existing Dike: 1.0km	Same as “Basic Plan”	Same as “Basic Plan”	Same as “Basic Plan”
		Spur Dike	Spur Dike (L=40m): 7 locations			
		Revetment	Concrete Block Type: 1.0km			
		Foot Protection	Foot Protection (B=2m): 1.0km			
	Spillway Guide Dike	Dike	Heightening of Existing Dike: 1.6km	Dike: 0.5km Heightening of Existing Dike: 1.6km	Same as “Basic Plan”	Same as “Basic Plan”
		Spur Dike	Spur Dike (L=40m): 10 locations	Spur Dike (L=40m): 14 locations		
		Revetment	Concrete Block Type: 1.6km	Concrete Block Type: 2.1km		
		Foot Protection	Foot Protection (B=2m): 1.6km	Foot Protection (B=2m): 2.1km		
	River Channel Excavation		None	Length=4.6km, Width= 0.3km, Depth=3.0m	None	None
	Groundsill		None	None	Groundsill: L=10.0km, W=41.2 m	None
Construction Efficiency (Evaluation)			Required Large scale of cofferdam. Workable period in the riverside is short. Implementing works need time (**B**)	River excavation work can only conducted during the low water periods, which is limited time. (**C**)	All the construction work can be conduct in dry-up condition. It will not affected by the water level changing. (**A**)	Required Large scale of cofferdam. Workable period in the riverside is short. Implementing works need time. (**B**)
Economical Efficiency (Evaluation)			**131.7 Million (TJS)** (**A**)	**164.2 Million (TJS)** (**B**)	**235.5 Million (TJS)** (**C**)	**137.5 Million (TJS)** (**B**)
Comment and Evaluation			Most economically and commonly adopted for countermeasure. (**A**)	Excavation of River channel works is required the consent of Afghanistan Government. River channel required maintenance. (**C**)	Easy construction but high project cost. (**C**)	Required bigger scale of cofferdam than Basic Plan. (**B**)

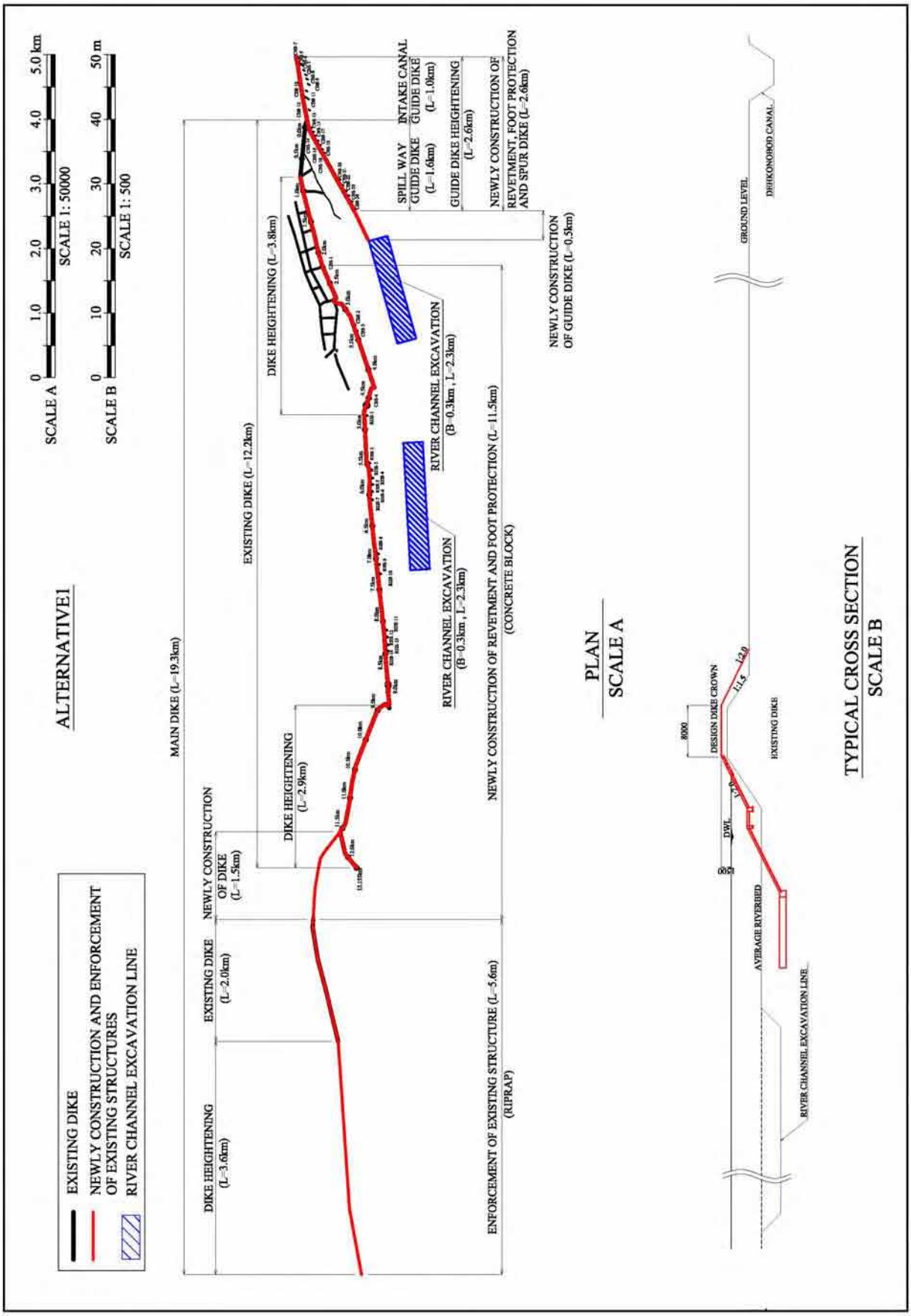
FIGURES AT THE BACK OF REPORT



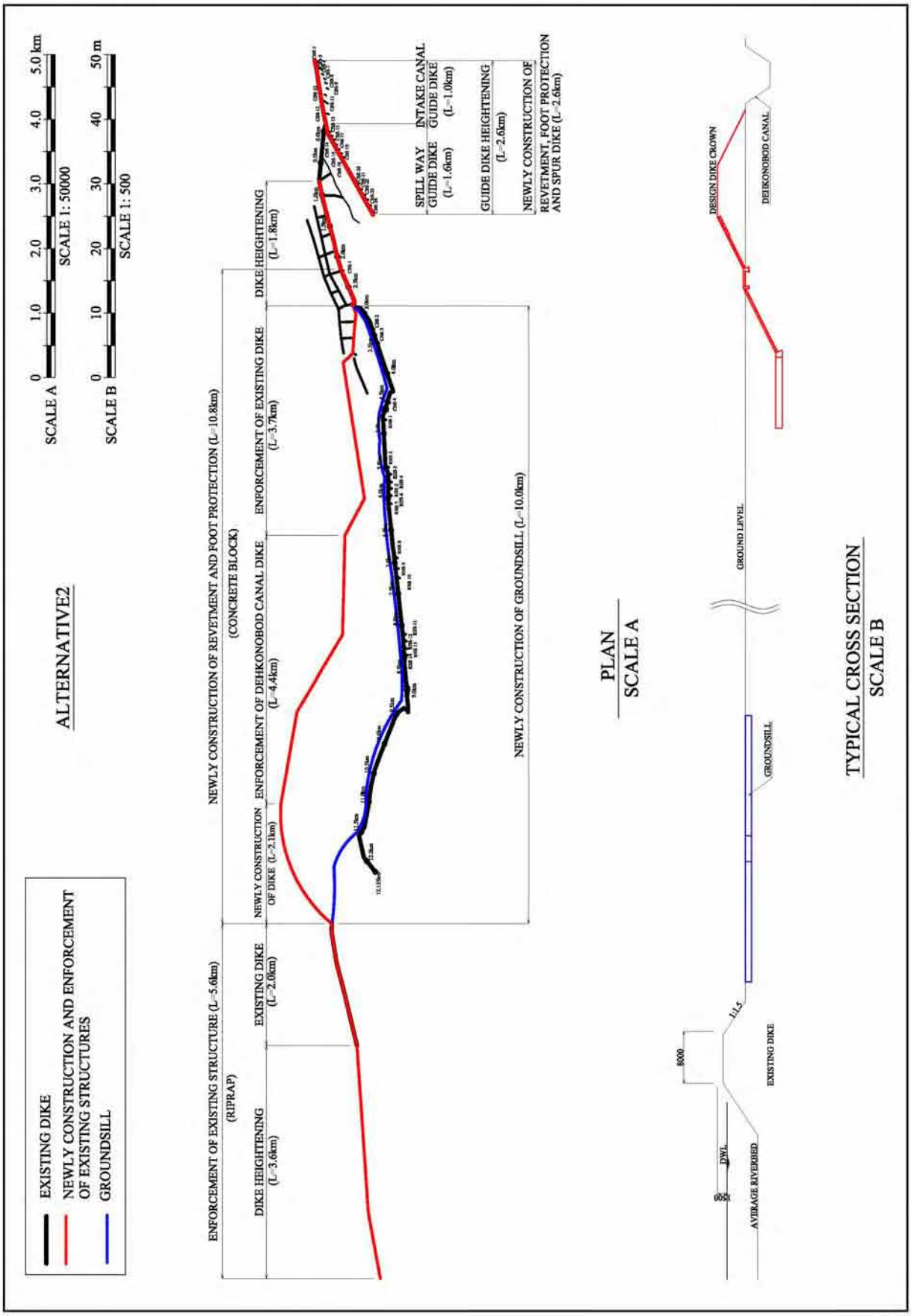
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.7.1 General Drawing of Urgency Countermeasure
CTI INTERNATIONAL ENGINEERING CO., LTD	



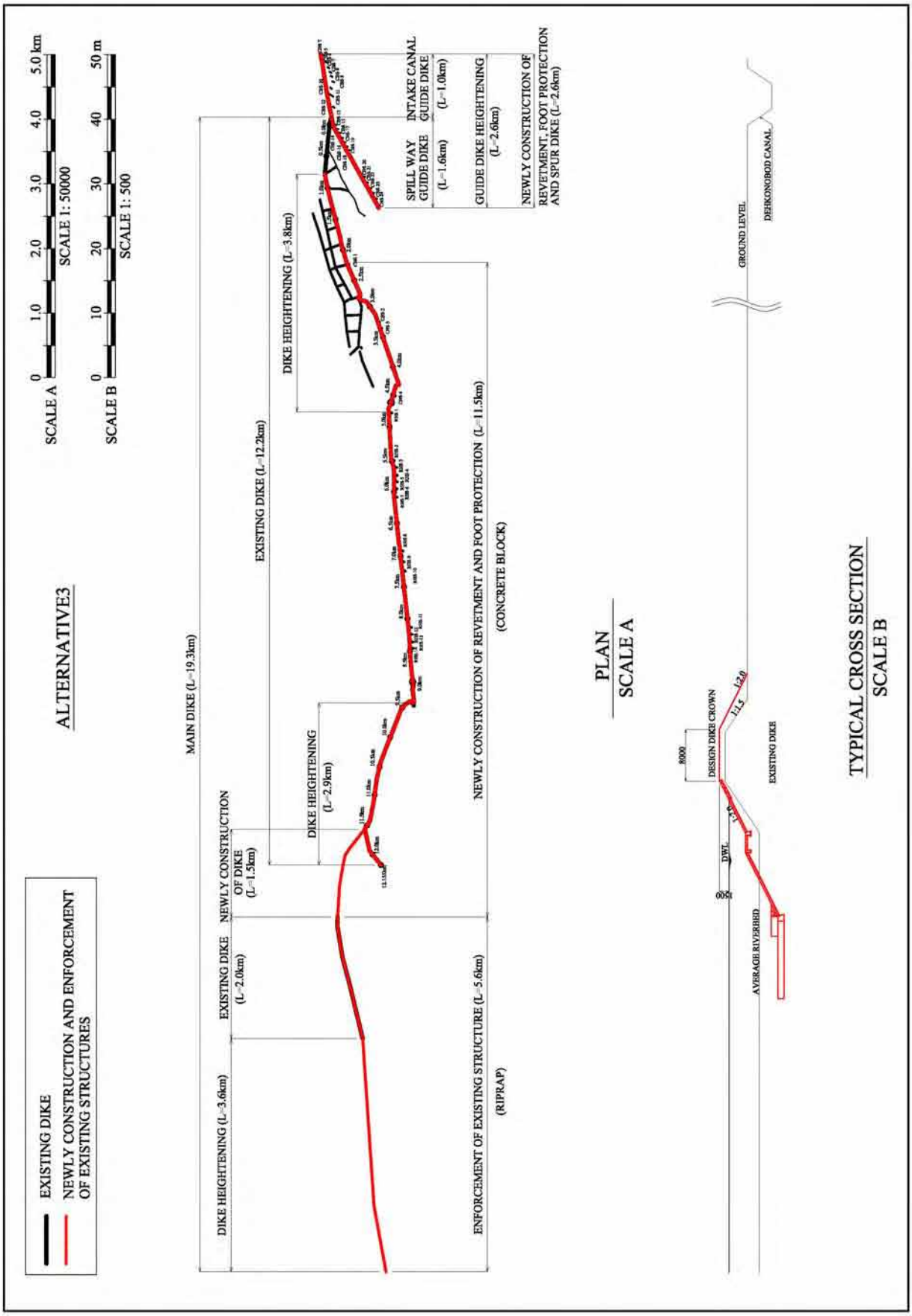
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.8.1 General Drawing of Basic Plan
CTI INTERNATIONAL ENGINEERING CO., LTD	



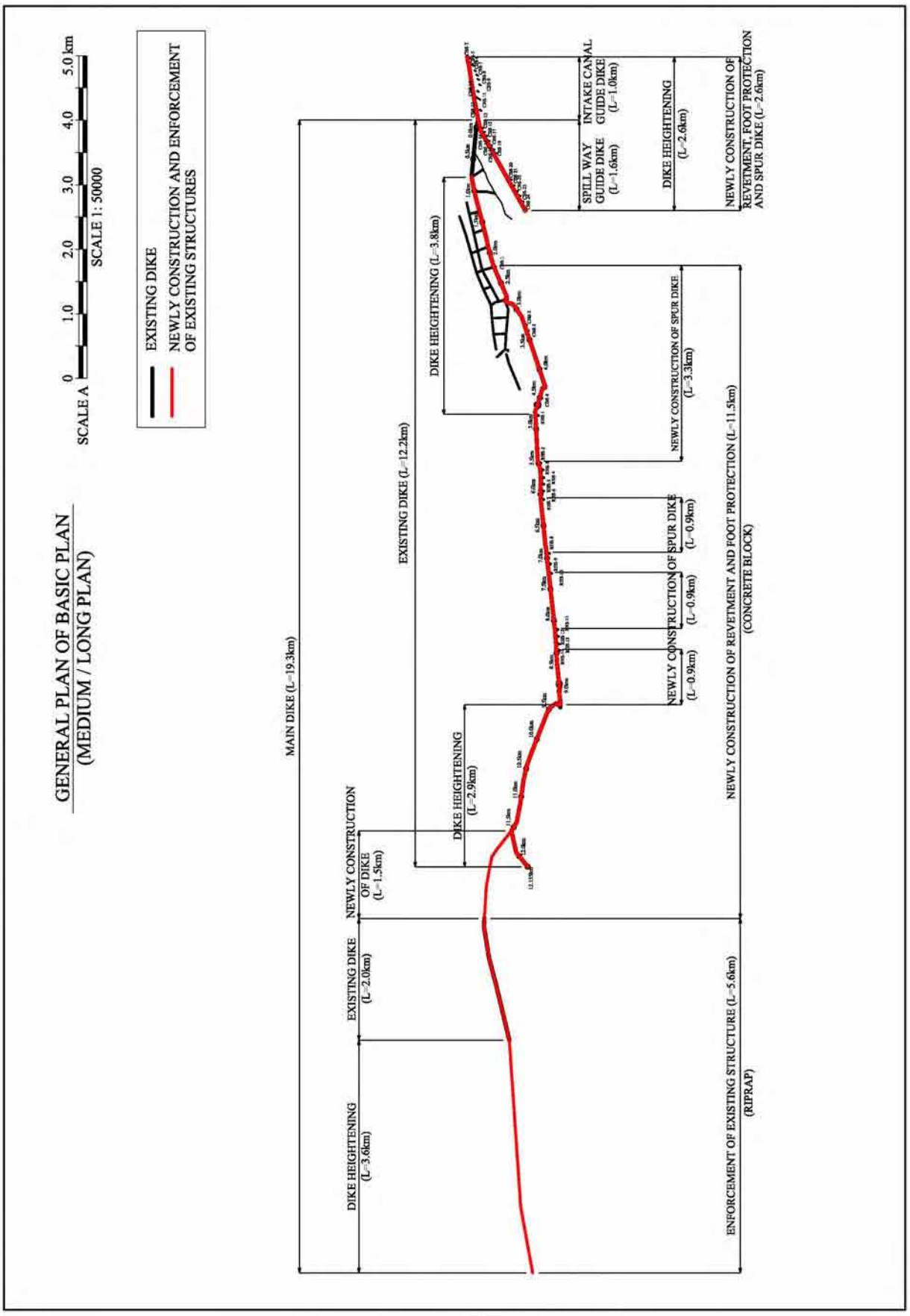
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.8.2 General Drawing of Alternative1
CTI INTERNATIONAL ENGINEERING CO., LTD	



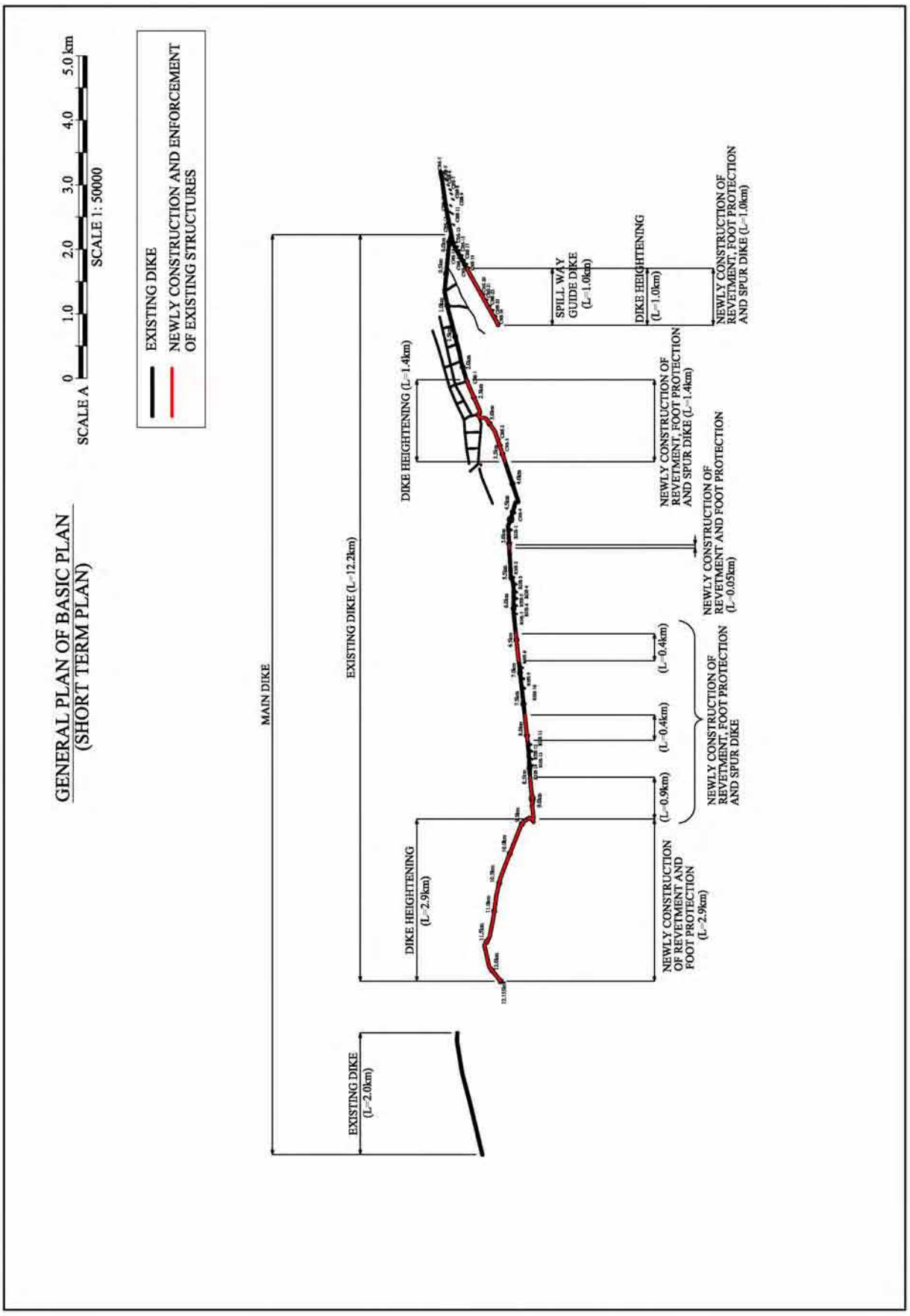
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.8.3 General Drawing of Alternative2
CTI INTERNATIONAL ENGINEERING CO., LTD	



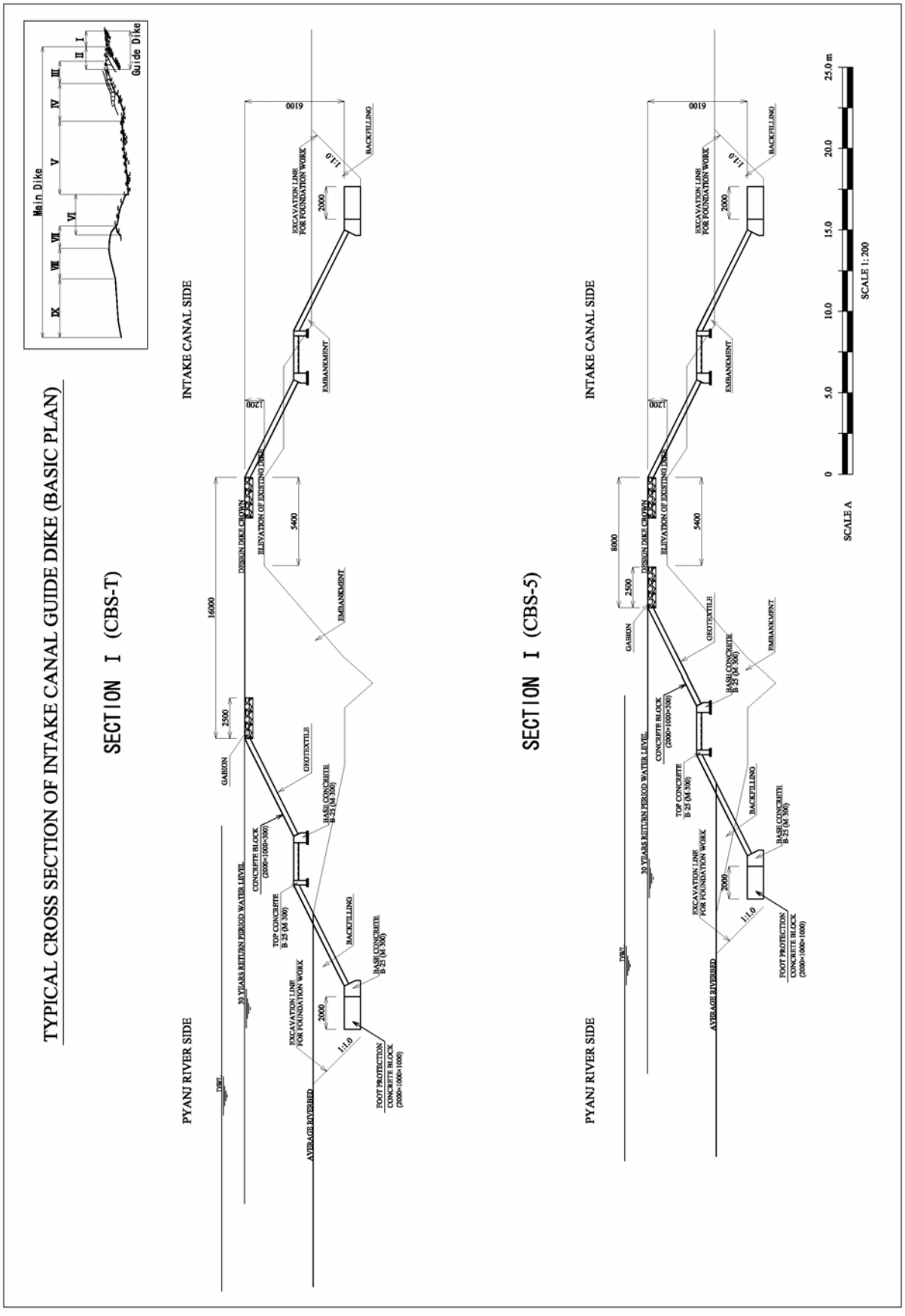
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.8.4 General Drawing of Alternative3
CTI INTERNATIONAL ENGINEERING CO., LTD	



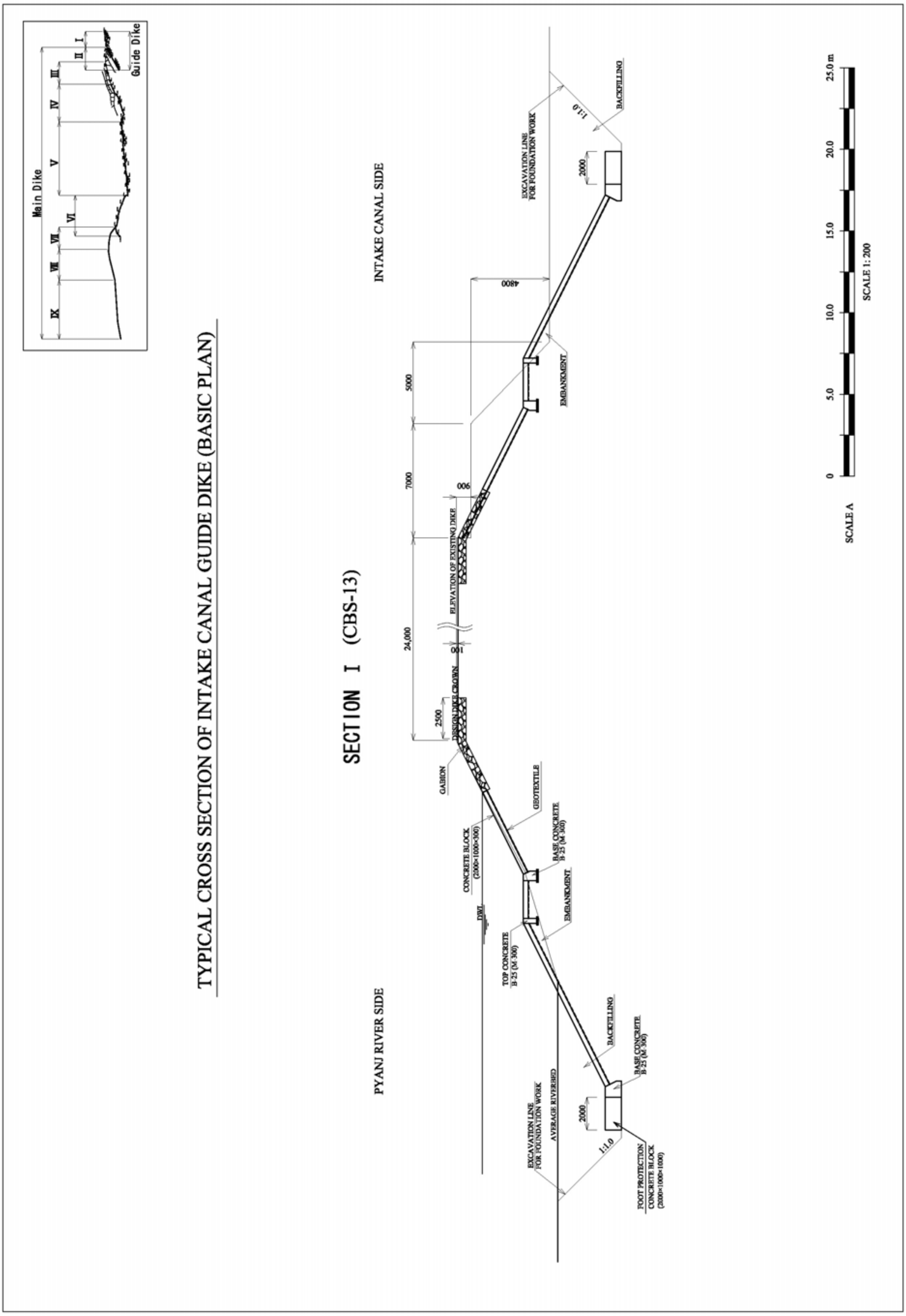
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.1 General Plan of Basic Plan (Medium /Long Plan)
CTI INTERNATIONAL ENGINEERING CO., LTD	



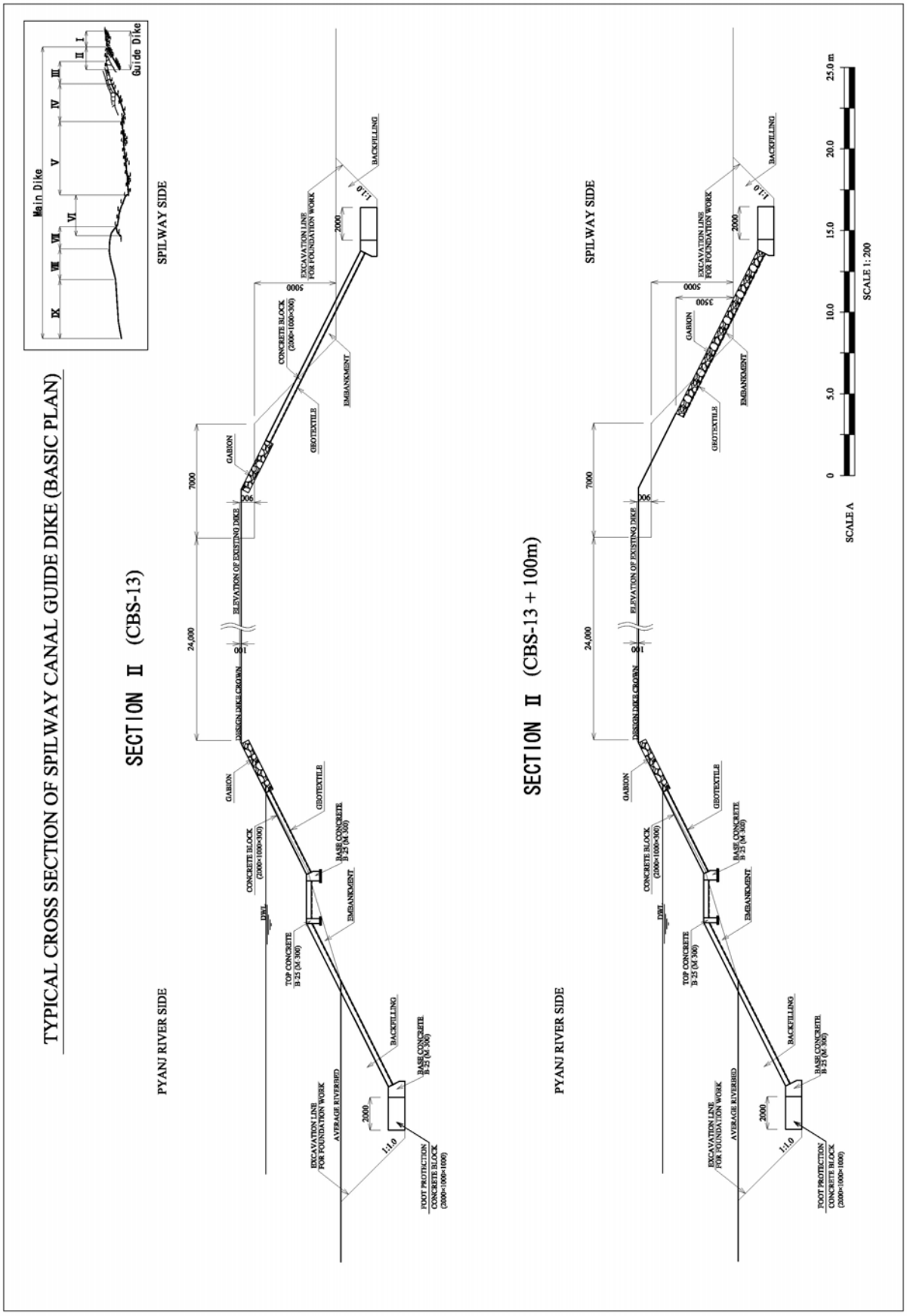
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.2 General Plan of Basic Plan (Short Term Plan)
CTI INTERNATIONAL ENGINEERING CO., LTD	



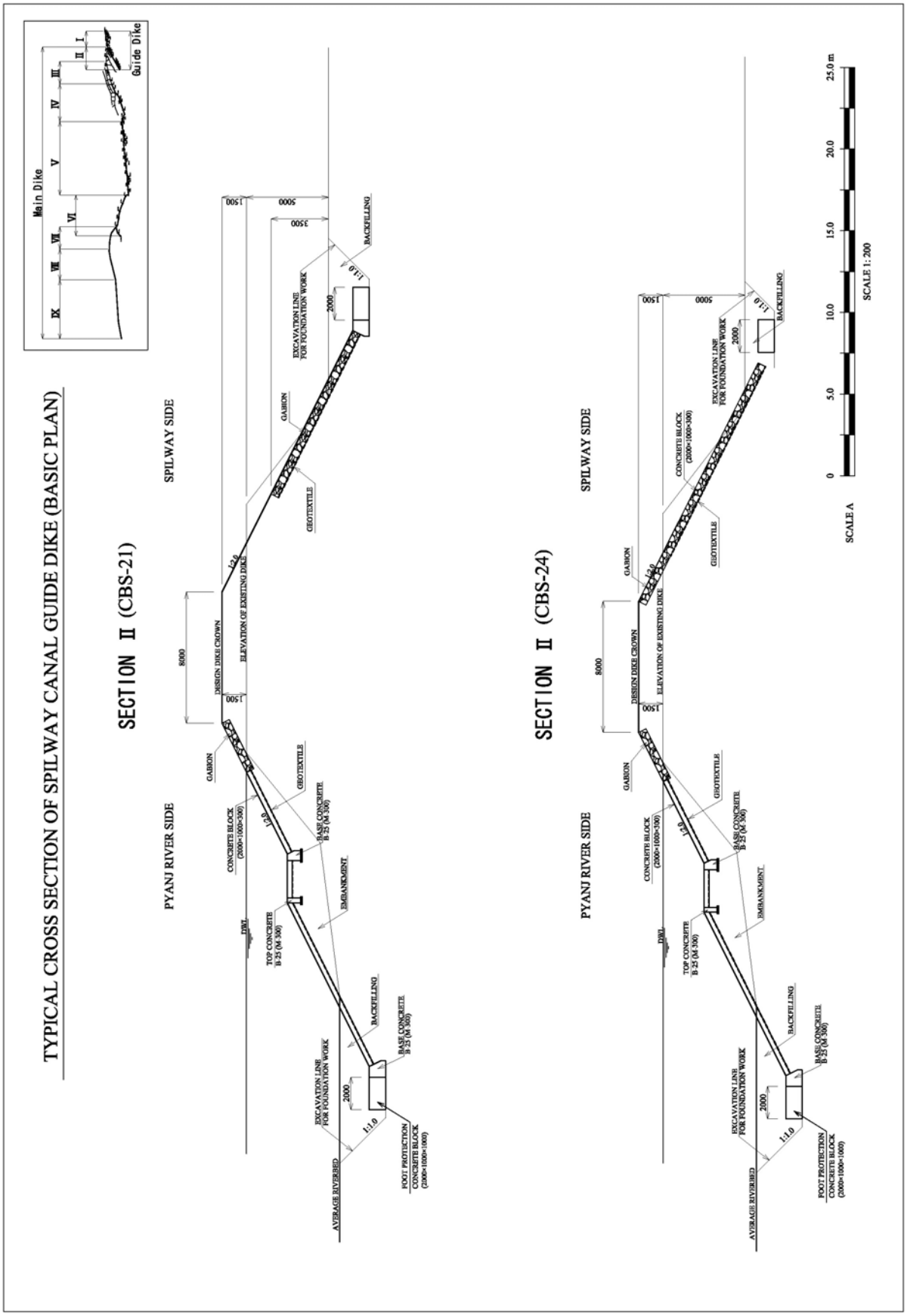
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.3 Typical Cross Section of Intake Guide Dike (1)
CTI INTERNATIONAL ENGINEERING CO., LTD	



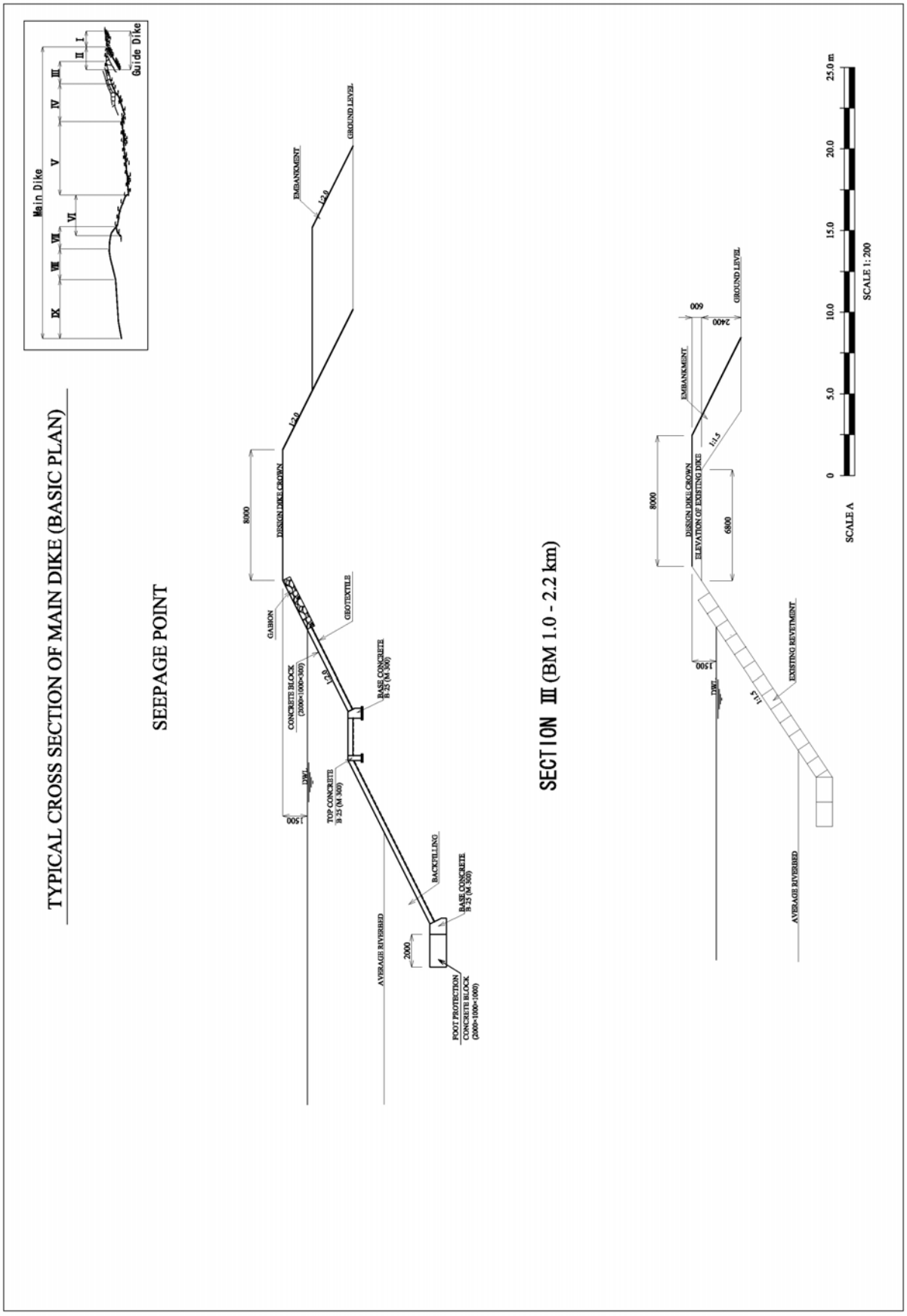
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.4 Typical Cross Section of Intake Guide Dike (2)
CTI INTERNATIONAL ENGINEERING CO., LTD	



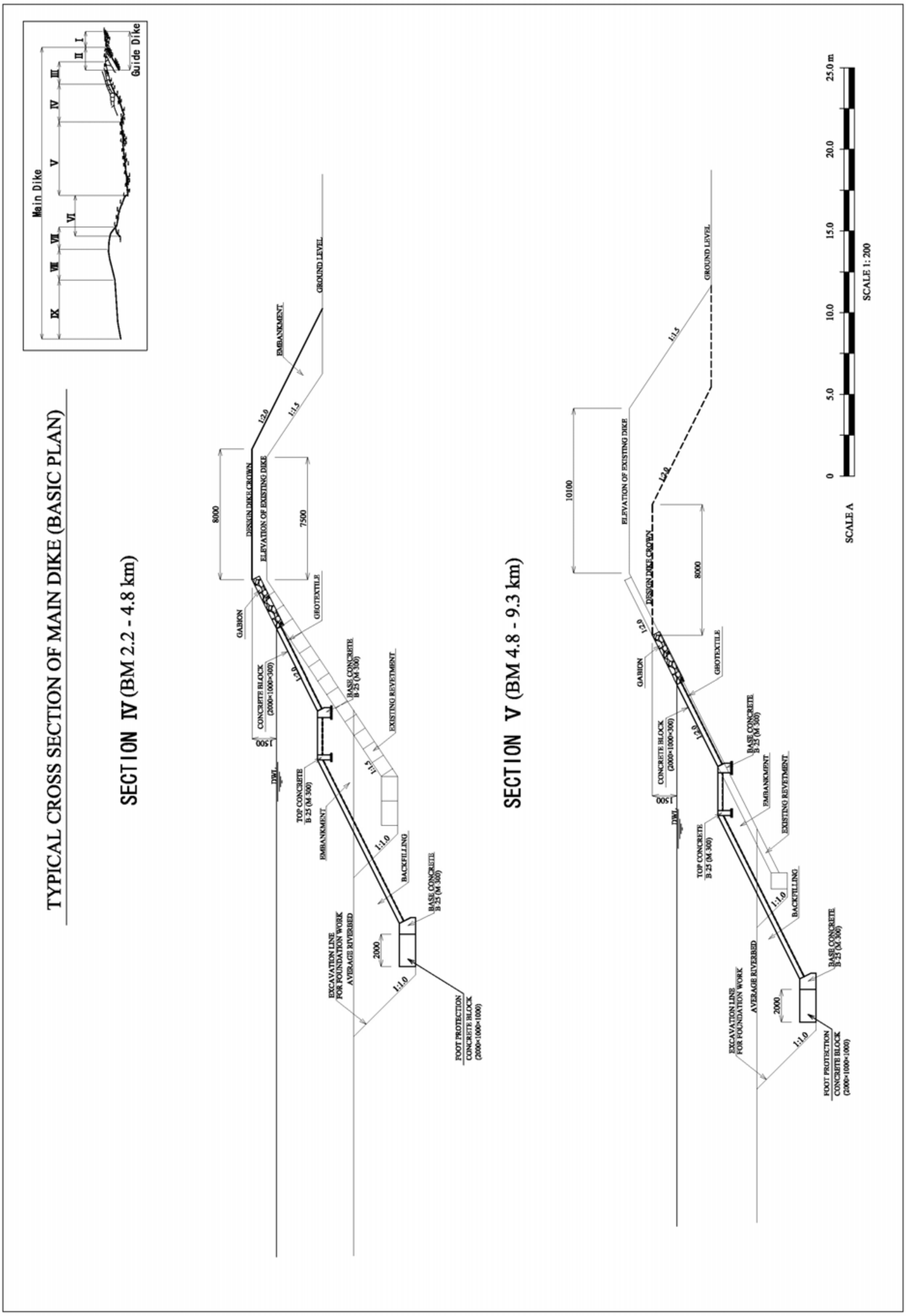
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.5 Typical Cross Section of Spill way Guide Dike (1)
CTI INTERNATIONAL ENGINEERING CO., LTD	



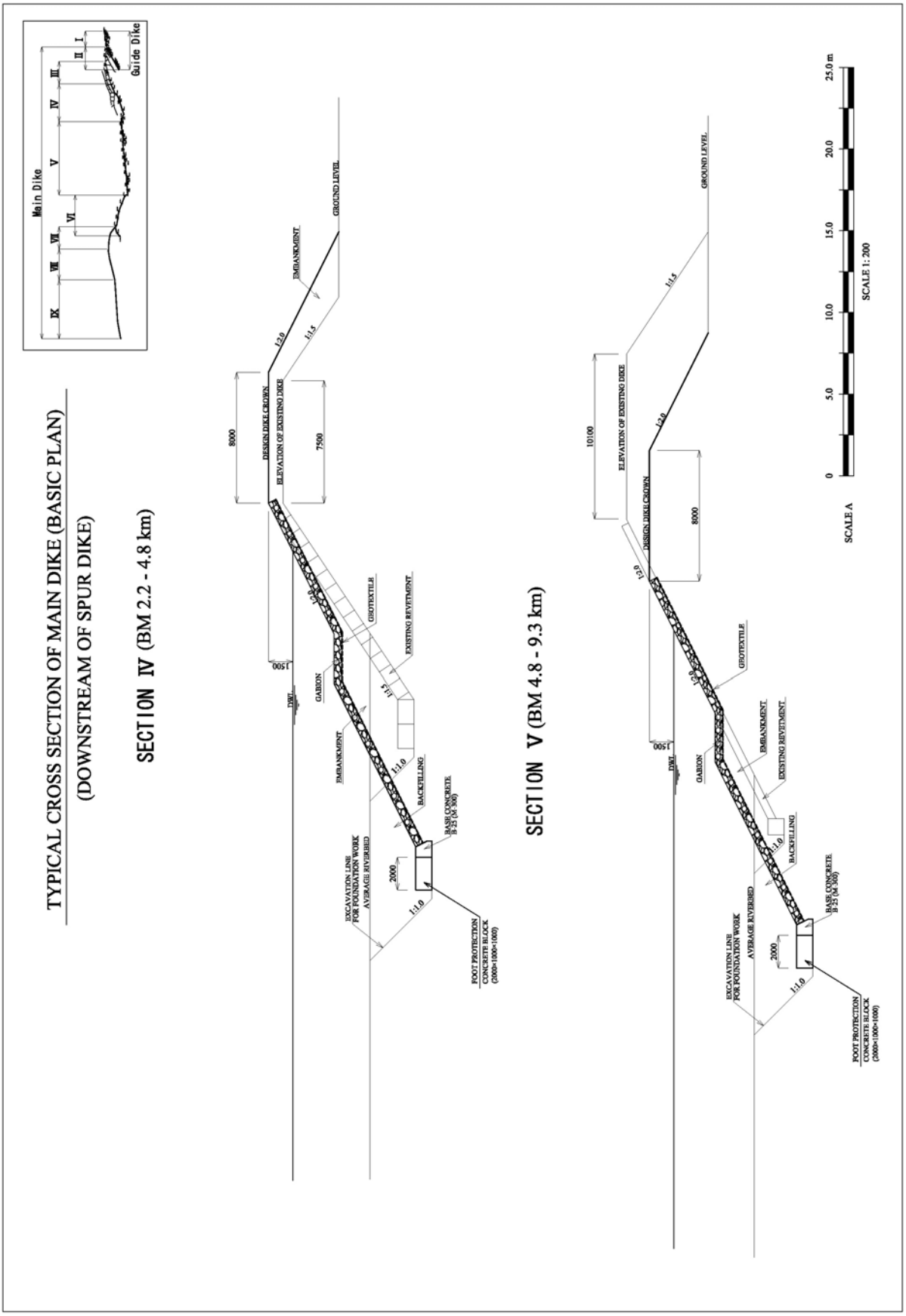
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.6 Typical Cross Section of Spill way Guide Dike (2)
CTI INTERNATIONAL ENGINEERING CO., LTD	



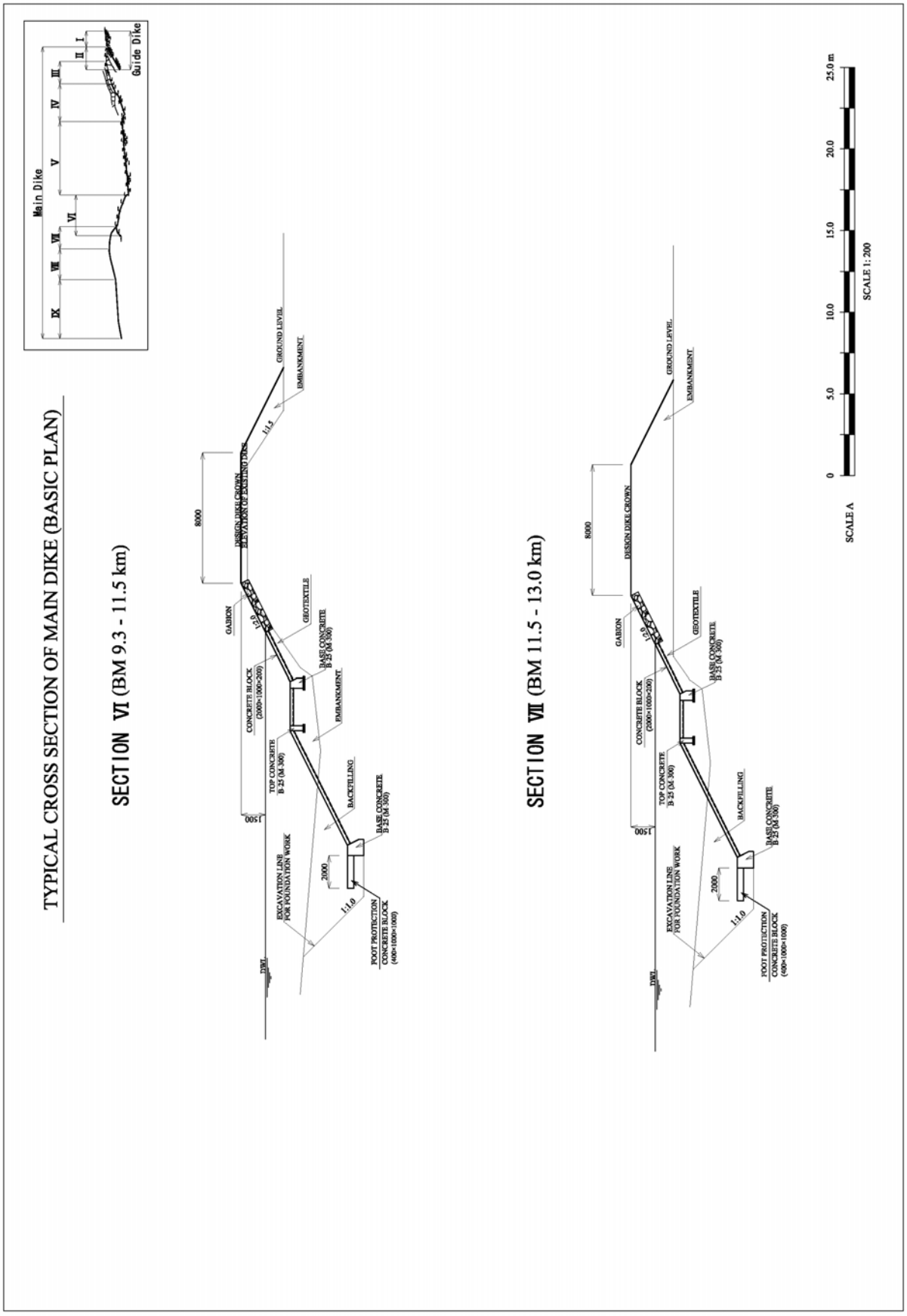
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.7 Typical Cross Section of Main Dike (1)
CTI INTERNATIONAL ENGINEERING CO., LTD	



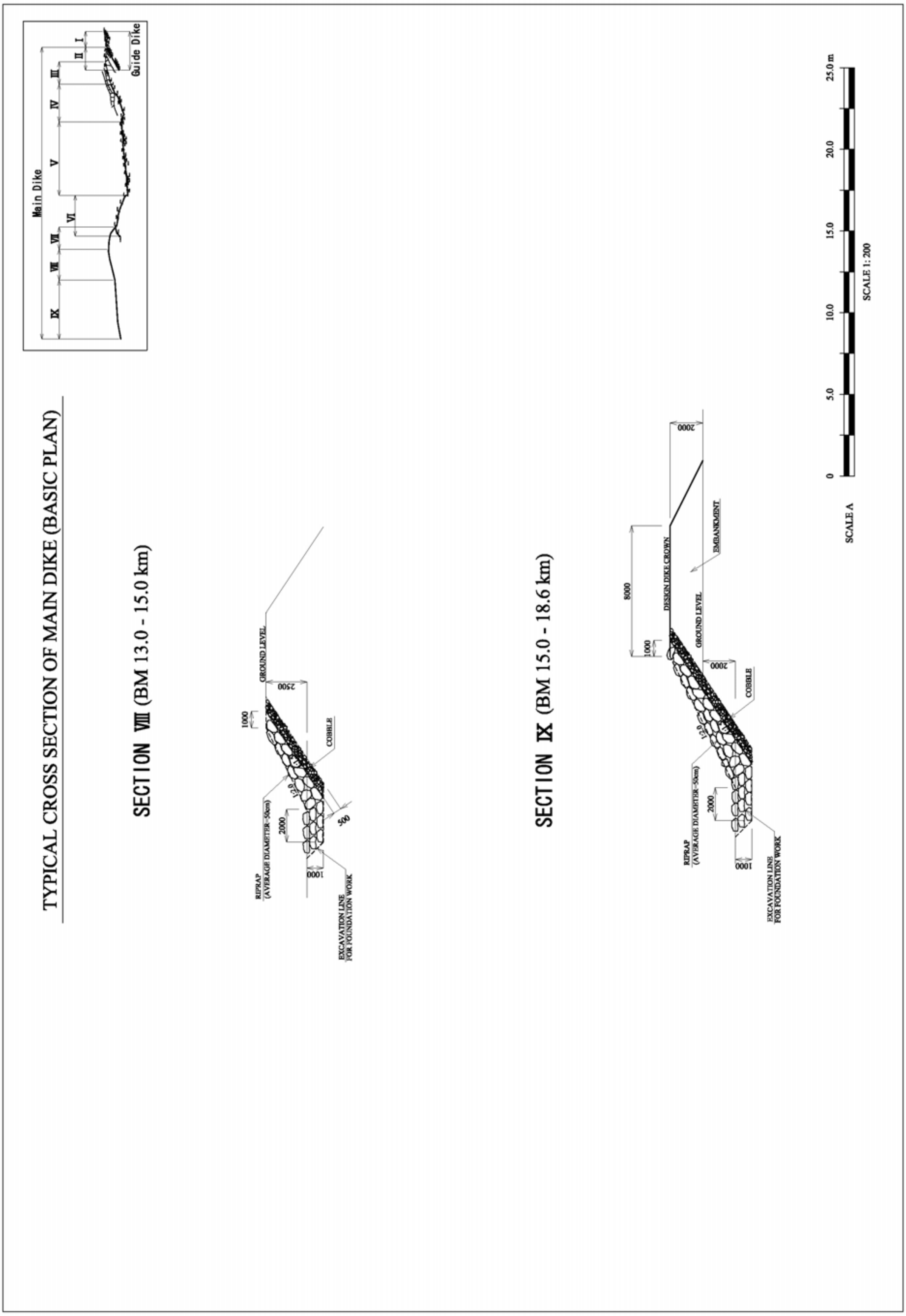
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.8 Typical Cross Section of Main Dike (2)
CTI INTERNATIONAL ENGINEERING CO., LTD	



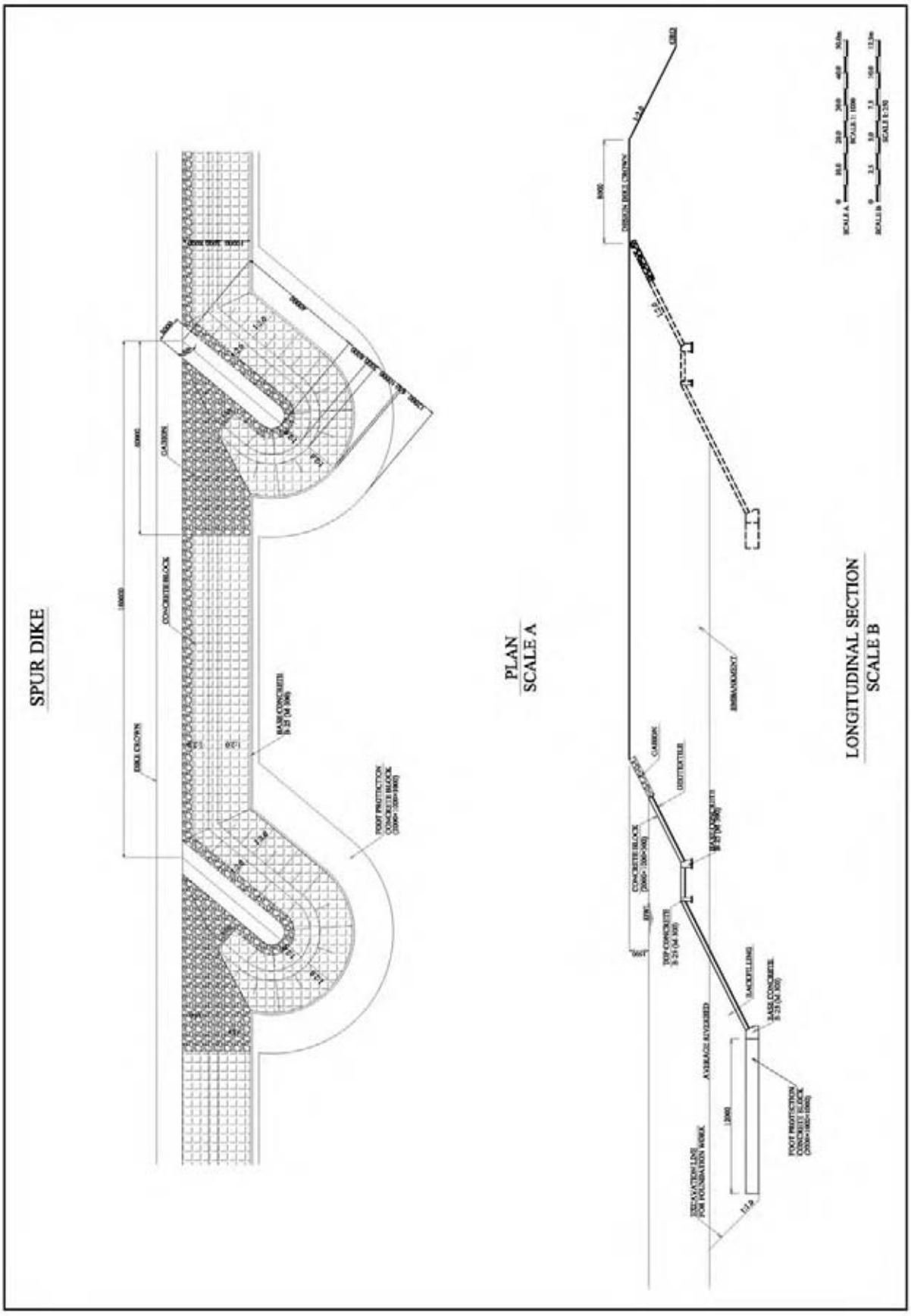
THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.9 Typical Cross Section of Main Dike (3)
CTI INTERNATIONAL ENGINEERING CO., LTD	



THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.10 Typical Cross Section of Main Dike (4)
CTI INTERNATIONAL ENGINEERING CO., LTD	



THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.11 Typical Cross Section of Main Dike (5)
CTI INTERNATIONAL ENGINEERING CO., LTD	



THE STUDY ON NATURAL DISASTER PREVENTION IN PYANJ RIVER	Fig. 5.9.12 General Drawing of Spur Dike
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SECTOR 6 CONSTRUCTION PLAN AND COST ESTIMATE

SUPPORTING REPORT

SECTOR 6 CONSTRUCTION PLAN AND COST ESTIMATE

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SECTOR 6. CONSTRUCTION PLAN AND COST ESTIMATE

6.1 CONDITION OF CONSTRUCTION PLAN

Based on the previous Section, the best alternative was chosen as the Basic Plan for Master Plan. In this Section, construction plan and cost estimated for Basic Plan will be discussed.

6.1.1 Construction Volume

Based on the urgence and budget allocation, the Basic Plan will be separated in two terms. Short Term Plan (hereinafter called "STP") will be conducted within five (5) years and Medium/Long Term Plan(hereinafter called "MLP") will be in eleven (11) years. The main work items and work volumes are summarized as below.

Table R. 6.1.1 The section and length of construction

Construction			Section		Length	
			MLP	STP	MLP	STP
Main Dike	Total		BM(1.0)~BM(18.6)	BM(2.2)~BM(12.2)	18.3km	6.1km
	Dike	Dike	BM(11.5)~BM(13.0)	-	1.5km	-
		Heightening	BM(1.0)~BM(4.8), BM(9.3)~BM(12.2) BM(15.0)~BM(18.6)	BM(2.2)~BM(3.6), BM(9.3)~BM(12.2)	10.3km	4.3km
	Spur Dike(L=40m)		BM(2.2)~BM(5.5), BM(6.0)~BM(6.9), BM(7.3)~BM(8.2), BM(8.4)~BM(9.3)	BM(2.2)~BM(3.6), BM(6.4)~BM(6.8), BM(7.7)~BM(8.1), BM(8.4)~BM(9.3)	6.0km (39 locations)	3.1km (21 locations)
	Revetment	Concrete Block	BM(2.2)~BM(13.0)	BM(2.2)~BM(3.6), BM(5.0)~BM(5.1), BM(6.4)~BM(6.8), BM(7.7)~BM(8.1), BM(8.4)~BM(12.2)	11.5km	6.1km
		Riprap	BM(13.0)~BM(18.6)	-	5.6km	-
	Foot Protection(B=2m)		BM(2.2)~BM(13.0)	BM(2.2)~BM(3.6), BM(5.0)~BM(5.1), BM(6.4)~BM(6.8), BM(7.7)~BM(8.1), BM(8.4)~BM(12.2)	11.5km	6.1km
Intake Canal Guide Dike	Total		CBS-T~CBS-13	-	1.0km	-
	Dike(Heightening)		CBS-T~CBS-13	-	1.0km	-
	Spur Dike				1.0km(7 locations)	
	Revetment(Concrete Block)				1.0km	
	Foot Protection(B=2m)				1.0km	
Spill way Guide Dike	Total		CBS-13~CBS-24	CBS-19~CBS-24	1.6km	1.0km
	Dike(Heightening)		CBS-13~CBS-24	CBS-19~CBS-24	1.6km	1.0km
	Spur Dike(L=40m)				1.6km(10 locations)	1.0km(7 locations)
	Revetment(Concrete Block)				1.6km	1.0km
	Foot Protection(B=2m)				1.6km	1.0km

Note;
STP: Short Term Plan
MLP: Medium / Long Term Plan

Table R. 6.1.2 The main work items and work volumes

Work Item	Specification	Unit	Work Quantity	
			MLP	STP
Earthworks				
Excavation		m^3	975,980	440,700
Embankment		m^3	644,270	322,010
Backfilling		m^3	749,560	350,280
Revetment Works				
Concrete	B-25, M-300	m^3	32,840	15,660
Concrete Block	B-15 (2000×1000×300)	m^3	96,190	44,490
Concrete Block	B-15 (2000×1000×1000)	m^3	116,200	57,160
Gabion	t=50cm, Stone size (15cm to 20cm)	m^3	75,290	35,810
Geotextile		m^2	409,260	191,610
Gravel		m^3	2,210	1,180
Cobble		m^3	27,330	0
Riprap	Average Diameter = 50cm	m^3	44,420	0

Note;
STP: Short Term Plan
MLP: Medium / Long Term Plan

6.1.2 Climate

1) Rain

Based on the 10 years Rainfall record at Hydrometeorology Moskovskaya Station, rainfall more than 10mm is average 2 days per a month. Maximum days is 3.60 days on March and minimum days is 0 days on June, July and August.

Rainfall more than 50 mm had twice during 10 years, it is very seldom happened in Moskovaskaya, Hamadoni Rayon (see Table R 6.1.3)

From the below data, embankment work for dike will be affected by rainfall in two days per month. It is not necessary to consider the dry up days for earthworks.

Table R. 6.1.3 Number of Rainfall Days Per Month from 1986 to 1995

NO. OF DAYS FOR RAINFALL > 10mm

Year	January	February	March	April	May	June	July	August	September	October	November	December
1986	0	1	1	2	1	0	0	0	0	0	1	5
1987	1	2	5	4	0	0	0	0	0	3	0	0
1988	3	2	3	4	0	0	0	0	0	0	0	4
1989	2	3	0	0	1	0	0	0	0	0	2	1
1990	3	4	4	0	0	0	0	0	0	0	0	1
1991	2	2	5	4	1	0	0	0	1	0	0	3
1992	4	2	4	3	4	0	0	0	0	0	0	3
1993	1	3	6	2	2	0	0	0	0	1	3	1
1994	2	4	6	2	1	0	0	0	0	1	1	4
1995	1	2	2	2	0	0	0	0	0	0	0	0
Average	***1.90***	***2.50***	***3.60***	***2.30***	***1.00***	***0.00***	***0.00***	***0.00***	***0.10***	***0.50***	***0.70***	***2.20***

Average 1.23 Days

NO. OF DAYS FOR RAINFALL > 50mm

Year	January	February	March	April	May	June	July	August	September	October	November	December
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	1	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	1	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0
1995	0											
Average	***0.00***	***0.00***	***0.11***	***0.11***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***

Average 0.02 Days Maximum Precipitation= 71.3 mm

2) Temperature

Concrete pouring work cannot conducted when the temperature below 4 degree, unless contractor have to make provision against the cold during pouring and curing period. In this Moskovaskaya, average days below than 4 degree are 8.9 days in December, 17.5 days in January and 9.3 days in February. Therefore, concrete pouring for concrete block shall be done in Batching Factory. Especially, in the year of 1989, from beginning of January to the end of February, in total of 51 days are below 4 degree. The Project area is located in wide-open area and there is no obstruction for wind. Feeling temperature in the construction site will be much colder than real temperature.

Table R. 6.1.4 Number of Days Below 4-Degree Temperature Per Month from 1986 to 1995

NO. OF DAYS FOR TEMPERATURE < 4℃

Year	January	February	March	April	May	June	July	August	September	October	November	December
1986	15	9	4	0	0	0	0	0	0	0	5	13
1987	4	7	0	0	0	0	0	0	0	2	4	5
1988	14	10	2	0	0	0	0	0	0	0	0	4
1989	30	21	0	0	0	0	0	0	0	0	0	3
1990	19	9	4	0	0	0	0	0	0	0	0	16
1991	20	0	0	0	0	0	0	0	0	0	0	9
1992	18	7	5	0	0	0	0	0	0	0	0	7
1993	25	6	2	0	0	0	0	0	0	0	1	13
1994	16	16	0	0	0	0	0	0	0	0	0	19
1995	14	8	1	0	0	0	0	0	0	0	0	0
Average	***17.50***	***9.30***	***1.80***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.20***	***1.00***	***8.90***

Average 3.23 Days

6.1.3 Workable Days

1) Workable period and Time

Based on the Khirmanjo water level station in Pyanj River, in which 80 km upstream of Hamadoni, the water level increased from the end of April and reach to the highest level in June or July. Then water level decreased from end of November and lowest period is February.

Therefore, a possible and safety construction period of civil work in riverside is from the month of December until beginning of April.

Normal daily working time is from 8:00 to 17:00 though Monday to Saturday. Public holiday is 9 days per year, which show in below;

Holiday	Date
New Year's Day	January 1
Women's Day	March 8
New Day (Tajik New Year)	One day in March
Labor Day	May 1
Victory Day	May 9
National Reconciliation Day	June 27
Independence Day	September 9
Ramadan Day	One day in October
Constitution Day	November 6
Total of Public Holidays for a year	9 days

Based on the 10 years daily observed water discharge volume in Khirmanjo Station, workable days will divided in three (3) phases, 1) high water period, 2) transition periods and 3) low water period.

The relation between phases and water volume is decided as shown in table. The total number of daily data is 9,825.

Table R. 6.1.5 Ratio for Each Water Level Period

Name of Phase	Discharge Volume	Number of Data	Ratio of the Total
High Water Period	More than 1000 m3/s	3,339	34 %
Transition Period	Between 300-1000m3/s	3,344	34 %
Low Water Period	Below 300 m3/s	3,142	32 %

At high water level, all the construction work at riverside will be suspended. During the transition period, revetment works such as gabion mattress, placing of concrete block and wet stone masonry work are practicable. Foundation works, foot protection and river dredging work are only available in low water period.

Therefore, the workable days with considering Public Holiday, Sunday and Water level conditions were listed in Table R 6.1.6.

Table R. 6.1.6 Workable Days by Water Level Condition

No.	Conditions	Subtraction day	Calculation	Workable day
1	Public Holiday	9	365-9	356
2	Sunday with 1.	52	356-52*	304
3	Transition Period	34% of available day	304*(1-0.34)	200.6
4	Low water Period	32 % of 2.	304*0.32	97.3

Note: * if holiday is Sunday next Monday becoming holiday.

2) Workable days for Concrete Works

Workable days for concrete work was mention in 6.1.1 2), 4 degree below is not able to placing concrete in the site. The ratio of the temperature below 4-degree days per an annual year is 38.7/365=0.11.

However, the day below 4 degree is also same period of dry level. Thus, workable days of the concreting works of partition wall is minimum 58.5 day at foundation and 161.9 days at revetment works.

3) Workable day for Each Work

Based on above study, workable day for each construction work can be summarized in following table.

Table R. 6.1.7 Workable Day for Each Construction Work

Location	Work Item	Workable Days	Remark
Facing River and Inside of river			
1.	Excavation/Dredging Work	97	
2.	Embankment Work	97	
3.	Backfilling Works	97	
4.	Foot Protection Work	97	
5.	Concrete Block Work	97	Fabricate in Factory
6.	Concrete Pouring in Foundation	58	Ready Mix Concrete
7.	Concrete Pouring in Revetment	161	Ready Mix Concrete
8.	Gabion Mattress Work in revetment	200	
9.	Wet Stone Masonry Work in Revetment	200	
Back Side of Dike and Inland Work			
1.	Excavation Works	304	
2.	Embankment Works	304	
3.	Fabricate Concrete Block	304	
4.	Gravel Pavement	304	

6.1.4 Procurement of Labor, Materials and Equipments

1) Labor

Common labor and operator are available in the Hamadoni rayon. During the planting and budding stage of cotton, number of labor can be decreased. Most of Engineer becomes migrant worker in Russian, because of the high income. They will come home during the winter in Russian.

Table R. 6.1.8 Availability of Construction Labor

Item	Available in Hamadoni	Available in Tajikistan	Remark
Common Labor	◎		In the site
Operator	◎		In the site
Foremen	◎	◎	Available in Dushanbe
Engineer		◎	Available in Dushanbe

Note: Based on the site interview in Hamadoni.

2) Construction materials

Construction materials in Tajikistan have a limitation. Soil and stone are available on the site, but other materials are mostly imported from abroad. The tax for these import materials and transportation fee will be added on the market price, therefore it makes difficult to use it on construction site. The ratio of materials is dominant more than 80 % of the project cost

Table R. 6.1.9 Availability of Construction Materials

Item	Available in Hamadoni	Available in Tajikistan	Import from Aboard	Remark
Boulder	◎			5 km from site
Gravel	◎			In the site
Stone	◎			In the site
Soil	◎			Near the site
Reinforcement Bar		◎	◎	Available in Gissar
Steel Plate		◎	◎	Available in Gissar
Gabion Mattress			◎	From Russian
Geotextile			◎	From Russian
PVC Pipe	◎			Available in Gissar
Cement		◎	◎	Available in Dushanbe
Wire		◎		Available in Gissar

Note: Gissar City is 20km west from Dushanbe.

Especially, there is an only one (1) cement factory in Dushanbe, Tajikistan and all the amount which product by this factory shall be used for the construction of the Hydro Power Stations by the Resolution of President Order. Therefore Tajikistan is shortage of Cement and market price is expensive than factory.

Reinforcement bar, steel and other steel products are available in Gissar City. However, the origins of these materials are come from aboard by train. The transportation of material from Gissar City to Hamadoni rayon is commonly used by truck. But truck will not deliver unless cargo space is full, because of high congestion charge at each checking station.

3) Construction Equipment

Common using equipment for earthwork is available in the site. Agitating truck is not available in Hamadoni, concrete factory is producing secondary product. If contractor need ready mix concrete, they have to provide an agitator. Excavation works of river channel are using bulldozer during the dry-up period. Dredger boat is not available in the site.

Most of constructions equipments can be seen in the site are old, but it is in workable condition under the proper management.

Table R. 6.1.10 Availability of Construction Equipment

Item	Available in Hamadoni	Available in Tajikistan	Remark
Grader	◎		In the site
Dump Truck 4ton	◎		In the site
Dump Truck 10ton	◎		In the site
Bulldozer, 21ton	◎		In the site
Bulldozer, 11ton	◎		In the site
Backhoe, 0.65m3	◎		In the site
Motor Roller	◎		In the site
Tractor, 80 Hp	◎		In the site
Truck Crane, 16ton	◎		In the site
Crawler Crane, 35ton		◎	Available in Dushanbe
Agitating Truck		◎	Available in Dushanbe
Dredger			Not Available

Note: Based on the site interview in Hamadoni.

6.1.5 Scale of Project Size

The project size of Master plan will be evaluated based on the following conditions.

- Implementing contractor is considering for local contractor.
- Project Cost is allocated in foreign loan basis.
- Project size will be examined based on the past and on-going related/similar projects.
- Detailed Design and Tender work will be adopted foreign and local consultant.

The actual Flood Mitigation Projects at Pyanj River is listed in below table.

Table R. 6.1.11 Actual Contract Size for Previous Related Project In Pyanj River

Year of Implementation	Type of Works	Name of the Contractor	Contract Amount	No. of Sub-contractor
2005-2006 (6 months) Under MMWR	Construction and Rehabilitation Works of Flood Control Facilities (Dike, Spur Dike, Revetment), Construction of Dike length is about 1 km per company.	・ Gayur ・ PMK-16 ・ PMK-31 ・ Ltd. "Ramz"	1million USD each	Form 0 to 4 sub-contractors
2007 (About 4 months) Under MMWR*	Maintenance work for Existing Dike and Spur Dike.	・ Ltd. "Ramz" ・ PMK-12 ・ Gayur ・ Obshoron ・ Neki	From 0.25million USD to 0.8million USD	
2007 (About 3 months) Under CoES	Construction of Spur Dike	・ PMK-39	2.0 million (TJS)	

Major work volume for each contract is following; Ltd. "Ramz": 600pc concrete block, 800m3 concrete grouting, PMK12: 2500pc concrete block, 112,000m3 cofferdam, Gayur: 3500 pc concrete block and 2.0 km cofferdam.

Based on the actual condition, tender Period was conducted within 2-3 months and construction work starts this February 2007 until May 2007. Guarantee period was 6 months. After guarantee period, constructed facilities will turn over to MMWR for Maintenance.

After the evaluation of above data, an annual workable capacity for single contractor is about 2million USD. Therefore, an aptitudinal scale for 3 years project will be 6 million USD.

6.1.6 Borrow Pit and Spoil Area

Borrow Pit can be found in village Sayyod where about 15 km from the Cubek Intake. In this area soil and sand is available. In order to utilize for embankment materials, blending soil and sand is required. For the transportation of soil and sand to the construction site, rehabilitation and maintenance works of existing road is necessary. There is only one main road from Sayyod to the site in which will be passing village Metintugay and village Panjob. People in these area using this road for all the works and the condition of existing road is not sustainable for heavy dump truck. Therefore, repair and maintenance cost of existing road shall be considered in cost estimate. There are two quarry sites available in this area, one is the back site of Cubek Intake and another is QARATOY Mountain Chain. Qaratoy Mountain is located 70 km west from the project site and it products good hardness of cobblestone.

Spoil area is available in near construction site. Lowland area is scattered between existing river dike and Dehkonbod Canal where is suitable for backfilling the excavated materials from river. The locations of borrow pit for sand, soil, quarry and spoil area are shown in Fig. R 6.1.1

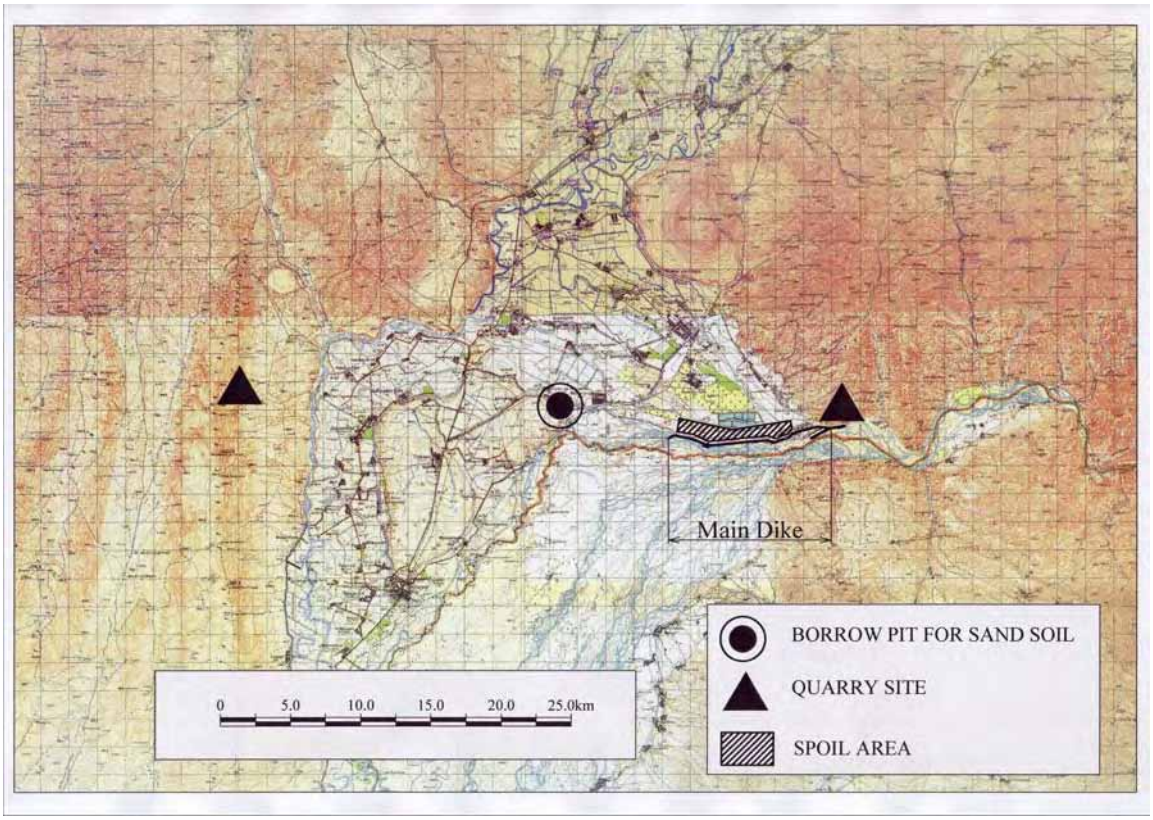


Fig. R.6.1.1 The locations of borrow pit and spoil area

6.1.7 Availability of Concrete Production in Hamadoni Area

There is one concrete plant in Hamadoni. This concrete factory is produced pre-cast concrete wall for building, u-ditch/pipe culvert for irrigation water cannel, and concrete block for dike protection. The maximum mixing volume for concrete is 200 m3 per day. Therefore, monthly and yearly product volume are calculated 5,000m3 (200*25days) and 60,000m3, respectively. However, based on the existing circumstance, stable electric power supplies is difficult in Hamadoni Area. Probable an operating rate is 50% and annual product will be 30.000m3.

For the STP and MLT of Master Plan, required concrete volume is 112,530m3 and 240,450m3. Implementation schedule for STP and MLT are 3 years and 5 years, respectively. In order to complete project for STP and MLT, concrete factory is not enough capacity for all the concrete works.

As the construction plan, portable concrete mixing plant shall be considering for the implementing the project.

6.1.8 Power Supply

Power supply is not reliable at Hamadoni and Government of Tajikistan. Storage of electric supply will be delayed the schedule of production of concrete block at factory and site. Generator shall be provided for the urgent works and backup the minor works.

6.2 CONSTRUCTION METHOD

The construction works employ conventional and effective styles. Construction works will be carried out by the standard and common equipment at the site.

6.2.1 Preparation Works

Preparation Works are considering in Master Plan. The major works of preparation works are following;

- Repair and Maintenance of Existing Road for hauling materials from village Sayyod.
- Portable Concrete Mixing Plant in the Construction Site
- Stock Yard for Materials
- Earthwork in borrow pit and spoil area.
- Mobilization and Demobilization of Equipment

6.2.2 Temporary Works

Temporary works are considering cofferdam works, dewatering works and access road works. Cofferdam is necessary for Dike Works, Spur Dike and Foot Protection Works. Especially, foot protection works for dike and spur dike required dry working condition, therefore, dewatering works have to be considered in any occasion. Coffering materials is available in the riverside and implementing of cofferdam shall be executed beginning of the Low Water Period.

Embankment work conduct inside of river channel required access road for hauling soil from the borrow pit. Access road shall be less than 10% of gradient with 4.0m width and access road shall be always allowed one-way traffic in order to avoid accident. Thus, work volume for an access road always counts two time because of up and down.

6.2.3 Earth Works

Earth works consist of excavation, embankment and backfill. Equipment for earth works is executing by bulldozer, excavator and dump truck.

The combination of equipment for earthwork is listed in below.

Table R. 6.2.1 The combination of equipment for earthwork

Work Item	Type of Work	Type of Equipment
Access Road/ Coffer Dam	Excavation	Backhoe 1.0m3、Bulldozer 16 ton
	Hauling	Backhoe 1.0m3、Dump Truck 11 ton
	Leveling and Compacting	Bulldozer 16 ton, Tire-Roller、Tamper
Removal of Existing Structures	Lifting	Track Crane 15 ton、Wheel Crane
	Hauling	Dump Truck 11 ton
Repair of Existing Road	Leveling and Compacting	Grader, Tire-Roller, Dump Truck

6.2.4 Revetment works

Revetment works are including concrete work, gabion work and masonry work. Concrete block is planned to fabricate in concrete factory or in the site. Gabion mattress will be imported from abroad. Boulder and Cobblestone are available in near the construction site. Equipment for revetment work is commonly used in the construction area.

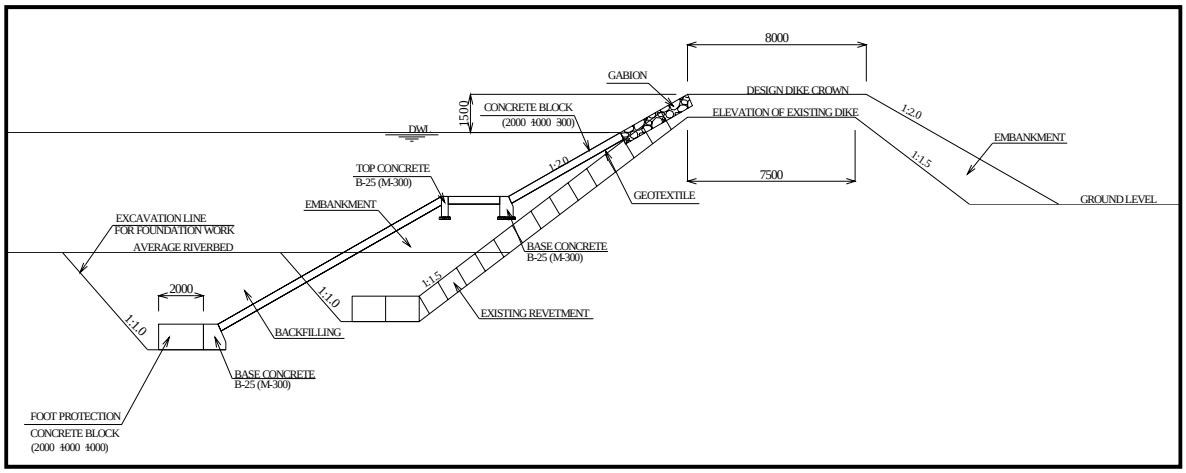
Table R. 6.2.2 The combination of equipment for revetment works

Work Item	Type of Work	Type of Equipment
Revetment	Concrete	Truck Crane 15 ton Vibrator
	Concrete Block	Truck Crane 15 ton, Dump Truck
	Gabion	Truck, Water Pump
	Riprap	Backhoe 1.0m3, Dump Truck

6.3 CONSTRUCTION PROCEDURE

6.3.1 Dike

Construction procedure for dike is similar with Spur Dike, starting foundation works and revetment works. Concrete block are placed up until the Design Water Level (DWL). Above of concrete block is applied gabion mattress. Typical cross-section and construction procedure of Dike is shown in Fig. R.6.3.1.



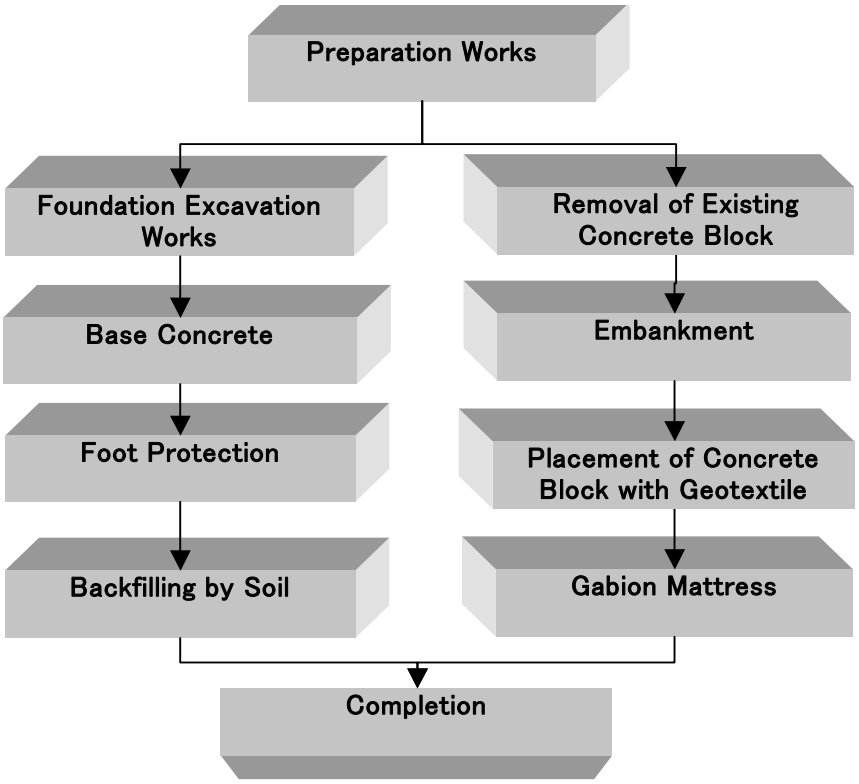
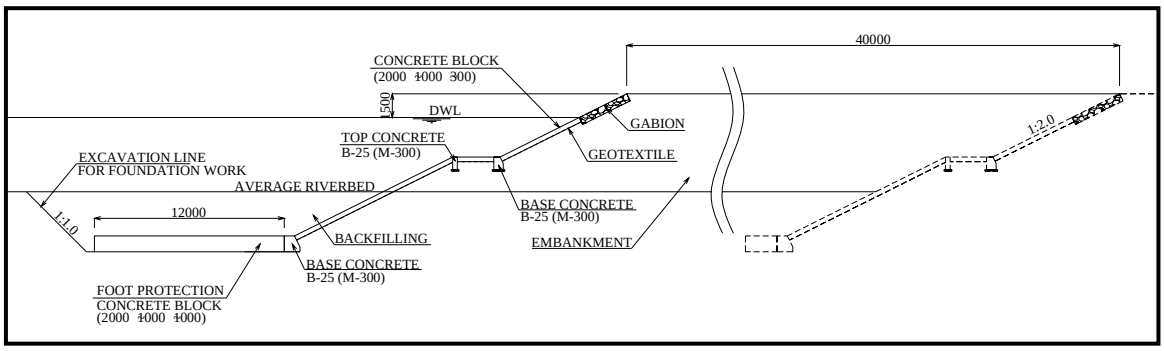


Fig. R.6.3.1 Typical cross-section and construction procedure of Dike

6.3.2 Spur Dike

Construction of Spur Dike starts from the excavation works, and base concrete works. Foot protection will be placed by concrete blocks with 12 meter length and each concrete block is connected with four ways by steel shackle. Concrete block will be produced in concrete bitching plant and transport to the site. Distance between site and bitching plant is 10 km approximately. Typical cross-section and construction procedure of Spur Dike is shown in Fig. R.6.3.2



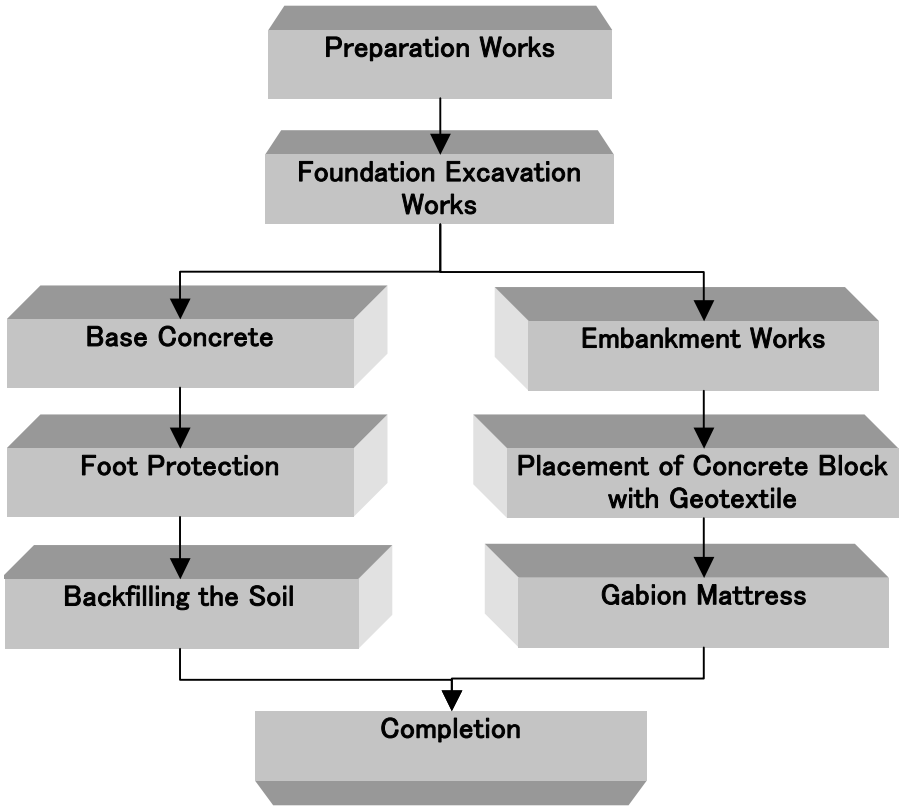


Fig. R.6.3.2 Typical cross-section and construction procedure of Spur Dike

6.3.3 Urgent Repair work for Existing Dike

Urgent repair works will be carried out two (2) years until the STP starts implementing. Repair is only concentrate to the critical portion of dike. Countermeasure for repair works have two ways. One is protection of scouring at the toe of dike by using boulder and concrete block. Another is by using gabion mattress to prevent damage of revetment.

6.4 IMPLEMENTATION SCHEDULE

Implementation schedule will consider three (3) stages as Detailed Design Stage, Construction Stage and Maintenance Stage.

6.4.1 Detailed Design Stage

Detailed Design stage will consist with basic survey works, structural detailed design and tendering. Survey works take 10 month and structural detailed design need 12 months. Tendering work is schedule for 6 months. Review the Detailed Design will be schedule one (1) year after the completion of construction of STP. Necessary engineer for the Detailed Design Stage is listed in the Table R. 6.4.1.

Table R. 6.4.1 Necessary engineer for the Detailed Design Stage

Position		1st DD	2ndDD
A	International Consultant		
A1	Flood Management Specialist and T/L	17	11
A2	Hydrologist	6	3
A3	Structure Engineer	10	3
A4	Specification Writer	3	1
Total Man-Month		**36**	**18**
B	Domestic Consultant		
B1	Hydrologist	8	3
B2	Environment Specialist	6	2
B3	Structure Engineer/Co-L	21	10
B4	Economist	3	1
B5	Cost Estimator	3	1
B6	Construction Planner	3	1
B7	Social Engineer	3	1
B8	Surveyor	12	3
B9	Flood Defense Specialist	5	5
Total Man-Month		**64**	**27**

6.4.2 Construction Stage

Construction Stage for STP and MLP are 3 years and 5 years, respectively. During the implementing of construction, consultant will be employed for construction supervision.

6.4.3 Maintenance Stage

Maintenance Stage has two components. One is monitoring for water level and existing structures until the completion of STP. Another is maintenance works for the completed facilities, which action starts after the completion of STP. Draft Monitoring Manual will be attached in Annex.

6.4.4 Implementing Schedule for Master Plan

The implementation schedule for master Plan will be shown in Fig. R.6.4.1.

Work Item	Required Period		Implementing Year
			1 2 3 4 5 6 7 8 9 10 11
	months		
	STP	MLP	
Detailed Design Stage	24.0	12.0	
Topographic Survey	10.0	2.0	
Structure detailed Design	12.0	4.0	
Tendering	6.0	6.0	
Construction Stage			
Urgent Repair Work	24.0		
Short Term Plan	36.0		
Meduim/Long Term Plan		60.0	
Maintenance Stage			
Monitoring for Water Level	60.0		
Maintenance for Facilities		72.0	

Note: STP: Short Term Plan
MLP: Meduim/Long Term Plan

Fig. R.6.4.1 The implementation schedule for master Plan

6.5 COST ESTIMATE

6.5.1 Conditions of Cost Estimate

Based on the data from Gyprowodokhoz, the cost estimate can be found by recent similar project.

Cost estimations for the project of "Rehabilitation of sadd in Khatlon Region Mir Sayeed Alii Hamadoni rayon (Code 0629) (II Variant)" complied from the collections of cost estimation norms and price lists for the construction works, approved by Gosstroy Republic of Tajikistan from May 29 1993 №3 and from the methodical recommendations on development of cost estimation calculations for the construction-montage works through the resource method, accepted and activated by the order of State Construction Committee and Architecture Republic of Tajikistan №30 from the April 7 2004.

Cost estimation's value determined by the norms of СниР-91 through the resource method (on 8.12.2005)

Cost of machine and mechanisms per hour, materials have considered according to catalogue №1 of Pricing Formation Center in current price level in 01.01.2006

Cost estimation is developed by following:

Expenses of the contracted organization 15%

Materials, main non-covered nomenclature 3%, according to attachment №2 into the letter of State Construction Committee and Architecture Republic of Tajikistan.

Technical supervision 1%

Quality control 0.15%

Reserve 2%

ФСЗН 25% (Fund for Social Protection of Population, 25% of Labor Cost)

VAT 20% according to Tax Codex Republic of Tajikistan

Technical Inspection

From 0.0 Somoni to 500,000 Somoni: 1%

From 500,000 Somoni to 50,000,000 Somoni: 3%

Implementing of Master Plan is allocated in foreign fund such as ADB Loan. Therefore, Detailed Design and Construction Supervision have to consider the engineering fee. Overall implementation schedule is show in section 6.4 and some of cost will be changed from above local procedure.

6.5.2 Cost Estimation Conditions

Project cost is estimated on the basis of the design, the construction plan, and the following assumptions and conditions.

1) Price Level

Price level is as of January 31 2007.

2) Currency Conversion Rate

Currency conversion rates among Tajikistan Somoni (TJS), U.S. Dollar (USD), EURO (EURO) and Japanese Yen (Yen) are: TJS 1.00 = USD 3.4386 = EURO 4.4430 = Yen 35.398

Currency conversion rates are based on the average rate of the national Bank of Tajikistan (NBT) as the end of January 2007.

Table R. 6.5.1 Currency Conversion Rate

Currency	Unit	Rate
Tajikistan Somoni	TJS	1
Japanese Yen	¥	35.398
U.S. Dollar	USD	3.4386
EURO	EURO	4.4430

3) Currency of Cost Estimate

Construction cost is estimated in foreign and local currencies. Both of the estimated costs are expressed in Tajikistan Somoni (TJS) using the currency conversion rates stated above.

6.5.3 Cost Estimation Method

Costs for civil works are estimated on the unit price basis. The construction unit costs are composed of the unit prices of labor, material, equipment, miscellaneous and contractor's indirect cost.

1) Unit Price

a) Labor Cost

The unit prices of labor are decided based on the result of interview and unit price of Pilot Project. Daily price for common labor is 2.4 TJS and skilled labor is 4.0 TJS.

b) Material Cost

Materials cost are evaluated by using the cost of quotations, personal interview and pilot project price.

Table R. 6.5.2 Materials cost

Materials		Unit	Unit Price (TJS)
1	Fine Aggregates	m3	17.00
2	Base Course	m3	28.00
3	Cobblestone	m3	18.00
4	Crushed gravel	m3	44.00
5	River Gravel	m3	17.00
6	Boulders	m3	18.00
7	Portland cement	bags	22.00
8	Ready Mixed Concrete;Class B-25	cu.m	261.00
9	Ready Mixed Concrete;Class B-15	cu.m	238.00
10	Reinforcing Bars, Deformed	kg	3.30
11	Gabion Mattress	pcs	230.00
12	Geotextile	sq.m	8.00

c) Equipment Cost

Equipment cost evaluated by using the cost personal interview and pilot project price. There are some equipment cannot be seen in Hamadoni area, but most of equipment can be supplied from Dushanbe, which as mention in section 6.1.4 3). Daily price of equipment price are listed in below.

Table R. 6.5.3 Equipment cost

Equipment		Unit	Estimated Cost (TJS)
1	Crane, 15ton	day	476.10
2	Bulldozer (D60)	day	960.00
3	Dumptruck , 6.88- 9.1 cu.m	day	288.00
4	Vibratory compactor (10 Ton)	day	499.51
5	Transit mixer (5cu.m)	day	522.93
6	Payloader (2.29 cu.m)	day	526.83
7	Roadgrader 125 Hp	day	468.29
8	Backhoe 1.15 cu.m 148 Hp	day	878.05
9	Water Truck	day	398.05
10	Welding Machine (300 amp)	day	117.07
12	Truck	day	261.46
13	Concrete Vibrator	day	31.22
14	Plate Compactor	day	54.63
15	Gas Welding	day	7.80
16	Bagger Mixer (0.1cu.m)	day	115.20
17	Bar Cutter and Bender	day	42.93
18	Chain Saw	day	23.41
19	Tamping Rammer	day	78.05
20	Submersible Pumps	day	101.46
21	Breaker	day	35.12

d) Indirect Cost

The Contractor's indirect cost is computed in percentage of each unit cost. Indirect cost is estimated at 20% of direct cost.

2) Value Added Tax

Value Added Tax is applied at 20 %, except for the direct foreign currency.

3) Administration Cost and Reserve

Administration cost is 0.5 % of Civil Work and reserve cost is 2% of Civil Work.

4) Detailed Design and Engineer fee for construction supervision

Detailed Design cost is calculated base on the survey cost, consultant cost and other miscellaneous cost. Engineer fee for construction supervision also considered consultant cost and miscellaneous cost.

6.5.4 Bill of Quantities

Based on the structural design, a draft Bill of Quantities for work items is prepared as hereto attached (see from Table 6.5.1 to Table 6.5.2).

6.5.5 Total Construction Cost for Each Component

The total construction cost for each stage is estimated and summarizes in the table below.

Table R. 6.5.4 Total Construction Cost for Each Component

No.	Name of Stage	Total Cost of STP (TJS)	Total Cost of MLP (TJS)
1	Detailed Design Stage (Survey, DD and Tender)	3,748,335.6	5,651,745.7
2	Civil Work	81,842,957.4	186,642,477.0

6.6 MAINTENANCE COST FOR CONSTRUCTED FACILITIES

Maintenance cost for Dike and Spur Dike starts 6th year when the STP is completed. Maintenance cost is estimated 0.05 % of Civil Work. Beside maintenance cost will be increasing at the 12th year, when the MLP is completed.

TABLES AT THE BACK OF REPORT

^

Table 6.5.1 (1/2) Bill of Quantities (Basic plan :MLP)

Name	Specification	Unit	Work Volume
Main Dike			
Removal Works	Removal of Concrete Block and Gabion	m2	147,180.0
Dike Work			
Earthwork			
Excavation		m3	431,906.6
Embankment		m3	263,559.3
Backfilling		m3	336,403.8
Revetment Works	Concrete Block Type		
Top Concrete			
Concrete	B-25, M-300	m3	2,276.4
Gravel		m3	496.8
Concrete Block	B-15 (2000×1000×300)	m3	46,479.3
Geotextile		m2	210,816.1
Gabion		m3	46,788.1
Base Concrete			
Concrete	B-25, M-300	m3	14,707.0
Gravel		m3	794.9
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	23,940.0
Revetment Works	Riprap Type		
Cobble		m3	27,324.0
Riprap		m3	44,418.0
Spur Dike	L=40.0m	Number	39.0
Earthwork			
Excavation		m3	282,409.0
Embankment		m3	193,561.5
Backfilling		m3	220,029.5
Revetment Works			
Top Concrete			
Concrete	B-25, M-300	m3	887.7
Gravel		m3	193.7
Concrete Block	B-15 (2000×1000×300)	m3	20,205.8
Gabion			7,483.2
Geotextile		m2	74,610.3
Base Concrete			
Concrete	B-25, M-300	m3	5,012.8
Gravel		m3	282.7
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	56,643.3
Countermeasure of Seepage			6.0
Embankment		m3	33,000.0

Table 6.5.1 (2/2) Bill of Quantities (Basic plan : MLP)

Name	Specification	Unit	Work Volume
Guide Dike			
Removal Works	Removal of Concrete	m3	13,860.0
Dike Work			
Earthwork			
Excavation		m3	138,553.5
Embankment		m3	69,774.4
Backfilling		m3	97,206.5
Revetment Works	Concrete Block Type		
Top Concrete			
Concrete	B-25, M-300	m3	907.2
Gravel		m3	198.0
Concrete Block	B-15 (2000×1000×300)	m3	20,691.8
Gabion			17,756.8
Geotextile		m2	91,303.9
Base Concrete			
Concrete	B-25, M-300	m3	6,468.0
Gravel		m3	316.8
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	10,920.0
Spur Dike	L=40.0m	Number	17.0
Earthwork			
Excavation		m3	123,101.4
Embankment		m3	84,373.0
Backfilling		m3	95,910.3
Revetment Works			
Top Concrete			
Concrete	B-25, M-300	m3	387.0
Gravel		m3	84.5
Concrete Block	B-15 (2000×1000×300)	m3	8,807.7
Gabion			3,261.9
Geotextile		m2	32,522.4
Base Concrete			
Concrete	B-25, M-300	m3	2,185.1
Gravel		m3	123.2
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	24,690.7

Table 6.5.2 (1/2) Bill of Quantities (Basic plan :STP)

Name	Specification	Unit	Work Volume
Main Dike			
Removal Works	Removal of Concrete Block and Gabion	m2	62,073
Dike Work			
Earthwork			
Excavation		m3	197,592
Embankment		m3	113,142
Backfilling		m3	167,157
Revetment Works	Concrete Block Type		
Top Concrete			
Concrete	B-25, M-300	m3	1,218
Gravel		m3	266
Concrete Block	B-15 (2000×1000×300)	m3	23,988
Geotextile		m2	104,533
Gabion		m3	21,859.9
Base Concrete			
Concrete	B-25, M-300	m3	7,638
Gravel		m3	425
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	12,285
Spur Dike	L=40.0m	Number	
Earthwork			
Excavation		m3	152,066
Embankment		m3	104,225
Backfilling		m3	118,477
Revetment Works			
Top Concrete			
Concrete	B-25, M-300	m3	478
Gravel		m3	104
Concrete Block	B-15 (2000×1000×300)	m3	10,880
Gabion		m3	4,029.4
Geotextile		m2	40,175
Base Concrete			
Concrete	B-25, M-300	m3	2,699
Gravel		m3	152
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	30,500
Countermeasure of Seepage			
Embankment		m3	33,000

Table 6.5.2 (2/2) Bill of Quantities (Basic plan :STP)

Name	Specification	Unit	Work Volume
Guide Dike			
Removal Works	Removal of Concrete	m3	3,300
Dike Work			
Earthwork			
Excavation		m3	40,348
Embankment		m3	36,894
Backfilling		m3	25,153
Revetment Works	Concrete Block Type		
Top Concrete			
Concrete	B-25, M-300	m3	252
Gravel		m3	55
Concrete Block	B-15 (2000×1000×300)	m3	5,985
Gabion		m3	8,573.4
Geotextile		m2	33,504
Base Concrete			
Concrete	B-25, M-300	m3	2,310
Gravel		m3	88
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	4,200
Spur Dike	L=40.0m	Number	
Earthwork			
Excavation		m3	50,689
Embankment		m3	34,742
Backfilling		m3	39,492
Revetment Works			
Top Concrete			
Concrete	B-25, M-300	m3	159
Gravel		m3	35
Concrete Block	B-15 (2000×1000×300)	m3	3,627
Gabion		m3	1,343.1
Geotextile		m2	13,392
Base Concrete			
Concrete	B-25, M-300	m3	900
Gravel		m3	51
Foot Protection Work			
Concrete Block	B-15 (2000×1000×1000)	m3	10,167

ANNEXES

MONITORING MANNUAL
FOR
FLOOD CONTROL STRUCTURES IN PYANJ RIVER

1. GENERAL

This monitoring manual is aimed for flood control structures including the main dike, guide dikes, spur dikes, Chubek intake weir and etc., which were implemented by Monitor(s). Basically, maintenance works and activities start with monitoring which is conducted with visual check on the condition of flood control and drainage structures considering the following objectives:

(1) To clarify any sign of damages/irregularities which hamper the natural or designed functions.

(2) To take proper actions in order to retrieve and/or compensate its functions and thus to avoid damage on people's lives and/or properties.

2. RESPONSIBILITY OF MONITORING

At present condition on 2007, MMWR or the related organization conducts monitoring of the flood control and drainage structures under their responsibility. When it is judged that damage of the structure may develop during the next flood event and may cause serious flood damages to the adjacent Kishlak(s) and Jamoat(S), the information of possible damage shall be informed to the MMWR, CoES, Hamadoni Hukumat and the related organization so that necessary emergency actions including flood fighting and evacuation can be conducted.

3. MONITORING ACTIVITIES

3.1 Frequency of Monitoring for Flood Control Structures

Three (3) types of monitoring shall be conducted as explained below.

(a) Monitoring during Dry Season (before the Flood Event)

Monitoring shall be conducted two (2) times during dry season, namely at the beginning and the end of dry season. Monitoring at the beginning of the dry season aims to prepare status report and that at the end of dry season to prepare inventory list.

(b) Monitoring during Flood Event

During the flooding is likely to occur, monitoring shall be made on needed and /or a timely basis.

(c) Monitoring after Natural Disaster

In addition to the above, special monitoring shall be conducted after occurrence of natural disasters such as earthquake, and so on.

3.2 Preparation and Implementation of Monitoring

To conduct the monitoring, the following items shall be considered.

(1) Problematic Sites and/or Structures to be Monitored

Problematic sites shall be given priority before implementing monitoring. Sites of waterways and structures to be monitored shall be selected by Monitor(s) in consideration of the river characteristics and portions of structures with possibility of damages/irregularities and conditions of structures identified from the evaluation report.

(2) Schedule of Monitoring

In consideration to the number of problematic sites and structures, implementation schedule of monitoring shall be estimated/determined to secure necessary budget and personnel. When monitoring is conducted with the related Monitor(s), schedule shall be informed and adjusted accordingly with the related Monitor(s).

(3) Composition and Number of Monitoring Team

Composition and number of monitoring team(s) shall be determined and route(s) to monitor the assigned sites/structures shall be prepared before hand. When monitoring is planned to be conducted by the Monitor(s) shall discuss and confirm their respective assignment.

(4) Communication System

Communication system and contact organization(s)/personnel during monitoring, especially emergency cases during flooding, shall be fully considered/prepared so that the related organization (especially, Hamadoni Hukumat) can take necessary emergency actions.

(5) Record and Report

Results of monitoring shall be recorded in the Monitoring & Recording Sheet as explained in 1.5 Implementation of Monitoring and be reported to the Chairman of Rayon to take necessary actions.

4. PROBLEMATIC SITES AND/OR STRUCTURES TO BE MONITORED

The Monitor(s) shall identify the problematic sites/structures referring to the information from the Inventory List (based on visual check result) and shall make the Information Map about the condition of river structures and river side. Problematic sites/points shall include the stretches of waterway and/or portion of structures, which might damage the structures rendering them ineffective to protect persons and properties.

4.1 Waterway (River Side)

(1) Water Colliding Front and Scouring Portion

(2) Location of Bank Erosion Protection Works

Bank erosion protection works should be placed on banks/dikes that have been eroded or are highly likely to be eroded. Potential erosion points can be identified based on alignment of low flow channel, sand bars and thalweg (drift stream part).

(3) River Bed Scouring

In addition to the scouring due to sand bars/meandering, there are several causes of the riverbed scouring, which can be caused by change in sedimentation balance, change of river channel alignment and newly constructed structures.

(4) Aggradation and/or Degradation

Aggradation is progressive rising of the riverbed elevation as a result of sediment accumulation, while degradation is progressive lowering of riverbed elevation mainly caused by the insufficient supply of sediment from the upstream. The insufficient supply is mostly due to quarrying of bed materials or presence of dam and crossing river structures.

4.2 Dike

(1) Overflow

Overflow from the dike is likely to occur at portions where;

(a) The height of the dike crest is low (below Design Flood Level) if Design Flood Level is decided.

(b) The end of dike is not connected to sufficiently high point, such as road and mountain, and

(c) The river bed rises (aggradation)

(2) Scouring

Scouring, which may cause dike breach, is likely to occur at the portions where:

(a) Flood water attacks due to river course meandering and sand bar (Flow Colliding Front),

(b) Alignment is not smooth, and

(c) Revetment or spur dike is damaged.

(3) Slope Failure

Slope failure is caused by increase in unit weight of soil saturated mainly due to rain water or rising seepage water and also by decrease of shearing resistance against the weight.

(4) Seepage/Leakage

Seepage water loosens the dike crest, the spilled water scours the toe at the land side, the scouring enlarges gradually, and finally the dike is breached. Leakage occurs at the following portions/locations and due to the reasons:

(a) Different quality of soil and/or voids where mixing of soil is not enough for dike material

(b) Permeable layer under the dike foundation including old river course

(c) Hydraulic pressure between the flood water level and inland ground water level during flood event

(5) Crack/Cave-in

The initial cause of crack/cave-in in dike is the occurrence of voids due to the following:

(a) Leakage of water, and

(b) Insufficient compaction of refilled soil for built-in facility and backfill sand of retaining wall, etc. Voids gradually develop into cavities, which appear on the dike crown.

4.3 Spur Dike

Damage to spur dike is incurred as a result of strong velocity of flow and sedimentation phenomena. Sediment deposition and scouring tend to occur at the points illustrated below.

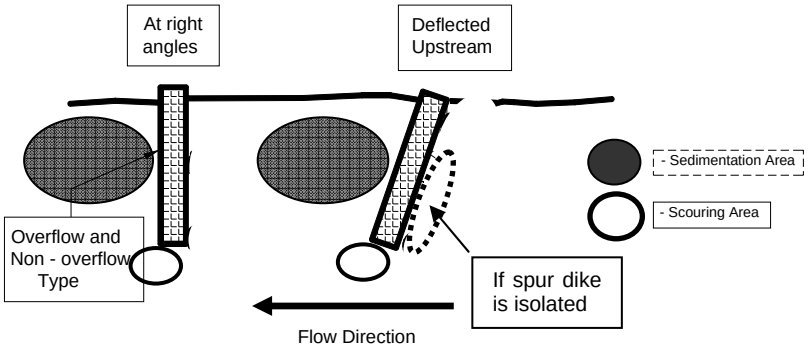


Figure 4.1 Sedimentation Phenomena by Spur Dike

Due to scouring and/or high velocity, main body and foundation may be destructed.

4.4 Revetment

(1) Crack, Voids and Sliding of Revetment

Crack/Void of the revetment occurs due to the following causes.

(a) Scouring of Bed/Degradation

If the foundation depth is not enough, scouring may weaken the foundation and cause damage to the revetment.

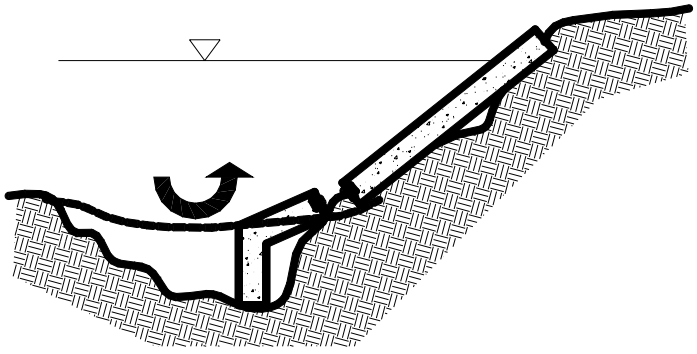


Figure 4.2 Revetment Damage by Scouring

Scouring may occur at the following points where;

(i) Flood water attacks due to river course meandering and sand bar (Holms),

(ii) Alignment is not smooth, and

(iii) Structure such as spur dike is not located

(b) Flowing Out of Backfill Material

Flowing out of fine backfill materials through the joints of revetment and concrete block, especially when filter cloth is not provided may cause cave-in of soil particles behind the revetment.

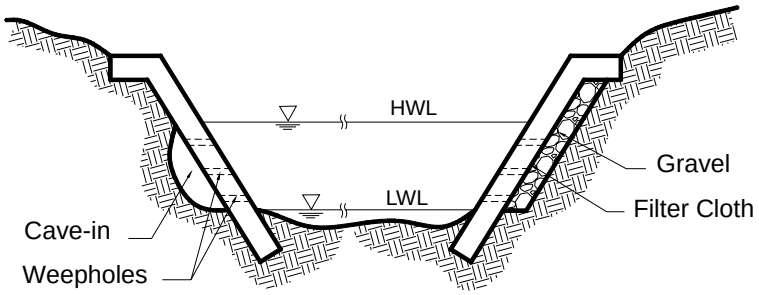


Figure 1.3 Flowing Out of Backfill Material

(2) Destruction of End Structure

Revetment edges of upstream and downstream portions shall be strengthened by making them thick and providing them with transition structures, called “end protection”. However, in case these are not enough, scouring occurs at both edges of the revetment (upstream and downstream). The scouring develops because of the flowing out of backfill material at the back of revetment and the destruction of foundation of revetment.

(3) Extraction of Boulder

Due to strong flow velocity, direct hit by debris or inadequate construction quality, boulder(s) of revetment may be detached. Once this damage occurs, area of damaged portion is easily widened.

(4) Corrosion, Abrasion and Cutting

These kinds of problems occur to the revetment made from steel such as gabion mattress, cylinder and steel sheet pile.

5. IMPLEMENTATION OF MONITORING

Monitoring shall be conducted based on the following procedures.

(1) Installment of Benchmark

The Monitor(s) should drove small wooden piles on the crest of the main dike from Chubek intake weir to the end of the present dike as benchmark point to clarify the location of damaged or problematic portion.

(2) Establishment of Information Map

Before the starting of monitoring, the basic information should be summarized on the map based on the results of past visual check investigation for the river structures. Then, this map should be modified during monitoring to be expressed the latest condition of the river structures. For reference, the following figure is the information map which was elaborated during the structural monitoring on July 2007 by JICA Study Team.

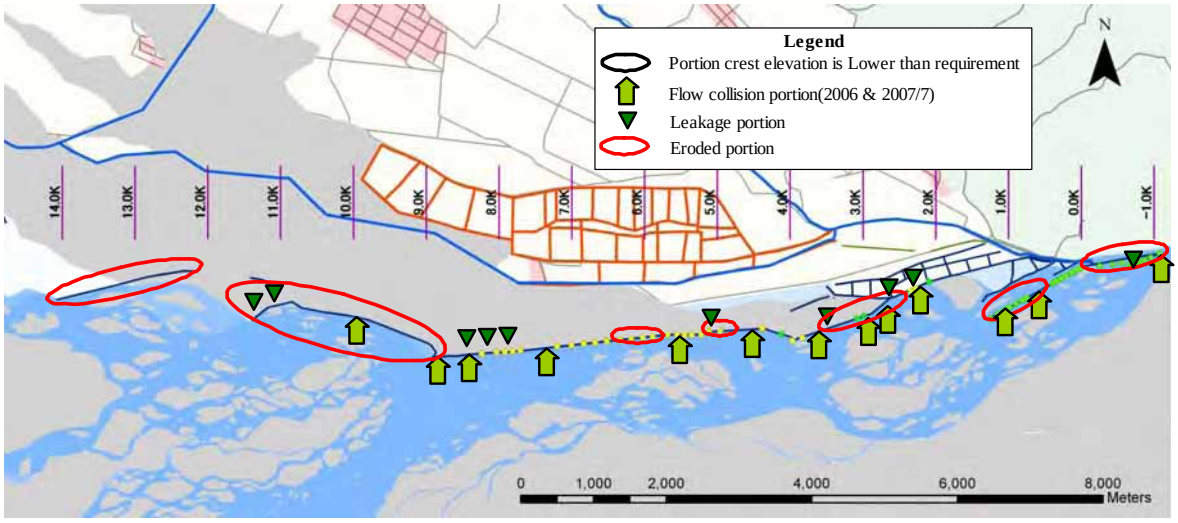


Figure 5.1 Information Map Based on Visual Check as of July 2007 (JICA Study Team)

(3) Monitoring Items

Based on the “Technical Information Concerning Monitoring by Visual Check (issued by Japan Institute of Construction Engineering)”, monitoring items have been modified for Pyanj River, as shown in the following table.

Table 3.1 Monitoring Items

Place	Recession Season	During Flood Season
River Side	- Deep Degradation of Riverbed - Situation of Vegetation - Condition of Sedimentation - Deformation of Spur Dike - Condition of Foot Protection for Spur Dike	- Situation of Vegetation - Condition of Sedimentation
Slope of River Side Revetment	- Crack or Erosion of Bank Slope - Deformation of Erosion Resistance Works such as Concrete Revetment and Wire Mat - Deformation of Foot Protection - Lair of Small Animals - Condition of Washing Away of Soil Cover	- Crack or Erosion of Bank Slope - Deformation of Erosion Resistance Works such as Concrete Revetment and Wire Mat - Lair of Small Animals
Crown of Dike	- Crack - Puddle - Erosion - Height of River Dike	- Crack - Puddle - Erosion
Back Slope	- Crack or Erosion of Bank Slope - Condition of Furrow by Vehicle - Lair of Small Animals	- Crack or Erosion of Bank Slope - Leakage or Seepage - Wet Condition - Condition of Furrow by Vehicle - Lair of Small Animals
Foot of Slope	- Deformation of Foot of Slope - Wet Condition - Lair of Small Animals - Existence of Depression Area	- Deformation of Foot of Slope - Sand Boiling or Leakage/Seepage - Wet Condition - Lair of Small Animals
Inland Area	- Wet Condition of Ground Surface - Ground Uplift or Depression	- Sand Boiling - Wet Condition of Ground Surface - Ground Uplift or Depression
Circumstance of River Structure (Chubek Weir)	- Deformation or Crack of Revetment - Difference in Level between Dike of Structure and River Dike - Aperture at Joint between Breast Wall and Wing Wall	- Leakage or Sand Boiling from Joint between Breast Wall and Wing Wall - Leakage or Sand Boiling from Joint with Dike - Color of Water Flow in Waterway

(4) Frequency

The Monitors should determine the frequency via their future and existing experience to prevent the oversight of the dangerous portion during monitoring from the viewpoint of hydraulics and structural safety. For reference, during the flood season in 2007, the Study Team monitor the river structure in the frequency summarized in table below (see Supporting Report Sector 11 of Final Report).

Table 3.2 Monitoring Frequency

No.	Monitoring Portion	Frequency	Remarks
1	Monitoring Point	Everyday	30 monitoring points
2	Whole Alignment of River Dike	Once a week	

(5) Monitoring and Recording Sheet

Monitoring shall be done visually. Based on the number of the existing structures or the problematic portion, Monitor(s) shall prepare the recording sheets. Based on the

"Technical Information Concerning Monitoring by Visual Check (issued by Japan Institute of Construction Engineering)", a check sheet was prepared to investigate and record the condition of the damaged area. The check sheet is given in the following table

Figure 3.1 Check Sheet for Structural Monitoring

Monitoring Form-1

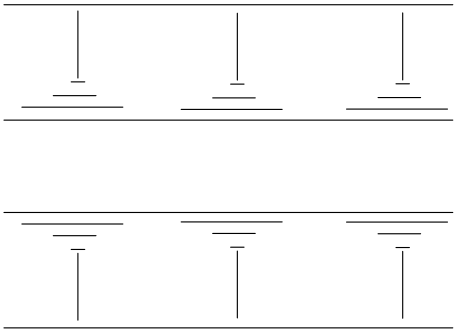
River System		River		Inspector		Date	Y M D
Side	Left/Right Bank	Site		Rayon		Jamoat	
Location	km Upstream / Downstream From						

■ **Inspection Point** : Inland Area, Back Slope, Top of Dike, River Side Slope, River Side Area

■ **Condition Diagram**

Plain View

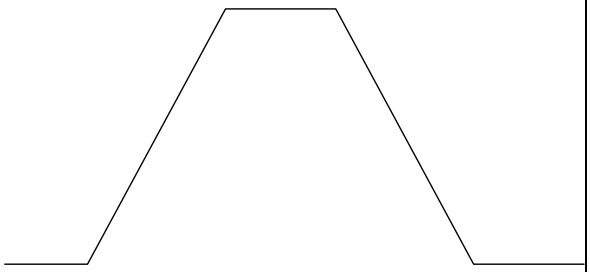
【Inland Area】



【River Side】

Cross-Sectional View

【River Side】 【Inland Area】



■ **Contents of Deformed Condition**

Category

Point	Item	No.
Around Chubek Weir	Leakage or Boil from Joint with Dike	
	Color of Water	
River Side	Condition of Vegetation	
	Condition of Sand Bar	
River Side Slope	Erosion	
	Crack	
	Slide of Concrete Block	
	Deformation of Gabion	
	Existence of Den	
Top of Dike	Crack	
	Erosion	

Point	Item	No.
Back Slope	Erosion	
	Crack	
	Leakage	
	Leakage	
	Existence of Den	
Foot of Back Slope	Collapse	
	Leakage	
	Seepage or Sand boil	
	Wet Condition	
	Infiltration of Surface	
Inland Area	Infiltration	
	Bulge of Ground	
	Depression of Ground	
	Flow Condition of Filtration Water	

Scale of Deformation

Unit (m)

No.	Degree	Scale and Range			
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	
	Large / Middle / Small	Width		Length	
		Depth		No.	

Comment of Deformation

(6) Evaluation of Damage and Decision of Action to Be Taken

The related organizations shall evaluate the urgency of countermeasures for damaged structure and decide the actions to be taken. If the damage of structure is reported by the monitoring made by the Monitor, the organization shall go to the site of the structure and confirm the reported damage/condition.

(a) Urgency of Countermeasures (exemplification)

Urgency of countermeasures shall be classified into three (3) levels, namely, Urgency A, Urgency B and Urgency C.

Urgency A

Damage is serious and huge flood damages to human lives and properties; 1) have occurred or 2) are expected to occur in the next flood event.

Urgency B

Damage is not serious and countermeasures are necessary, but urgency is not so high.

Urgency C

(i) Small repair is necessary

(ii) No repair is necessary but continuous monitoring is necessary.

Some damages and their classification are shown in Table 3.2.

Table 3.2 Damages of Structure and Urgency Classification (Sample)

Urgency	Waterway (River Side)	Dike/Revetment
A		• Overflow • Dike breach • Revetment damage due to flowing out of backfill material • Revetment damage due to scouring • Damage to large area of revetment • Seepage/Leakage
B	• Due to the Degradation, alignment of waterway is facing the Dike.	• Small flowing out of backfill material of revetment • Small revetment damage with small leakage • Scouring exposing the revetment foundation • Crack and cave-in of dike