CHAPTER 6

DETAILED DESIGN

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6.1 River Improvement and Floodway

6.1.1 Percut River

Based on the river longitudinal profiles, the target river stretch is divided into two segments, the lower and upper stretches bounded by PE129+50.

Standard Cross Section

The standard cross section of Percut River is prepared for the detail design of channel including alignment, longitudinal profile and cross section.

(1) Conditions for Hydraulic Design

The standard cross section is determined by applying non-uniform and uniform steady flow calculation based on the following conditions:

Design discharge	320 m^3/s	Immediate Plan (25-year return period)
Coefficient of Roughness	0.033 0.035 0.040	Low Water Channel (excavated) Low Water Channel (existing) Floodplain (existing)
Initial Water Level at River Mouth	EL 1.300 m	Mean High Water Spring

(2) Standard Cross Section

The standard cross sections are prepared as shown in DWG. 6.1.1.

(a) Lower Stretch

A wide compound cross section is employed in the stretch between PE14 and PE129+40 to ensure channel stability and to protect the dike slope from erosion by strong current. The width of the channel bed ranges from 8 to 13 m in the stretch from PE129+40 to PE47. As for the lowest stretch from PE47 to the river mouth where the flow capacity is extremely low, the width of the channel bed is expanded to 40 m.

Leveling/excavation of the flood channel is executed only when the elevation of the existing channel is higher than that of the proposed channel. Filling/embankment is not performed for the flood channel with elevation lower than that of the proposed, except a counterweight fill for the dike in the stretch from the river mouth to PE14.

(b) Upper Stretch

Based on river characteristics such as flood flow condition, channel meandering and erosion on the channel, and land use in the neighboring urban area, single trapezoidal section without diking is employed. The riverbed width is designed at 8 m, which is a little wider than the average width of the existing channel. For slope stability, a small berm with a width of 1.5 m is provided in the middle of the slope.

(3) Side Slope

A side slope of 1 : 2 (vertical to horizontal) is adopted for the low water channel to ensure bank stability. A gentle side slope will provide inhabitants with easy access to the water surface as well as maintenance of the dike slope.

(4) Right-of-Way

The right-of-way is delineated 5 m away from the toe of dike or edge of inspection road in accordance with the government regulation for river administration. The government may acquire and control all lands to a distance of 5 m beyond the outside toe of dike or inspection road. This area will serve as access road to the site during construction.

<u>Alignment of Low Water Channel</u> (refer to DWG 6.1.2)

(1) Lower Stretch

Most parts of the low water channel in this stretch has less meandering. Therefore, the channel widening is made with a smooth alignment conforming to the existing one except the following stretches.

(a) PE129 to PE110

Since the existing right dike is built close to the channel bank, channel excavation is made on the left side bank so that the right riverbank can maintain its slope stability. The minimum distance between the right channel bank and the dike is 5 m.

(b) PE33 to PE14

Channel widening is made only in the right bank to reduce compensation works in the congested residential area in the left bank. Besides, the left riverbank forms a water colliding front and is prone to erosion during floods. Therefore, the whole stretch of the left bank is provided with slope and foot protection works.

(2) Upper Stretch

The alignment in this stretch is in principle designed by conforming to the existing one to minimize land acquisition and house evacuation as well as construction cost. A cut-off channel is not employed. Instead, smoothing and widening of the meandering portion is made to provide a smooth flood flow based on the following criteria:

(a) The maximum allowable degree of curvature of the channel (curve radius from centerline) is at least five times the average river surface width. This criterion is not applied to bending sections.

(b) At bending section of the channel, the alignment of the channel bank top in the convex side is set back by 10 to 60% of the standard channel width, depending on the degree of bend. As a result, an open space is secured on the flood channel, which can serve for river utilization.

<u>Alignment of Dike</u> (refer to DWG 6.1.2)

Both right and left dikes are in principle smoothly aligned almost in parallel with the low water channel, with a bigger distance than that of the standard channel cross section. The following conditions are also employed in the dike alignment.

(1) Existing dikes in the stretch between PE33 and PE129+40 are raised and enlarged. The alignment of dike shall conform to the existing one. In the stretch where the distance between the existing right and left dikes is smaller than the proposed one, new dikes are provided backward.

(2) The dike is aligned throughout the whole stretch, at least 5 m away from the low water channel (distance between the channel bank and the toe of dike slope) to protect the dike from scouring by floods.

(3) In the non-diking downstream stretch from PE33, the dike is aligned in parallel with the proposed low water channel. The left dike is aligned in the area sandwiched by the existing riverbank and the paved village road to save on compensation cost.

(4) Aiming at protecting the fishpond area along the right riverbank from flooding, and at leading floods and sediment smoothly into the sea, a river mouth dike is provided on the right side bank of the channel downstream of PE14. The dike is aligned in parallel with the low water channel, keeping a distance of more than 6 m from the channel bank. On the other hand, no dike is provided along the left riverbank in the downstream stretch from the river mouth to PE14. An earth dike is provided along the branch channel joining Percut River from the left at PE14 in order to protect the village therearound from floods of Percut River and high tide.

Longitudinal Profile (refer to DWG 6.1.3)

(1) Design Riverbed

The design riverbed profile primarily conforms to the existing average riverbed profile to avoid imbalance causing scour and sedimentation, as well as to minimize relocation and modification of the existing river structures. The rate of altering the riverbed gradient of the upper stretch to the lower stretch shall be basically set at less than 0.5 to ensure the stability of the river channel. The riverbed profile is designed as follows:

Section No.	Riverbed Elevation	Riverbed Gradient
PE0	EL -1.800 m	-
PE46	EL -1.195 m	1/8000
PE106	EL +3.790 m	1/1200
PE274+27	EL +24.255 m	1/825

(2) Design High Water Level

The design high water level is determined by non-uniform steady flow calculation for the downstream of PE46 and by uniform steady flow calculation for the upstream of PE46. In addition to the calculation results, the following items are taken into account:

(a) In the upstream stretch from Bandar Sidoras Weir to the junction with the Floodway, the design high water level is to be nearly equivalent to the average elevation of the adjoining ground or the existing dike.

(b) In the downstream stretch, the design high water level is set at around 2.0 m above the ground elevation so that the dike height is lower than 3.5 m.

(3) Elevation of Dike Crown

The design elevation of dike crown is higher than the design high water level by a freeboard of 0.8 m.

Channel Relocation

(1) Lalang River

Lalang River, which joins Percut River from the right bank at PE8, is relocated in connection with the Percut River Improvement Works. The Lalang River is extended by providing a new channel with a length of about 1,240 m from PE8 to the river mouth (PE0-60). The new channel is aligned with the channel bed width of 10 m, keeping a clearance of 5 m just behind the right dike of Percut River. The channel dimensions are determined based on the existing channel conditions, as follows (refer to DWG 6.1.4):

Channel Bed	EL -1.500 m	Average channel bed elevation of Lalang River
DHWL	EL 1.300 m	Mean high water spring in river mouth
Dike Height	EL 1.500 m	0.3 m above DHWL
Width of Channel Bed	10.0 m	Existing channel width
Channel Side Slope	1 : 2	Stable side slope

(2) Irrigation/Drainage Channel

The irrigation/drainage channel which flows along Percut River at the left dike in the stretch from PE103 to PE96, is relocated by about 7 m to the left due to the left dike construction. The new channel is aligned with a channel bed width of 4.5 m, keeping a 3.0 m distance from the toe of dike, connecting with the sluice (SL2).

6.1.2 Medan Floodway

Standard Cross Section (refer to DWG 6.1.5)

The standard cross section of the Floodway is prepared for the detail design of channel such as alignment, channel profile and cross section. In the hydraulic design, the standard cross section is determined by uniform steady flow calculation based on the following conditions:

Design Discharge	120 m^3/s 70 m^3/s	Urgent Plan (40-year return period) Immediate Plan (25-year return period)
Manning's Coefficient of Roughness	0.030 0.025	Channel with wet stone masonry Channel with leaning wall
Initial Water Level	EL 30.398 m	DHWL at Section PE274+27 (FW0)

Two types of cross section are applied: the single trapezoidal section (Section 1) protected by a wet stone masonry for the downstream from FW28+50 to the confluence point and the double trapezoidal cross section (Section 2) with leaning walls for the upstream from FW28+50 to the Floodway Weir. Based on the design water level, the channel bed slope and the design discharge, the hydraulic design was made to determine the channel width (channel bed and water surface) and the gradient of side slopes. The results are as follows:

Dimension	Section 1	Section 2
Water Depth	5.80 m	5.80 m
Width of Channel Bed	5.0 m	8.9 m
Width of Water Surface	24.4 m	14.7 m
Side Slope	1 : 1.5 (Right and Left)	1 : 0.5 (Right and Left)

(1) Single Trapezoidal Cross Section with Wet Stone Masonry (Section 1)

The width of riverbed is set at 5.0 m on account of the prevention of lateral erosion, easy channel maintenance and economy of construction. On the middle of the side slopes, small berms with a width of 1.0 and 1.5 m are provided to ensure slope stability.

(2) Double Trapezoidal Cross Section with Leaning Walls (Section 2)

To minimize the number of houses to be evacuated in the congested urban area in the upper stretch from FW28, a double trapezoidal cross section with leaning wall is applied. The design flood is confined in the lower part of the channel, while the space of the upper channel is used for maintenance works.

<u>Alignment</u> **(refer to DWG 6.1.6)**

The Floodway starts at around UD13 of Deli Retarding Channel and joins Percut River at 27 m upstream of PE274 having a total channel length of 3,920 m. The main part of the Floodway is aligned as straight as possible. The design alignment of the Floodway takes the following considerations into account:

(1) The alignment is to minimize the number of houses, buildings and facilities to be evacuated and land to be acquired.

(2) The alignment is to be free of sharp bends or curves.

(3) In the starting and ending portions of the Floodway, the smooth curves with a big radius are to stabilize the channel bed and to avoid sediment deposits. In the design, the radius of curvature is set to at least ten times the average river width of the channel.

(4) A smooth alignment is made for the junction section with Percut River. The deflection angle between Floodway and Percut River shall be limited to less than 60 degrees.

Longitudinal Profile (refer to DWG 6.1.7)

(1) Design Channel Bed

Basically the channel bed elevation of the Floodway is delineated by connecting the channel beds of the Percut and Deli rivers. In addition, dimensions of diversion such as overflow depth, height and length of weir are essential in determining the channel bed elevation of Floodway. Through the study on these parameters, the channel bed profile was determined, as follows:

Location	Channel Bed Elevation	Channel Bed Slope
Section FW3* (PE274+233)	EL 24.930 m	-
Top of Weir Apron (FW39+50.5)	EL 26.500 m	1 / 2,350

(Note) * Groundsill

(2) Design High Water Level (DHWL)

Like the design channel bed elevation, the design high water level is obtained by connecting the water levels of the Percut and Deli rivers. Based on the two water levels and the uniform flow calculation, the design high water level was determined, as follows:

Location	DHWL	Water Depth
Section FW3 (PE274+233)	EL 30.73 m	5.8 m
Top of Weir Apron (FW39+50.5)	EL 32.30 m	5.8 m

6.1.3 Upper Deli River

In improving the retarding channel, zoning is made to clarify land use, as shown below and in DWG 6.1.8.

Zoning	Utilization	Area (m^2)
Low Water Channel	(Water flow passage)	-
Zone A	Sports ground, Recreation Park and Walkway	18,400
Zone B	Free Open Space and Walkway	27,140
Zone C	Waterfront Activity, Fishing and Walkway	9,040
Zone D	Residential Area, Recreation Park	33,760

Alignment

(1) Low Water Channel

The existing channel course is maintained.

(2) Flood Channel Terrace

The design alignment of each zone terrace conforms with the existing topographic condition of the inundation channel which could attain a smooth flood flow to both the Deli River Weir and the Floodway Weir.

(3) Flood Protection Dike

Two flood protection dikes are provided: one along the river bank between Deli River Weir and Floodway Weir and the other along the right bank in the bending stretch approaching the Floodway Weir. The former dike is aligned in a straight line between the two weirs, and the latter dike is aligned with a smooth curve conforming to the existing topography.

Longitudinal Profile

The longitudinal profile including riverbed and design high water level of Deli River Retarding Channel (Upper Deli River) is presented in DWG 6.1.9.

(1) Design Riverbed Profile

Deli River Weir is constructed at UD12 on the Toba Tuff which is a relatively hard diluvium layer. Based on the geological condition, the design elevation of the weir bed is EL 24.200 m, and the bed elevation of the outlet orifice is set at EL 24.700 m to prevent sediment deposits in the orifice. For the upstream stretch from UD12, the design riverbed is determined according to the existing bed profile. A riverbed gradient of 1/170 is employed only in the stretch from Deli River Weir to the Floodway Weir (UD12 to UD13) to smoothly connect both structures.

Location	Elevation	Length	Riverbed Gradient
UD12	EL 24.200 m / EL 24.700 m	-	-
UD13	EL 24.933 m	210 m	1 / 170
UD23	EL 25.624 m	622 m	1 / 900

(2) Design High Water Level

The design high water level is set at EL 34.00 m for the section between the Deli River and Floodway weirs (UD12 to UD13) under both the Immediate and Urgent plans. In the upstream stretch from UD13 to UD50, the design high water level is determined by the non-uniform steady flow calculation results as shown below.

Location	Elevation	Length	Riverbed Gradient
UD12 to UD13	EL 34.00 m	210 m	Level
UD25	EL 34.20 m	810 m	1 / 4,000
UD50	EL 34.98 m	2,570 m	1 / 3,300

(3) Flood Channel Terrace and Dike Crown

The elevation of the flood channel terrace with zoning is determined depending on the frequency of inundation, as follows:

Location	Zone Classification	Elevation	Inundation Occurrence
Top of Low Water Channel	C	EL 28.000 - 29.000 m	20 times/year
Channel Terrace (I)	A	EL 32.600 m	1 time/year
Channel Terrace (II)	B	EL 31.500 m	10 times/year
Dike Crown	D	EL 35.000 m	No inundation

<u>Cross Section</u> (refer to DWG 6.1.10 for Typical Cross Section)

The design cross section of the retarding channel is the same compound trapezoidal section as indicated by the standard cross section. The low water channel is improved by channel excavation with a riverbed width of 10 m and a side slope of 1 : 2. For the river utilization plan, an embankment is provided on the existing flood channel in accordance with the land zoning plan. A high embankment along the right bank is designed to be safe against slope failure and flowing force. A berm with a width of 3.0 m is provided on the slope at a vertical interval of around 3.0 m.

6.2 Riparian Structures

6.2.1 Dike

A river dike including small embankment for inspection road is provided in the following stretches:

Classification	Location
Existing Dike to be reinforced or relocated backward (Setback Dike)	PE33 to PE129+40 (Right bank) PE33 to PE129+40 (Left bank)
New Dike	
- Percut River	PE0 to PE14 (Right Bank)
	PE14 to PE33 (Right Bank)
	PE14 to PE33 (Left Bank)
- Deli Retarding Channel	Between Deli River and Floodway Weirs
- Left Channel at River Mouth	Along Right Bank (L=1,000m)
Embankment for Inspection Road	
- Percut River	PE129+40 to PE274 (Right and Left Banks)
- Floodway	FW4 to FW7 (Left Bank)

(1) Earth Dike

The materials excavated in Percut River and the Floodway, except those in the downstream from the Bandar Sidoras Weir, are found suitable for embankment from the geotechnical survey results. In heightening and enlarging the existing dike, an embankment is made on the land-side slope of dike of which surface is stripped by 25 cm thick. The earth dikes are designed as shown in DWG 6.2.1.

(2) Combined Dike Composed of Earth Embankment and Parapet Wall (PE14 to PE33 Left Bank, L=1,785 m)

A dike composed of a combination of earth embankment and parapet wall is employed in the housing area along the left bank downstream from PE33 to minimize land acquisition. Further, where less consolidation settlement is expected, a lower embankment is made in the lower reaches of Percut River. Since the crown of embankment is set at the same elevation as the design high water level, the height of embankment could be less than 2.0 m. A parapet wall is provided on this embankment covering the freeboard of the dike as shown in DWG 6.2.1. This parapet wall is made of wet stone masonry with a waterproof design.

(3) Flood Retaining Wall (PE17-6.5 to PE18+20 Left Bank, L=120 m)

This stretch is subject to water colliding, where diking is difficult due to the limited area between the riverbank and the village road. Based on the conditions, a flood retaining wall, as shown in DWG 6.2.2, is employed as a part of the river dike. This flood retaining wall is made of concrete with prestressed concrete sheet piles and wooden foundation piles. An embankment is provided in the backside wall, connecting the upstream and downstream earth dikes. This wall is designed to be stable against flowing force and seepage flow, and the forefront area is protected with gabion mattress and riprap from scouring during floods.

6.2.2 Slope and Riverbed Protection Works

Revetment

The wet stone masonry type, as shown in DWG 6.2.3, is basically adopted in the Project from the technical requirements, availability of materials and lower construction cost. In addition to this, gabion cylinder, riprap and concrete wall types are employed independently or in combination with the wet stone masonry type, as shown in the table below.

Type of Revetment	Location
Wet Stone Masonry	(1) Dike/bank slope at bend and at the water colliding front in the lower Percut River (2) At down and upstream sides of river structures and bridge (3) Floodway (FW0 to FW28+50)
Concrete Wall	
- Flood Retaining Wall	(1) PE17-6.5 to PE18+20, Left Bank
- Leaning Wall	(1) Floodway (FW28+50 to FW38+95) (2) Side wall at diversion weirs and protection for bridge foundation
Gabion Cylinder	(1) Low water channel slope at bend in lower Percut River (2) On the side slope of wet masonry type revetment
Riprap	(1) At the water colliding front in lower Percut River (2) On the slopes of the river mouth dike

Leaning Wall of Floodway

The leaning wall is commonly used for a steep and long slope. Since the upper portion of the Floodway has a slope gradient of 1 : 0.5 and a slope height of 8 to 14 m, the leaning wall, as shown in DWG 6.2.4, is applied. The wall is 995 m long and designed to ensure slope stability and to resist flowing force. The wall is made of concrete with spread foundation. Weep holes with filter are installed to relieve hydrostatic pressure of the ground behind the wall.

Lining of Channel Bed of Floodway

The channel bed is lined with concrete of 0.15 or 0.20 m thick to protect the bed from scouring and to ease maintenance work.

Riprap

Riprap is applied to the slope and foot protections in the estuary. The weight of stone for riprap shall be heavy enough to maintain stability under wave action. Weight of stone shall be more than 30 kg, so that a stone with a diameter of 0.3 to 0.5 m should be suitable for riprap.

Groin

The lower reaches of Percut River has a gentle riverbed slope of 1/8,000, and riverbed materials are mostly silt or clay. The permeable type of groin consisting of piles, as shown in DWG 6.2.5, is used to facilitate sedimentation thereabout by controlling the flow velocity and, consequently, assure the stability of the low water channel bank.

Reinforced concrete piles are used for the groin with structural dimensions as follows:

Direction	90° to flow line	
Length (L)	10.0 m	About 10% of flood channel width
Top Elevation (E)	EL 1.300 m	Same elevation as riverbank elevation
Height (H)	2.0 m to 3.0 m	(E) - Riverbed
Interval (D)	30.0 m	Assuming (D) ÷ (L) = 3
Pile Length	6.5 m long	
Pile Section	0.20 m x 0.20 m	

Tops of concrete piles are connected by concrete frames to stabilize the structure. Riprap with thickness of at least 0.6 m is provided around the foot of concrete piles to prevent scouring.

Groundsill

Since the design riverbed elevation is about 1.0 m above the existing riverbed, the crest elevation of the groundsill is designed to conform to the design riverbed, resulting in a groundsill with a height of 1.0 m. This groundsill is of concrete gravity type with an apron which should prevent scouring at the foot or foundation during flood time.

As for the foundation of the groundsill, prestressed concrete piles, ϕ300 mm in diameter and 9 m long, are driven to increase the bearing capacity of the subsurface layer to support the weir body. Gabion mattress for riverbed protection is placed on the riverbeds upstream and downstream of the groundsill with appropriate lengths of 6.0 m and 12.0 m, respectively.

The structural features of the groundsill are given below and shown in the DWG 6.2.6.

Work Item	Dimensions
Main Body	
- Crest Elevation	EL -0.44 m
- Elevation of Apron	EL -1.44 m
- Elevation of Foundation	EL -2.24 m
- Height of Groundsill	1.00 m
- Crest Width	1.00 m
- Downstream Slope	1 : 0.8
- Length of Apron	4.50 m
- Thickness of Apron	0.80 m
Foundation	
- Waterstop (Steel Sheet Pile Type II)	2.0 m long at 2 locations
- Foundation Treatment	PC Pile ϕ = 300 mm, L=9 m
Riverbed Protection	
- Gabion Mattress, Upstream Downstream	L = 6.0 m L = 12.0 m

Junction Works

At the junction of the Floodway to Percut River, the flow condition of the floodway channel is changed before meeting Percut River to make a smooth confluence, as follows:

Item	Floodway	Percut River
Flow Direction	West to East	South to North
Riverbed Elevation	EL 24.930 m	EL 24.570 m
Cross Section, Bed Width	5 m	8 m
Slope	1 : 1.5	1 : 2.0
Channel Gradient	1/2,350	1/825

To facilitate the smooth flow at the bending point, the curve radius of river alignment is preferably more than 10 to 20 times the average river width. Generally, a bigger radius for the alignment at the confluence gives a smaller angle to the main river. Since the average channel width of the Floodway is about 20 m, the curve radius of 300 m is applied to the junction.

To obtain a steady flow after the confluence, the transition channel length requires about three times the total width of the two channels. The channel section at the confluence gradually conforms to the standard cross section of Percut River within 120 m from the confluence.

The bed elevation of the Floodway is 36 cm higher than that of Percut River at the junction. To connect both channel beds smoothly, a chuteway with a length of 30 m and a slope of 1/80.4 is provided at FW3+30. A groundsill is provided at 220 m upstream from the junction (FW3+00) to protect the channel bed. The alignment and standard structural details of the groundsill is given in DWG 6.2.7.

<u>Jetty: Landing Stage and Mooring Facilities</u> (PE14+57)

(1) Location and Purpose

A landing stage for fishing boats exists at the lower section (PE14+57) of Percut River. This landing stage is reconstructed in the Percut River Improvement Works at the same location.

(2) Structural Details

The landing stage is designed to keep more than 75 cm draft depth under all tide levels. Since the MHWL is EL 1.190 m and MLWL is EL -0.937 m, four stages are provided alternately with the retaining wall height of 1.50 m in total. The elevation of each landing stage is set at EL -0.819 m, EL -0.069 m, EL 0.681 m and EL 1.431 m. The surface of each stage is paved with concrete blocks.

The lower two stages are retained by concrete sheet piles in consideration of easy construction under water, while the upper two stages are wet masonry type gravity wall. To pass over the parapet wall and dike, three locations of steps, 3 m wide, are provided. The structural details are given in DWG 6.2.8.

6.2.3 Bridge Protection Works

Titi Runtuh Bridge (PE129+43)

(1) Stretch to be Protected

Protection works are carried out for the abutment of Titi Runtuh Bridge as well as the riverbanks and riverbed in the stretch for a total length of 70 m. This stretch forms a transition from a single trapezoidal section in the upper stream to a double trapezoidal section in the lower stream.

(2) Cross Section

To secure an adequate flow area to confine the design flood, a single trapezoidal section with a side slope of 1 : 1 and a riverbed width of 13 m is employed.

(3) Type of Protection Works

The side slopes are covered with concrete retaining walls for a length of 31 m in the central portion of the stretch and wet stone masonry with the lengths of 14 m and 21 m in the up and downstream sides. The riverbed is protected with gabion mattress. The concrete retaining walls are reinforced with steel bars and supported by log piles, and connected smoothly to the wet stone masonry revetments of the up and downstream. (refer to DWG 6.2.9)

Railway Bridge (PE176+66)

(1) Stretch to be Protected

The stretch of about 70 m up and downstream of the existing railway (Mean-Deli Tua Line) is provided with bridge protection works. The river stretch covers the proposed drainage outlets (SL-5, SL-6 and SR-2).

(2) Cross Section

In conformity with existing abutment structures and bridge length, a single trapezoidal section with a side slope of 1 : 0.5 and a riverbed width of 15.5 m is employed.

(3) Type of Protection Works

To meet the design cross section, leaning walls with the length of 42 m are employed for the side slope protection in the central portion of the stretch. The up and downstream sides are covered with wet masonry revetments for 14 m each at up and down portions to form a smooth channel alignment. For riverbed protection, gabion mattresses are placed. The plan and cross section of the structures are shown in DWG 6.2.10.

National Road Bridge (PE269+76)

(1) Stretch to be Protected

The stretch to be protected is estimated at 96 m which corresponds to the width of the bridge and the river.

(2) Cross Section

In conformity with the existing piers and abutments, the double trapezoidal cross section with slope gradients of 1 : 1.5 and 1 : 0.72 and riverbed width of 8.0 m is applied to secure an adequate flow section. To satisfy the hydraulic requirements, the surface of the channel, especially side slopes, are smoothened.

(3) Type of Protection Works

The lower channel side slopes are protected by concrete retaining wall built on the foundation log piles for the central portion of 60 m. At the toe of bottom slab, concrete cutoff wall is provided to protect the riverbed from scouring. Wet stone masonry with the lengths of 18 m each in up and downstream, plastered on the surface, is used for the upper side slopes between pier and abutment. For riverbed protection, concrete blocks with a weight of 1.25 ton are placed with a flat surface. The retaining walls are reinforced with steel bars to resist water and earth pressures. The general structural plan is presented in DWG 6.2.11.

(4) Other Works

The existing pipe bridge supports erected at the immediate downstream points of the bridge are protected by covering with a concrete wall.

6.2.4 Drainage Outlet

Confluence Treatment of Batuan River

Batuan River, a small tributary of Deli River, crosses the proposed floodway at FW25+24. The improvement of Batuan River will be carried out for a stretch of 85 m from the junction with the floodway to the upstream. The design discharge for the improvement is 16 m^3/s corresponding to a 10-year return period flood, which will be discharged to the floodway through the outlet of double box culvert (2 m × 2 m). Since the riverbed elevation of Batuan River is about 5.1 m higher than the channel bed of the floodway, a stepwise fall structure is provided at the junction to dissipate the energy of river flow. The structural detail is shown in DWG 6.2.12.

Drainage Outlet

Since the inspection roads are constructed alongside the riverbanks, the drainage ditch is required to be replaced by a box culvert embedded in the riverbank. If the bottom elevation of the drainage ditch is higher than 1.0 m below the crest elevation of dike and it is impossible to have enough thickness of cover soil, an open ditch type sluice is applied.

(1) Box Culvert

The following thickness of each member is applied to the box culvert.

Side Wall and Top Slab	40 cm
Base Slab	50 cm
Center Wall	30 cm

For a box culvert with the total length of more than 20 m, the culvert is divided into two portions and a joint is provided. Wing walls, 3.0 m wide and 1.0 m higher than the height of box culvert, are provided at inlet and outlet.

Ground elevations of drainage areas of SL2, SL3 and SL4 are lower than the design high water level at sections where the respective outlets join. Therefore, sluice gates are installed to prevent counterflow from the river. A spindle type steel slide gate and manual operation system are applied to the gate.

To prevent piping, steel sheet piles, 3.0 m long, are provided at the outer section, and cut-off wall at the center for the box culvert with gates. (refer to DWG 6.2.13.)

(2) Pipe Culvert

A precast centrifugal reinforced concrete pipe is applied to pipe culverts. To attain easy maintenance of the culvert, the minimum diameter of the pipe is limited to 60 cm. The base of pipe is fixed at 180 degrees by plain concrete considering the foundation condition and thickness of cover soil. The joint of pipe is covered with in-situ reinforced concrete.

Since the ground elevation of the drainage area for outlet SL1 is lower than the design high water level, an operation-free flap gate is employed to prevent counterflow from the river during floods. (refer to DWG 6.2.14)

(3) Open Ditch Type Sluice

The depth of ditch is fixed at 1.0 m, and a width of 0.6 m or 1.0 m is applicable depending on the design discharge. For the inspection road, a reinforced concrete cover with a width of 3 m is provided. (refer to DWG 6.2.15.)

6.2.5 Bandar Sidoras Intake Weir

Structural details of the proposed weir and related irrigation structures through the hydraulic design are summarized below as shown in the DWG 6.2.16.

Work Item		Dimensions
Main Rubber Dam		
- Crest Elevation		EL 4.06 m
- Bottom Elevation		EL 0.92 m
- Auto-deflation Water Level		EL 4.87 m
- Height of Rubber Body		3.14 m
- Width of Rubber Body		13.00 m at bottom
- Maximum Water Head		3.95 m at auto-deflation water level
- Design Overflow Depth		0.81 m
- Concrete Footing with Steel Pipe Pile		28.0 m long
- Waterstop (Steel Sheet Pile Type II)		2.0 m long at 4 locations
- Foundation Treatment		PC Pile ϕ=600, L=12m~14m, 76 units PC Pile ϕ=400, L=12m, 62 units
Intake Facilities		
- Intake Gates (Steel slide gate)	Right Left	H×B=1.00 m × 1.25 m, 2 units H×B=1.00 m × 1.00 m, 2 units
- Size of Box Culvert	Right Left	H×B×L=1.50 m × 1.50 m × 37.3m, 2 units H×B×L=1.50 m × 1.25 m × 73.3m, 2 units
Irrigation Channel		
- Shape and Type		Trapezoid-section, wet masonry type
- Channel Size	Right Left	Bottom Width B=3.3m, L=257m Bottom Width B=2.8m, L=218m
Maintenance Bridge (Steel)		W=1.1m, L_1=29.0m, L_2=33.0m
Control House		1 site
Protection Works for Flood Channel		3,000 m^2

Spillway Bed Structure (Main Dam Body)

(1) Length of Apron and Riverbed Protection

The lengths of apron and riverbed protection are designed using the Bligh's Formula. The required lengths of spillway bed, apron and protection works are as follows:

Item	Length	
	Upstream	Downstream
Spillway Bed	4.0 m	4.0 m
Apron	8.0 m	16.0 m
Protection Works	5.0 m	10.0 m

To withstand scouring force and uplift pressure, the thickness of spillway bed and apron is designed at 1.6 m and 1.2 m.

(2) Foundation

The foundation of weir consists of fine sand having the N-value of 16 on average. The supporting layer which has the N-value of more than 50 is observed below EL -10.00 m in Borehole B7. As for the foundation of the inflatable rubber-made dam, prestressed concrete piles with a diameter of ϕ600 mm are driven to increase the bearing capacity of the subsurface layer to support the weir body.

(3) Prevention of Piping

Steel sheet piles, 2 m long, are driven at four locations; upstream and downstream edges of apron and spillway bed structure, to assure the required creep length and prevent piping, which is estimated at about 20 m by Bligh's Method and Lane's Method.

Inflatable Rubber-Made Dam

An air-filled inflatable rubber-made dam with an automatic deflation system is employed. The power for operation is availed from the local power line. One set of diesel engine generator is provided for emergency power source.

Machine Room and Control House

A control house is provided at the left side of the left dike. The control house is composed of entrance hall, operator room, operation room and machine room at the basement. The minimum area for each room is estimated as follows:

Entrance Hall	2.5 m^2
Operator Room	14.5 m^2
Operation Room	8.0 m^2
Machine Room	8.0 m^2
Total	33.0 m^2

Maintenance Bridge

A maintenance bridge is provided upstream of the weir to access the control gates for irrigation. The bridge is designed as follows:

Span	L_1 = 29.0 m (control house to left control gate) L_2 = 33.0 m (left control gate to right control gate)
Steel Girder	I-Beam (60 cm high, 30 cm wide)
Width	1.5 m

Flood Channel Protection Works

For flood channel protection works, crib-type concrete blocks with boulder filling, each 1.5m × 1.5m × 0.2m in size and 0.5 ton in weight, are provided to prevent erosion along the dam body and intake facilities for irrigation. The protection works shall cover the area along the low water channel and box culverts for irrigation intake. The area to be covered by protection works is 3,000 m^2 in total.

6.2.6 Diversion Weirs

Foundation of Weirs

Toba Tuff formed in the diluvium stratum and composed of stiff sandy soil is applied to the bearing foundation of weirs. SPT of Toba Tuff shows N=30 to more than 50 and the coefficient of permeability is 10^{-4} to 10^{-5} cm/s. Based on these soil properties, Toba Tuff is evaluated to be an adequate stratum for the spread foundation of a 5 to 10 m high gravity weir. The foundation of both diversion weirs is designed as follows:

(1) Deli River Weir

An outcrop of stiff Toba Tuff stratum is observed at the riverbed, and the stratum having a high bearing capacity (N-value is mostly more than 40) is confirmed at EL 22.0 m to EL 23.0 m in Boreholes B35, B38 and B39. The base elevation of the weir is set at EL 21.700 m which is 2.5 m below the surface of apron.

(2) Floodway Weir

Borehole B37 and additional Boreholes B40 and B42 along the Floodway axis show that a stiff and uncemented Toba Tuff as supporting layer (N-value is more than 40) appears at EL 20.0 m to EL 23.0 m.

From the geological condition, a spread foundation requires the embedment depth of weir to reach 5 m, while the weir height is only 6 m. Further, a pile foundation is made by driving piles of only 3 to 4 m long. These two foundation types could be hardly employed for the Floodway Weir due to disadvantages in construction cost.

Therefore, to ensure the strength of the foundation, foundation improvement works by cement-treated material is employed from the economical point of view. The thickness of the improved foundation is 3 m and the area is 2 m wider than the weir base. The required strength of the improved foundation is 50 tf/m^2 and it is assumed that about 70 to 100 kg/m^3 of cement will be sprinkled.

Hydraulic Design

Hydraulic analyses were made to verify the results of the hydraulic model test which resulted in the modification of the following items:

(1) Crest elevation of Floodway Weir;

(2) Baffles for orifice;

(3) Length of apron of Deli River Weir; and

(4) Approach wall (wing walls) of Deli River Weir.

In addition, a hollow space was observed on the vein of the overflow water at the floodway weir crest. To check the effect of this hollow space, the tested and the calculated overflow coefficients of the Floodway Weir were compared, as shown below.

Discharge (m^3/s)	Water Level (EL m)	Water Depth (m)	Overflow Coefficient	
			Tested	Calculated
99.0	34.32	1.82	1.52	1.73
70.0	33.98	1.48	1.47	1.67
29.5	33.44	0.94	1.22	1.50

(Note) Overflow coefficients are calculated by Beresinski's Formula.

The tested coefficients of overflow are smaller than the calculated by 14% to 23%. The results show that the hollow space obstructs the smooth and effective flow at the crest and the differences are caused by the warped shape of crest. Therefore, the rounded crest is employed to avoid the occurrence of cavitation at the crest edge.

(1) Deli River Weir

As mentioned before, the lowest crest elevation and maximum overflow depth for both the Immediate and Urgent plans of Deli River Weir are as follows:

Dimension of Deli River Weir	Immediate Plan	Urgent Plan
Crest Elevation	EL 31.000 m	EL 31.500 m
Overflow Depth	3.00 m	2.50 m
Weir Length	17.5 m	17.5 m
Discharge from Orifice	68.9 m^3/s	78.5 m^3/s
Discharge from Overflow Section	161.1 m^3/s	121.5 m^3/s

(2) Floodway Weir

The design dimensions of the Floodway Weir are primarily determined by the condition of the Urgent Plan, as mentioned above. To obtain a perfect overflow at the crest, the lowest crest elevation and maximum overflow depth for both the Immediate and Urgent plans of the Floodway Weir are as follows:

Dimension of Floodway Weir	Immediate Plan	Urgent Plan
Crest Elevation	EL 32.500 m	EL 32.500 m
Overflow Depth	1.50 m	2.00 m
Weir Length	17.5 m	25.0 m

Structural Dimensions

The dimensions prepared through the hydraulic design calculation are as follows:

(1) Deli River Weir

Item	Dimensions
Structural Type	Gravity, Trapezoid-Shaped Weir
Design Water Level	EL 34.000 m
Elevation of Crest	EL 31.000 m (EL 31.500 m)
Elevation of Apron	EL 24.200 m
Elevation of Foundation	EL 21.700 m
Length of Overflow Weir Crest	17.5 m
Width of Overflow Weir Crest	3.0 m (2.5 m)
Height of Overflow Weir Crest	6.8 m (7.3 m)
Orifice for Low Water	3.0 m x 2.0 m
Number of Orifice	2
Bottom Elevation of Orifice	EL 24.700 m
Overflow Depth	3.00 m (2.50 m)
Inclination of Weir Face	Vertical (up) and 1 : 1 (down)
Modification of Weir from Immediate to Urgent Plan	0.5 m (Raising weir crest)

(Note) Figures in parentheses are for the Urgent Plan.

(2) Floodway Weir

Item	Dimensions
Structural Type	Gravity, Trapezoid-Shaped Weir
Design Water Level	EL 34.000 m
Elevation of Crest	EL 32.500 m (EL 32.000 m)
Elevation of Apron	EL 26.500 m
Elevation of Foundation	EL 24.000 m
Length of Overflow Weir Crest	25.0 m
Width of Overflow Weir Crest	2.0 m (2.5 m)
Height of Overflow Weir Crest	6.0 m (5.5 m)
Overflow Depth	1.50 m (2.00 m)
Inclination of Weir Face	Vertical (up) and 1 : 1 (down)
Modification of Weir from Immediate to Urgent Plan	0.5 m (Lowering weir crest)

(Note) Figures in parentheses are for the Urgent Plan.

Structural Details

(1) Deli River Weir

The Deli River Weir consists of major structures such as main weir body, apron, breast wall, wing wall, riverbed protection and revetments. The basic features of the structures are presented in DWG 6.2.17, and the design conditions are described below.

(a) Direction

The weir axis is placed at right angle with the flow direction of the existing channel.

(b) Elevation of Apron Bed

The elevation of apron bed is set at EL 24.200 m, which conforms to the existing riverbed elevation at UD12.

(c) Length and Thickness of Apron

The apron, 30 m long, is proposed by the hydraulic model test to ensure the dissipation of flow energy, as the creep lengths against piping are estimated at 20.4 m for Deli River Weir and 23.4 m for the Floodway Weir. Therefore, a cut-off wall such as sheet pile is not provided. The apron thickness is set at 2 m to withstand the scouring force and uplift pressure.

(d) Breast Wall

A gravity type of breast wall is provided at both sides of main weir body to contact the weir body and the impermeable foundation and thus prevent horizontal seepage.

(e) Wing Wall

To minimize the excavation volume and its construction cost, and to ensure the connection between wall and foundation, a semi-gravity type of wing wall and a gravity type wall are applied to the upstream and downstream wing wall, respectively.

(f) Protection Works

Concrete blocks as flexible riverbed protection are provided for the upstream and downstream riverbeds of weir. For the upstream protection, crib-type concrete blocks with boulder filling (1.5m × 1.5m, 0.5 ton each) are provided, and for the downstream, square type concrete blocks (1.0m × 1.0m, 1.0 ton each) are provided, corresponding to the water velocity.

The length of downstream protection works is estimated by the Bligh's Formula. It is 45.0 m from the end of apron. The length of upstream protection is set at about half of the downstream length. Slope protection is also provided to protect side slopes from erosion caused by overflow discharge.

(g) Orifice

To pass the low water discharge of 10.6 m^3/s by open channel flow, two orifices, 2.0 m high and 3.0 m wide, are provided at the center of the weir. Bed elevation of the orifice is raised by 50 cm from the bed elevation of the apron. At the outlets of the orifices, two baffles of column type are provided to dissipate the energy of flow from the orifices.

(2) Floodway Weir

The main structures are almost the same as those of the Deli River Weir. The design is shown in DWG. 6.2.18, and the design conditions are as follows:

(a) Direction

The weir axis is placed at right angle with the centerline of the Floodway, which is nearly parallel to the flow direction of Deli River.

(b) Height of Apron Bed

The height of weir apron bed is set at EL 26.500 m, which is about 1.0 m higher than the elevation of the adjacent riverbed.

(c) Length and Thickness of Apron

The same design conditions as those of the Deli River Weir are applied. As a result of the hydraulic model test and structural calculation, the length of apron is set at 20 m, and thickness of apron is 1.5 m.

(d) Breast Wall

A gravity type of breast wall is provided at both sides of main weir body, to contact the weir body and the impermeable foundation and prevent horizontal seepage.

(e) Wing Wall

A reinforced concrete wall (inverted T-type wall) is provided along the approach channel of the Floodway Weir to retain both bank embankments. To ensure the connection between wall and foundation, a gravity type wall is applied to the downstream wing wall.

(f) Protection Works

The same design conditions as those of the Deli River Weir are applied, and a 40 m long downstream protection works is provided. For the approach channel bed, crib-type concrete blocks with boulder filling are applied.

6.2.7 Waterfront Facilities

Environmental Improvement Works

(1) Walkways and Tree Plantings in Retarding Channel

Walkways are provided along both banks of the retarding channel, for strolling along the river. This pedestrian road is paved with gravel, 3.0 m wide. Further, tree plantings and side ditches are provided alongside the walkway in Zone D.

(2) Walkway and Tree Planting along Floodway

Walkways, which can be used also as inspection roads, are provided along the Floodway. Planting of high and low trees, stone pitching, side ditch and fence are also provided alongside the walkway, as shown in DWG 6.2.19.

(3) Tree Planting along Inspection Road in the Upstream of Percut River

Tall trees are proposed to be planted alongside the inspection road of both right and left banks. Side ditches are also provided along the inspection road to drain adjacent inland water.

(4) Waterfront Steps for Percut and Deli Rivers

The river channel is used by inhabitants near the river for domestic purposes. Therefore, approach steps to the waterfront are provided on the riverbanks at the interval of about 500 m along Percut River and 8 places in the Deli Retarding Channel. The waterfront steps are made of concrete or wet masonry, and riprap as shown in DWG 6.2.20 is provided at both sides of the step.

(5) Sodding and Boulder Pitching in Deli Retarding Channel

Check sodding is provided over Zone A in the Deli Retarding Channel to prevent surface erosion by rain. Further, boulder pitching is executed along the boundary between Zone A and Zone B to protect the boundary slope.

(6) Roofed Bench and Information Board in Deli Retarding Channel

Four roofed benches and three information boards are placed in Zone D and around the Floodway Weir.

Reconstruction of Road

(1) Kabupaten Road and Farm Road of Lower Percut River

In connection with the dike construction, the existing kabupaten road, running along the right bank of the stretch from PE15 to PE34, is reconstructed in almost the same location as that existing behind the new dike. This road is classified as Class III according to the standards of the Directorate General of Highways. The road is designed with a total road width of 5.0 m, a pavement width of 4.0 m and a total length of 1,985 m. As for the pavement, asphalt treated base (ATB) is provided.

The existing farm road in the stretch from PE84 to PE95 is also relocated and reconstructed due to the construction of the dike nearby. The road is 5.0 m wide with a gravel pavement of 3.0 m wide.

(2) Road Pavement along Floodway

The following two roads running along the Floodway are also paved by ATB with a total width of 5.0 m and a pavement width of 4.0 m.

Load Stretch	Length
FW20+50 to FW28+18 (Left bank)	780 m
FW 28+18 to FW33+33 (Right bank)	515 m

(3) Approach Road

An approach road connecting to the inspection road in the floodway channel/channel bed is provided in the downstream of Percut River as well as the Medan Floodway. The approach road is designed, as a passageway of maintenance vehicles, with a width of 4.0 m and a longitudinal slope of 10%.

6.3 Bridges

6.3.1 Road Bridge

General plans of 13 road bridges are presented in DWGs 6.3.1 to 6.3.13.

Superstructure

The design conditions of bridge superstructure are as follows:

(1) Deck Slab

The deck slab spans in one direction and the bending moment of live and dead loads is computed as in continuous slab over the longitudinal beams. For concentrated load the bending moment per unit width of slab is computed using the effective width. Details of deck slab are given in DWG 6.3.14.

(2) Prestressed Concrete Beam

Beams are precast prestressed concrete and constructed with deck slab as composite beam which has the advantages as follows:

(a) Construction time is substantially reduced when precast elements are used;

(b) The precast prestressed concrete units are erected first and can be used to support the forms needed for the cast-in-place deck slab with no additional scaffolding, which are replaced by stay-in-place precast concrete panel; and

(c) The cast-in-place slab can be poured continuously over the supports of precast and after slab hardening is assumed to act only for superimposed dead and live loads.

In the design of prestressed concrete members, loading is taken as not only external load such as dead load and live load but often a combination of these loads acting with the prestressing force on the concrete section.

(a) Initial Loading

The initial loading refers primarily to the stage where the prestressing force is transferred to the concrete and no external loads act except the weight of the member. At this time the prestressing force is taken at the maximum, as prestress losses have not yet taken place and concrete strength is minimum.

(b) Final Loading

The final loading stage refers here to the most severe loading under service condition. It is then assumed that all prestress losses have accumulated and the prestressing force is final.

Loads acting on a beam are divided into dead load and live load. Dead load involves deck slab, longitudinal beam and cross beam, and live load is defined by the standards of the Directorate General of Highways, consisting of "D" load involving uniform load and knife load.

The details of PC girder beam for the lengths of 31.6 m and 40.8 m are presented in DWG 6.3.15 and DWG 6.3.16, respectively.

Substructure

(1) Abutment

An abutment is the substructure which supports one terminus of the superstructure of a bridge and at the same time, laterally supports the embankment which serves as an approach to the bridge. For a river bridge, the abutment also protects the river bank/slope from scouring, and abutment is made of reinforced concrete in the design.

An abutment generally consists of the following:

(a) The breast wall which directly supports the dead load and live load and retains the filling of embankment in its rear;

(b) The wing wall, which acts as extension of the breast wall in retaining the embankment; and

(c) The back wall, which is a small retaining wall just behind the bridge seat, preventing the flow of material from the fill onto the bridge seat.

In abutment design, the forces to be considered are:

(a) Dead load of superstructure and live load;

(b) Self weight of abutment; and

(c) Horizontal load of surcharge load.

Horizontal load by earth pressure rear of abutment depends on soil characteristics. Stability of abutment and working stresses on base footing are checked in four conditions:

(a) Normal condition in high water level;
(b) Normal condition in low water level;
(c) Earthquake condition in high water level; and
(d) Earthquake condition in low water level.

The typical design of abutment is given in DWG. 6.3.17.

(2) Pier

In pier design, the forces to be considered are:

(a) Dead load of superstructure and live load;

(b) Self weight by pier;

(c) Horizontal load by breaking load (Breaking force = 5% of "D" load, without impact coefficient); and

(d) Gravity load by earth filling above pier footing, depending on soil characteristics.

Stability of pier and stresses working on base footing are checked in four conditions, as follows:

(a) Normal condition in high water level;
(b) Normal condition in low water level;
(c) Earthquake condition in high water level; and
(d) Earthquake condition in low water level.

The typical design of pier is given in DWG 6.3.18.

(3) Foundation

The design of foundations is an important part of the overall design for bridges. The design demands a detailed knowledge of hydraulics, soil mechanics and structural analysis.

In various calculation methods of the pile top reactions, the "Displacement Method" is used on assumption of distributing loads on footing as axial load, lateral load and moment to each pile.

6.3.2 Railway Bridge

(1) Location

The railway bridge is constructed at FW32+0, the same location as the existing bridge which crosses the floodway channel. The width of the floodway is 33.0 m at the top of the channel bank.

(2) Dimensions and Load of Train

The dimensions and load of a train are in accordance with the standards used by the railway authority in Indonesia, as follows:

Train Cross Section	H=3.85m, W=3.70m
Track Width	1,067 mm
Design Speed of Train	80 km/hr
Live Load (RM 1921)	12.0 ton/m

(3) Type of Bridge

Based on the span length, two types of bridges are conceivable, namely PC Single I-Girder Bridge and Warren Truss Steel Bridge. Through the comparison study focusing on structural characteristics, construction cost and maintenance, the PC Single I_Girder Bridge was selected as the best alternative.

(4) Structural Details (DWG 6.3.19)

(a) Superstructure

The superstructure is composed of PC girders and concrete track bed on which the ballast is lain. The length of the girder and the width of concrete track bed are 31.6 m and 3.5 m, respectively.

(b) Substructure

The abutment is designed with a width of 7.5 m and a height of 4.3 m. The pile foundation is employed to convey the loads from the superstructure to the bearing layer below EL +16.5 m.

6.3.3 Pedestrian Bridge

Beside of the bridge mentioned above, there are three bridges used by pedestrians. One on Percut River is to be reconstructed, the second one is on Medan Floodway, and the third one is to be reconstructed upstream of the diversion weir.

The pedestrian bridge on Percut River is 2.0 m wide with a span length of 40.8 m. The pedestrian bridge on Medan Floodway has a span length of 31.6 m, while that on the Deli River upstream of the diversion weir has three spans of 58.8 m in total.

All of these pedestrian bridges are prestressed concrete bridge structures. The detail design for pedestrian bridges is the same as that of road bridges, but a different live load of 500 kg/m^2 is applied. Typical designs of superstructure and abutment of the pedestrian bridge are shown in DWG 6.3.20 to 6.3.22.

6.3.4 Water Pipe Bridge

Municipal Water Supply

The existing water pipelines for municipal water supply under PDAM Tirtanadi are usually installed side by side with the bridge, but for a special diameter of water pipe of over ϕ300 mm the bridge for water pipeline is independently constructed to support the pipe. There are also some water pipelines buried underground crossing the route of the Medan Floodway.

In the course of project construction, all water pipes shall be replaced or reinstalled. For the replacement or reinstallation of water pipes, water pipe bridges shall be constructed for water pipes with a diameter of more than ϕ400 mm, while the water pipe with a diameter of less than ϕ400 mm will be installed only under the sidewalks of reconstructed or newly constructed bridges.

The locations of water pipelines on both channels are as given below. The typical design of water pipes to be installed under the sidewalk of bridges is shown in DWG 6.3.23, while the general plan of new pipe bridges are presented in DWG 6.3.24 to 6.3.26..

(1) Percut River

Bridge	Station	Location	Pipe Diameter (mm)	Crossing System
Br. P7	PE 169+59	Medan Tembung	100	under sidewalk
Br. P9	PE 200+25	Medan Denai	150	under sidewalk
			100	under sidewalk
Br. P11	PE 222+00	Binjai	150	under sidewalk
			400	under sidewalk
Br. P13	PE 246+57.5	Amplas	300	under sidewalk
			150	under sidewalk
			125×4	under sidewalk
New (WB1)	PE 255+10	Amplas	600+600	new truss bridge

(2) Medan Floodway

Bridge	Station	Location	Pipe Diameter (mm)	Crossing System
New (WB2)	FW 20+55	-	800	new truss bridge
New (WB4)	FW 32+10	-	600+300	new truss bridge
Br. F5	FW 33+65	-	350	under sidewalk

Irrigation Water

Since the floodway cuts across the irrigation channel for the downstream paddy field at FW24+70, a new water bridge is required to be constructed to convey the irrigation water over the Medan Floodway.

(1) Hydraulic Design

The irrigation area to be delineated downstream of the crossing point with the floodway is about 25 ha and the irrigation requirement is estimated to be 0.025 m^3/s. In accordance with the design cross section of the floodway, the pipe flow shall be siphon type so as not to disturb the inspection road and the side drainage ditch. The pipe diameter is estimated to be 0.300 m by the following conditions:

(a) To allow the design discharge through the pipe, the diameter shall be larger than "D"; where $D \geq 1.6258 \times C^{-0.38} \times Q^{0.38} \times I^{0.205} = 0.212$ m, and C = 110.

(b) The flow velocity (V) inside the pipe shall be bigger than 0.3 m/s to avoid inside sedimentation; where D = Discharge/Flow Area ≥ 0.3 m/s

(2) Structural Design

Cost comparison of several types of water bridges such as pipe beam type and stiffened type of either truss, flange, tie rod or langer, the pipe beam type is found to be most economical and easiest to construct. Further, a continuous support type is selected as the optimum on account of the length and diameter of the pipe. As shown in DWG 6.3.27, the structural dimensions of the water bridge for irrigation are as follows:

Structural Item	Dimension
Bridge Length	3-span (16 m and 5.7 m × 2)
Pier	PC Pile ϕ300 mm, 12 m long × 2
Elevation	
- Inlet Water Level	EL 34.900 m
- Outlet Water Level	EL 34.700 m
- Design Water Level	EL 31.665 m
Pipe	
- Length	55.0 m
- Diameter	300 mm
- Thickness	6.9 mm

6.3.5 Approach Road

Due to site conditions, centerlines of reconstructed bridges may sometimes change. In accordance with the change of bridge centerline, new approach road shall be constructed with the standard design of 10 m or 19 m in width and 10% of road surface slope.

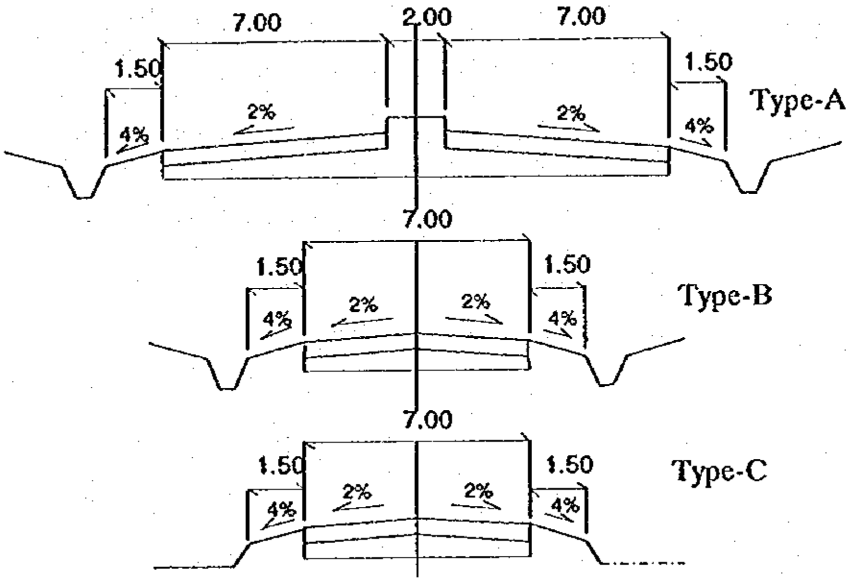
Features of approach road are as summarized below. Details are shown in Table 6.3.1.

(1) Percut River

Bridge	Station (m)	Total Width (m)	Total Length (m)	Type
Br. P1	PE 57+05	7.0	60.0	Type B
Br. P2	PE 84+28	7.0	60.0	Type B
Br. P3	PE 115+06	7.0	50.0	Type B
Br. P5	PE 137+49	7.0	36.0	Type B
Br. P6	PE 147+58	2.0	-	Pedestrian
Br. P7	PE 169+59	9.0	20.0	Type B
Br. P9	PE 200+25	16.0	20.0	Type A
Br. P11	PE 222+00	16.0	20.0	Type A
Br. P13	PE 246+57.5	16.0	20.0	Type A

(2) Medan Floodway

Bridge	Station	Total Width (m)	Total Length (m)	Type
Br. F1	FW 06+90	7.0	10.0	Type C
Br. F2	FW 20+45	9.0	10.0	Type C
Br. F3	FW 28+22	9.0	10.0	Type C
Br. F4	FW 32+00	3.6	10.0	Railway
Br. F5	FW 33+65	16.0	15.0	Type A
Br. F6	FW 37+60	2.0	0.0	Pedestrian
Br. F7	FW 38+78	3.5	10.0	Gravel Pavem't
Br. F8	DU-19+00	2.0	0.0	Pedestrian



TABLES

CHAPTER 6

DETAILED DESIGN

Table 6.3.1 TYPE AND DIMENSION OF APROACH ROAD FOR BRIDGE

(1) Percut River

Bridge	Width		Length		Road Pavement			
	Pavement (m)	Shoulder (m)	Left (m)	Right (m)	Surface Course (cm)	A.T.B. (cm)	Base Course (cm)	Sub-base Course (cm)
Br. P1	7.0	1.5 x 2	57.0	68.0	5.0	10.0	15.0	30.0
Br. P2	7.0	1.5 x 2	65.0	65.0	5.0	10.0	15.0	30.0
Br. P3	7.0	1.5 x 2	32.0	65.0	5.0	10.0	15.0	30.0
Br. P5	7.0	1.5 x 2	38.5	38.5	5.0	10.0	15.0	30.0
Br. P6	2.0	-	5.0	5.0	-	-	-	-
Br. P7	9.0	1.5 x 2	51.0	52.0	5.0	10.0	15.0	30.0
Br. P9	16.0	1.5 x 2	37.0	49.0	5.0	10.0	15.0	30.0
Br. P11	16.0	1.5 x 2	50.0	53.0	5.0	10.0	15.0	30.0
Br. P13	16.0	1.5 x 2	38.0	46.0	5.0	10.0	15.0	30.0

Note :

1. Length of road includes a horizontal part of 10m and transition section.
2. Side slope of road embankment is 1 : 2.

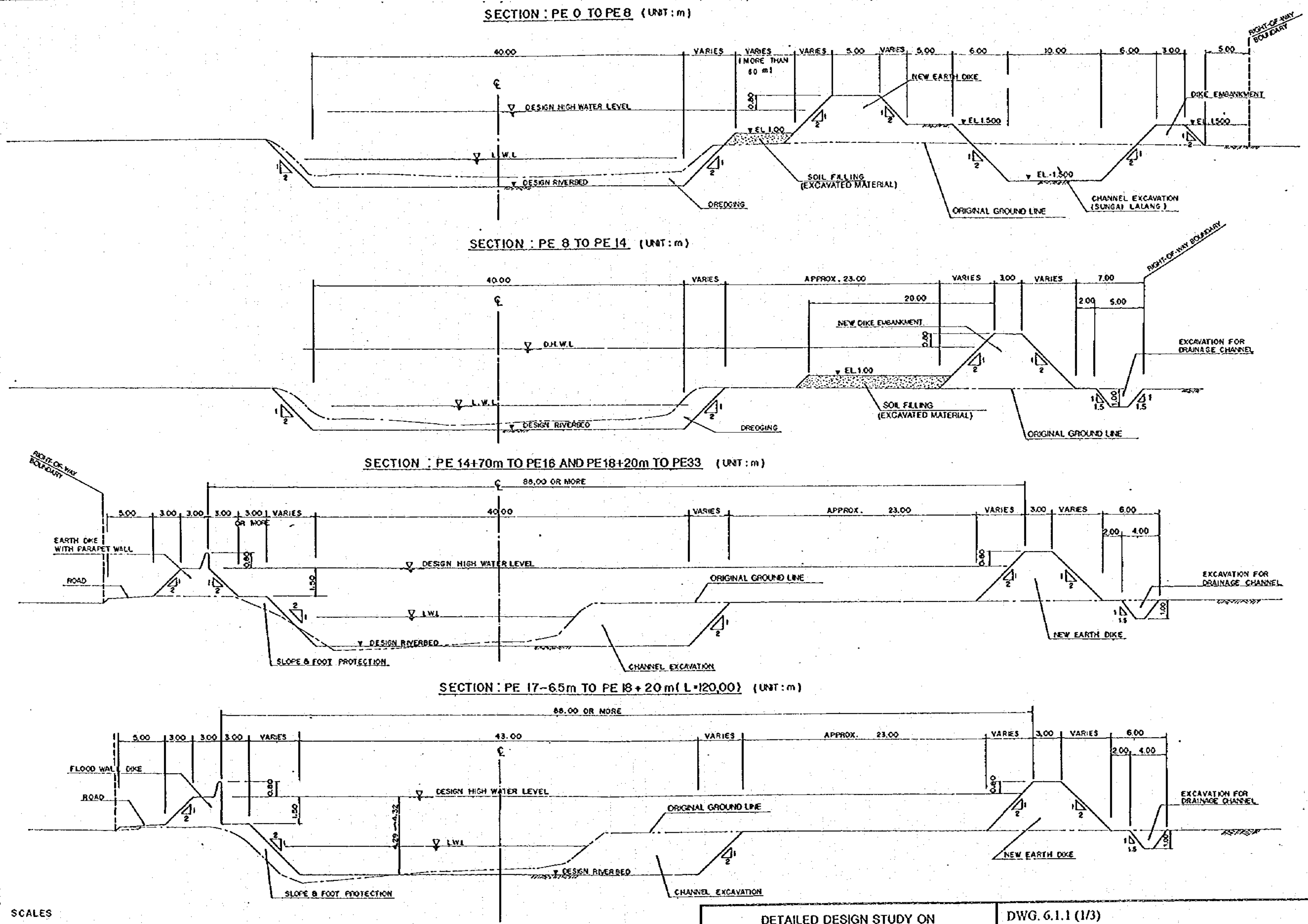
(2) Floodway

Bridge	Width		Length		Road Pavement			
	Pavement (m)	Shoulder (m)	Left (m)	Right (m)	Surface Course (cm)	A.T.B. (cm)	Base Course (cm)	Sub-base Course (cm)
Br. F1	7.0	1.5 x 2	10.0	6.5	5.0	-	15.0	20.0
Br. F2	9.0	1.5 x 2	10.0	10.0	5.0	-	15.0	20.0
Br. F3	9.0	1.5 x 2	10.0	10.0	5.0	-	15.0	20.0
Br. F4	3.6	-	-	-	-	-	-	-
Br. F5	16.0	1.5 x 2	23.0	23.0	5.0	10.0	15.0	30.0
Br. F6	3.0	-	11.0	11.0	-	-	20.0	-
Br. F7	4.5	-	3.0	40.0	-	-	20.0	-
Br. F8	3.0	1.25 x 2	28.8	28.8	-	-	20.0	-

DRAWINGS

CHAPTER 6

DETAILED DESIGN



SCALES

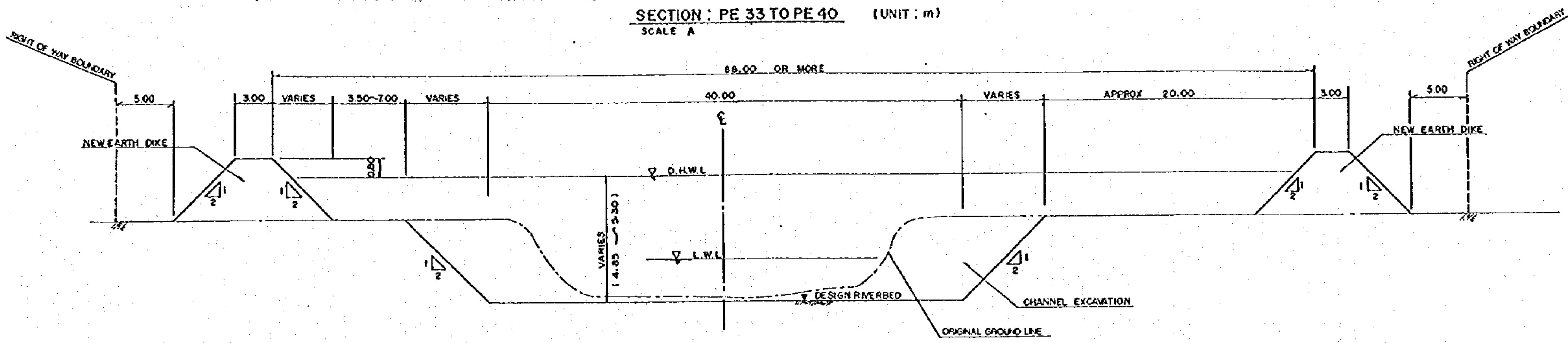
0 20 40 60 80 100m
SCALE VERTICAL 1:100

0 5 10 15 20 m
SCALE HORIZONTAL 1:200

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.1 (1/3) STANDARD CROSS SECTION OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	

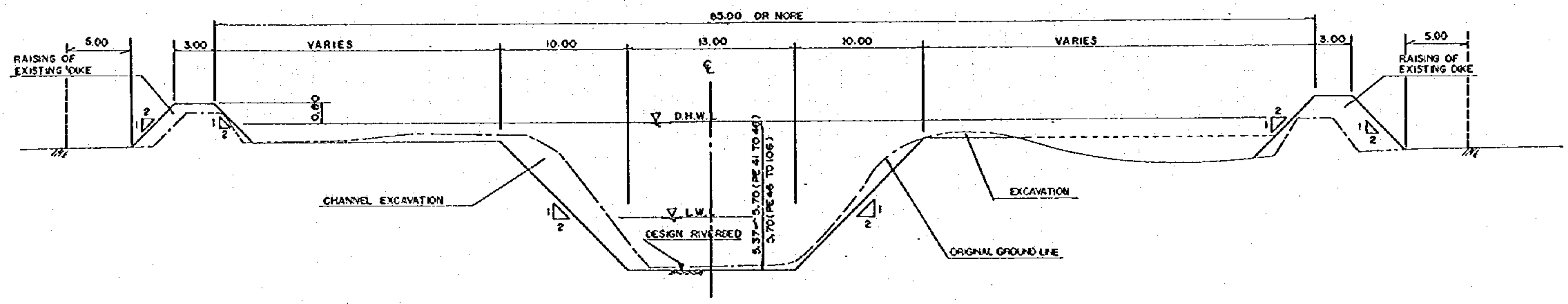
SECTION : PE 33 TO PE 40 (UNIT : m)

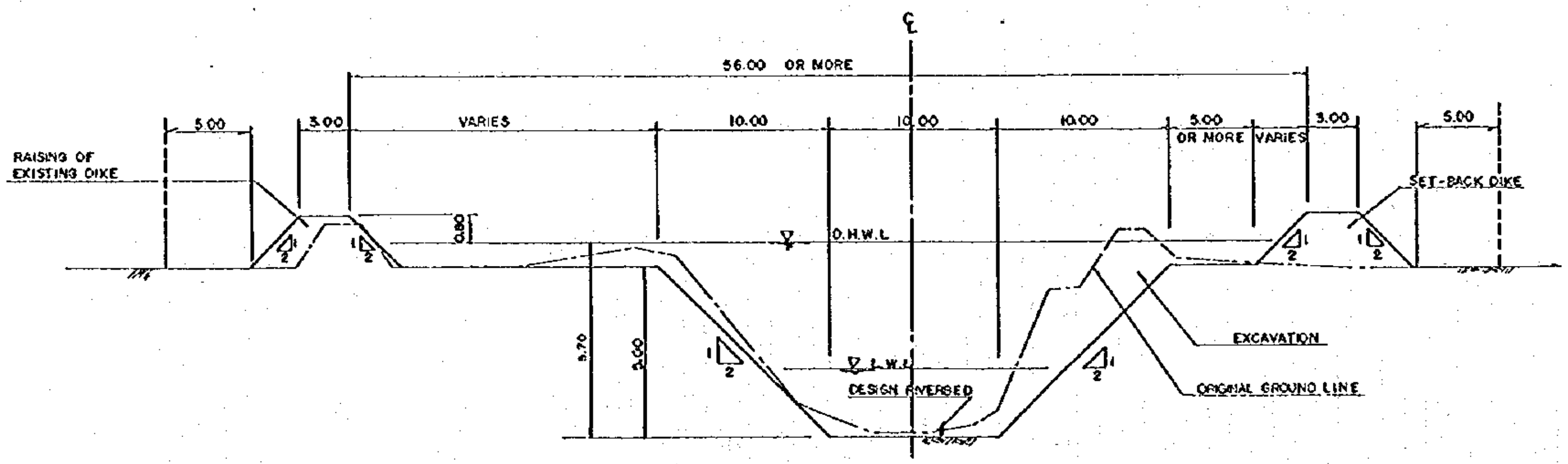
SCALE A



SECTION : PE 41 TO PE 106 (UNIT : m)

SCALE A

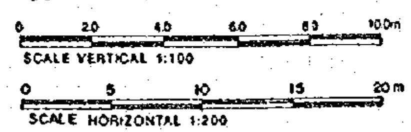




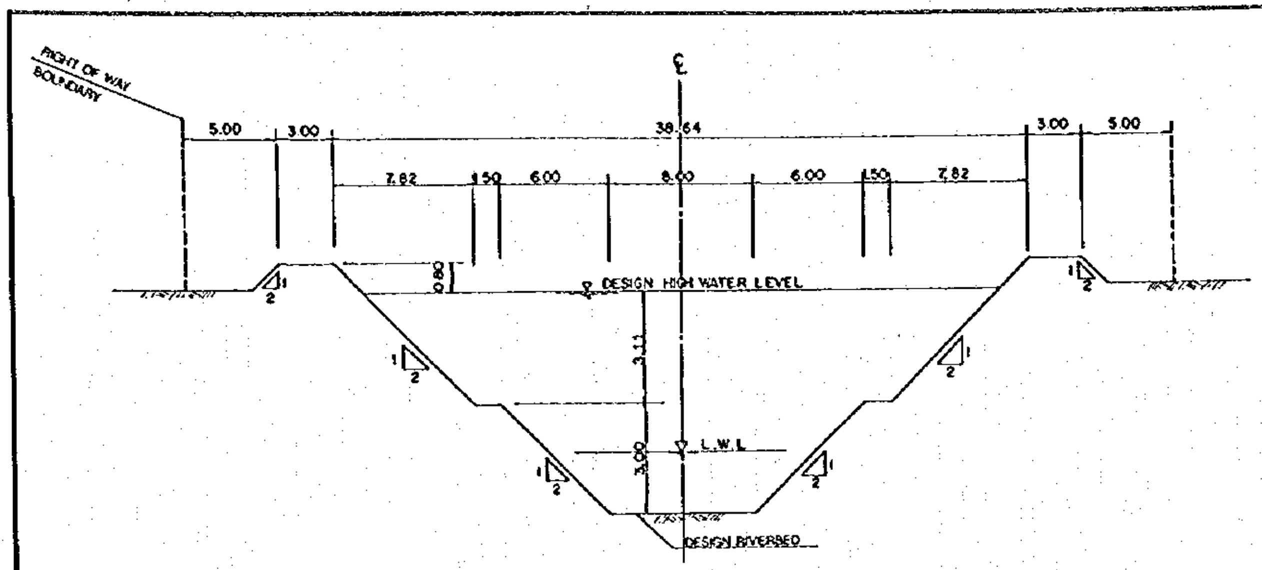
SECTION : PE 107 TO PE 129 + 43m (UNIT : m)

SCALE : VERTICAL 1 : 100
HORIZONTAL 1 : 200

SCALES

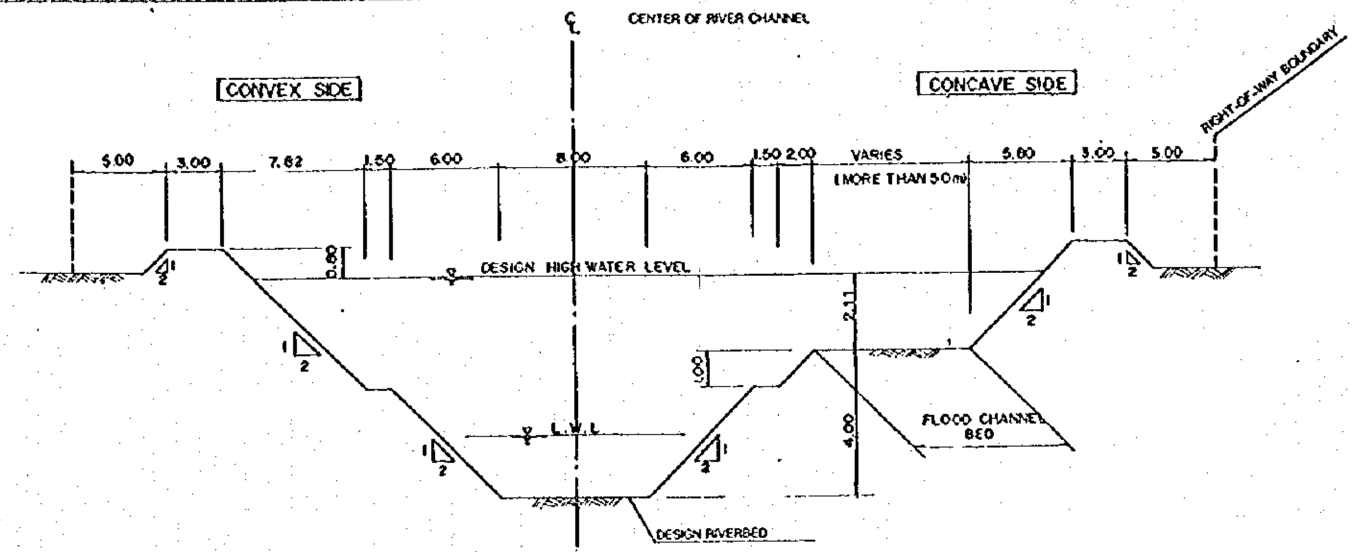


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.1 (2/3) STANDARD CROSS SECTION OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



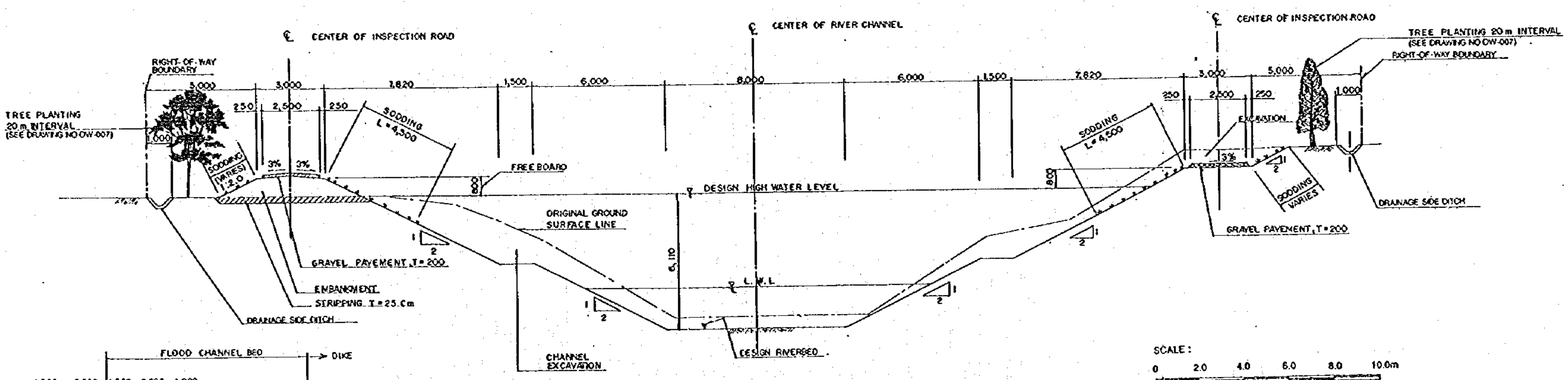
STANDARD CROSS SECTION OF PERCUT RIVER (PE 129 + 43m TO PE 247 + 0m) (UNIT : m)

SCALE VERTICAL 1 : 100
HORIZONTAL 1 : 200



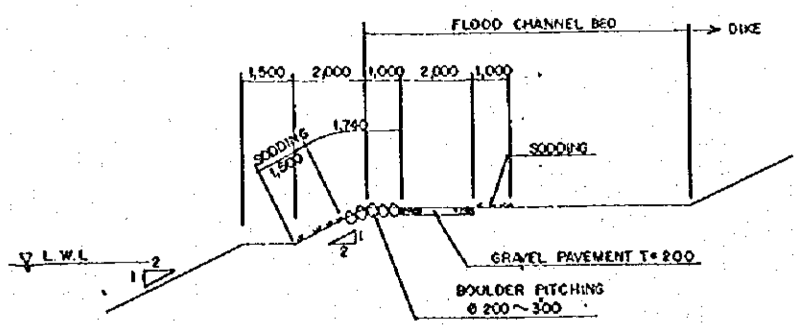
STANDARD CROSS SECTION AT BEND (UNIT : m)

SCALE VERTICAL 1 : 100
HORIZONTAL 1 : 200



TYPICAL CROSS SECTION OF RIVER CHANNEL AND INSPECTION ROAD (UNIT : mm)

SCALE 1 : 100

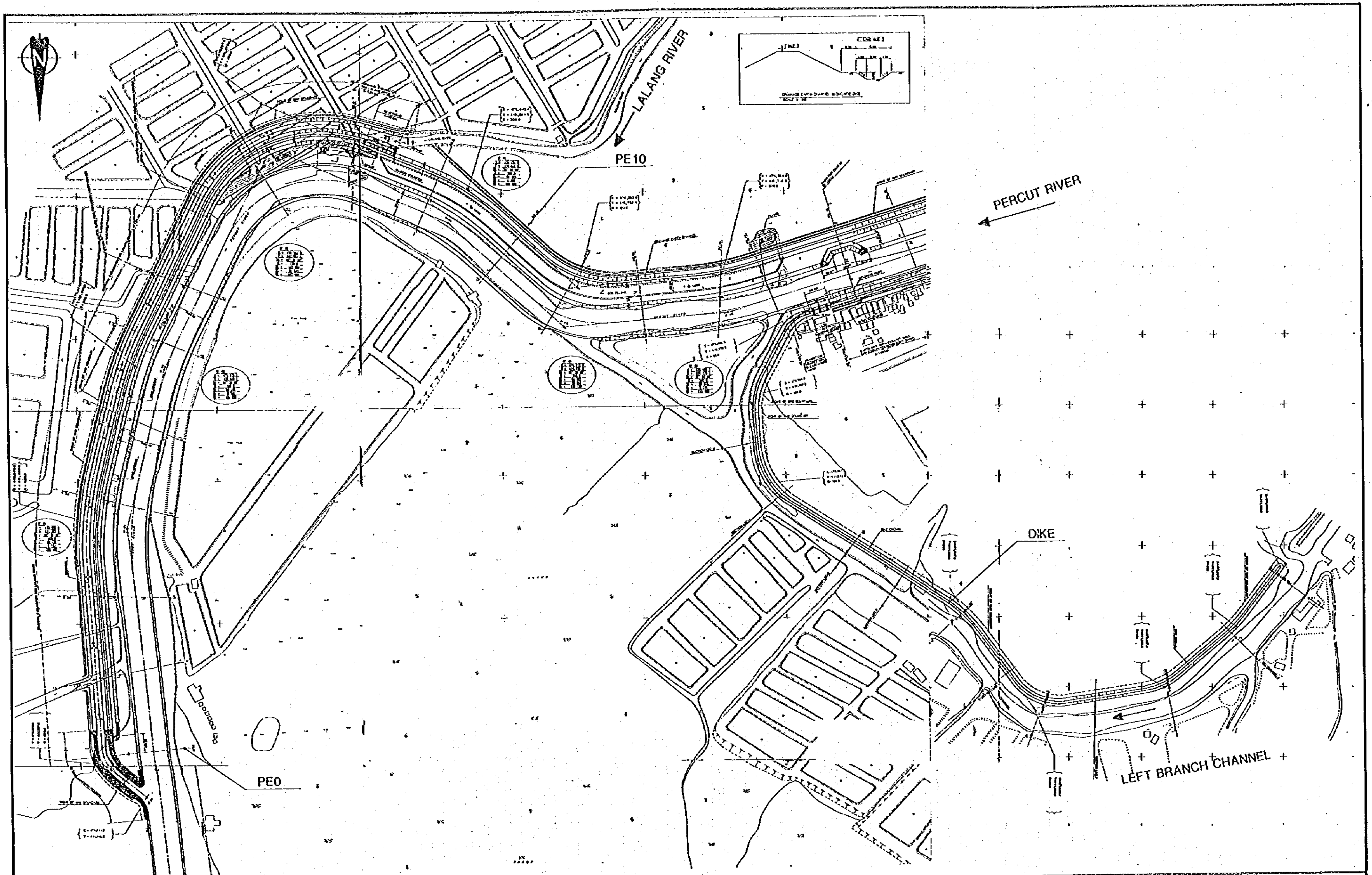


DETAIL OF WALKWAY ON FLOOD CHANNEL BED

SCALE 1 : 100

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.1 (3/3) STANDARD CROSS SECTION OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	

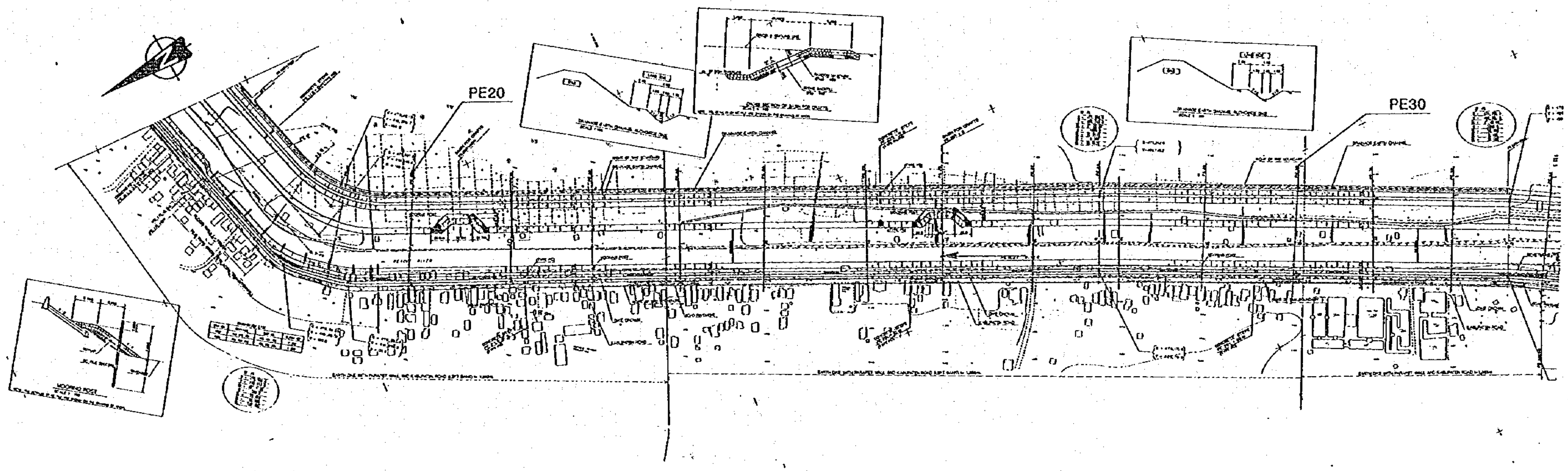
6-3

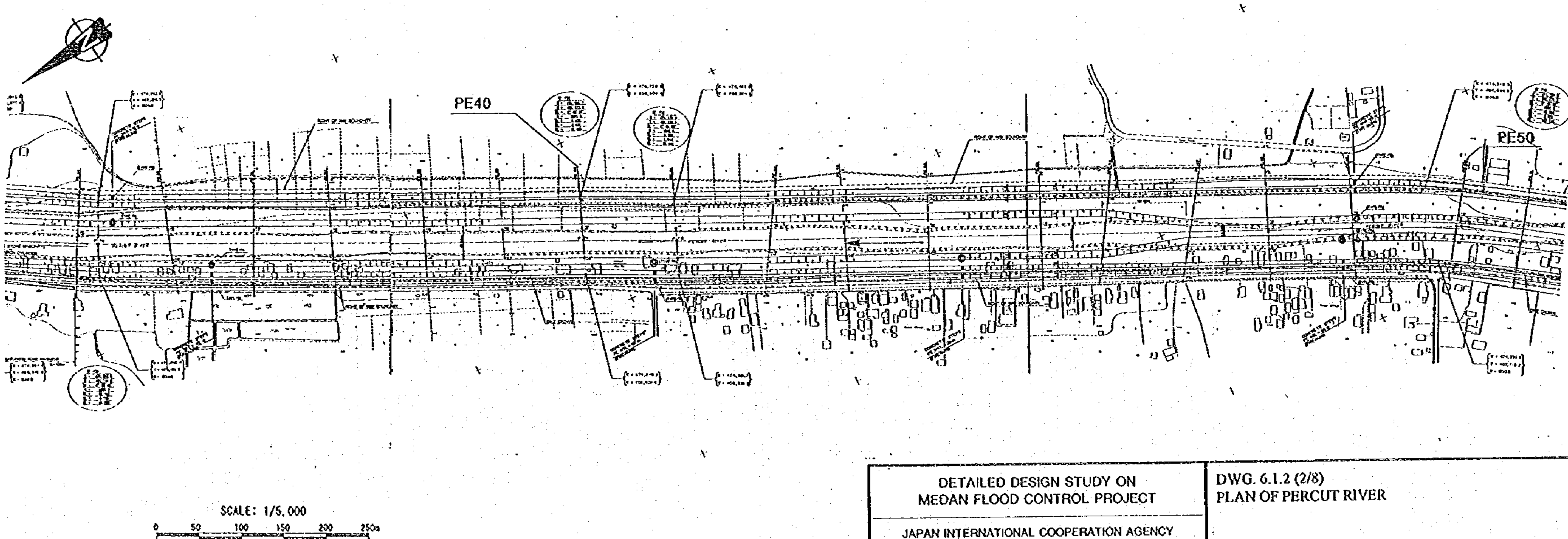


DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

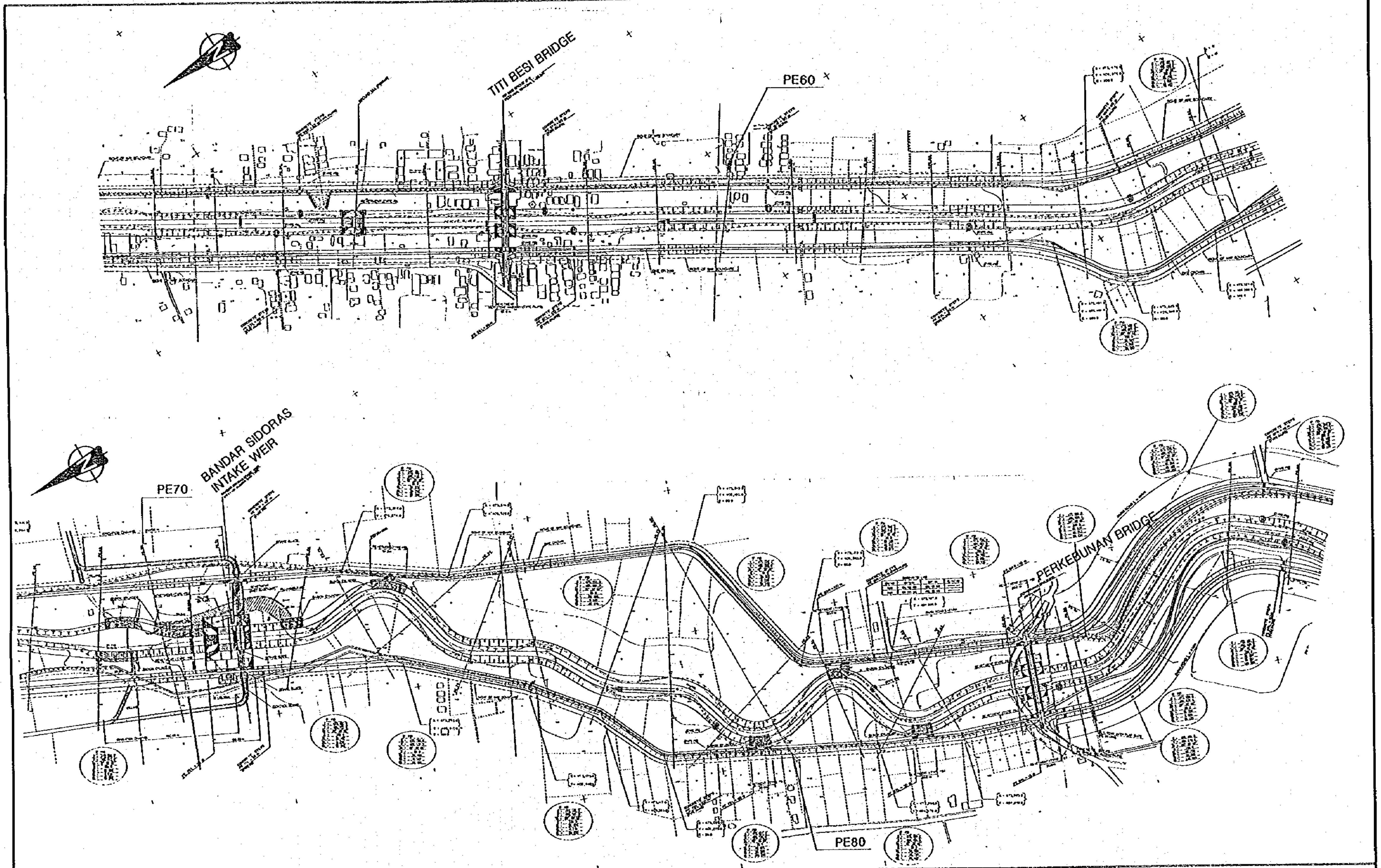
JAPAN INTERNATIONAL COOPERATION AGENCY

DWG. 6.1.2 (1/8)
PLAN OF PERCUT RIVER





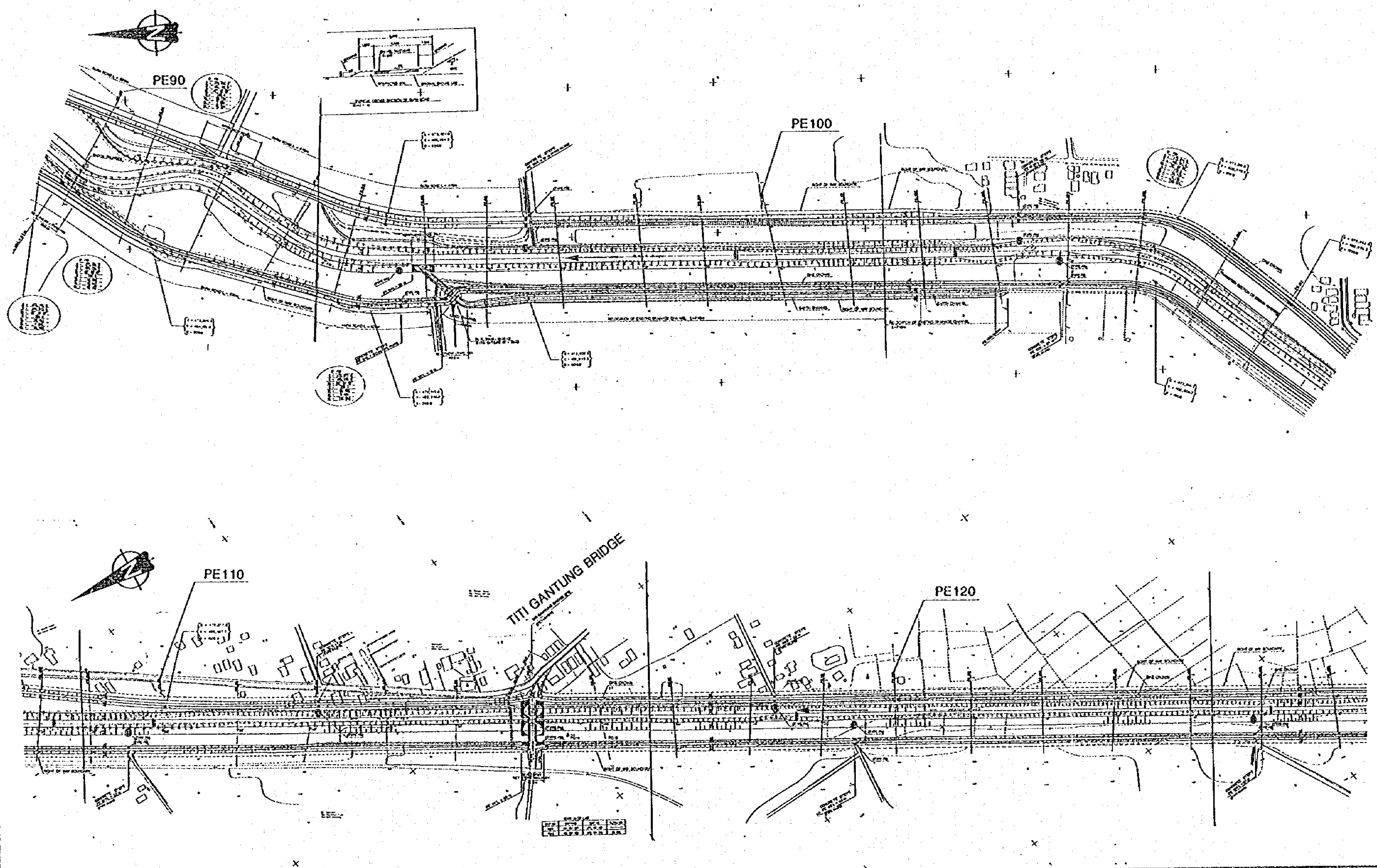
DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.2 (2/8) PLAN OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



SCALE: 1/5.000

0 50 100 150 200 250m

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.2 (3/8) PLAN OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	

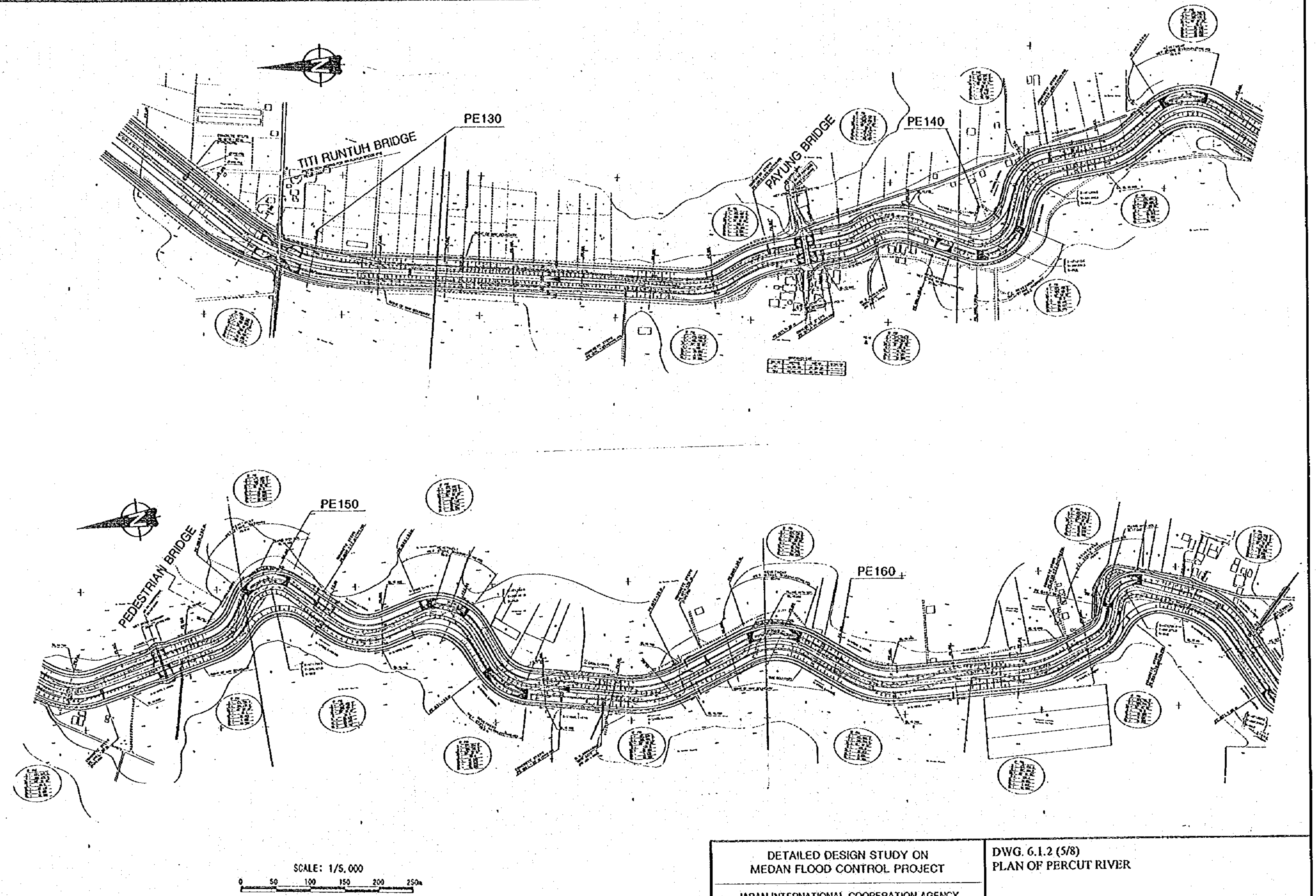


SCALE: 1/5,000

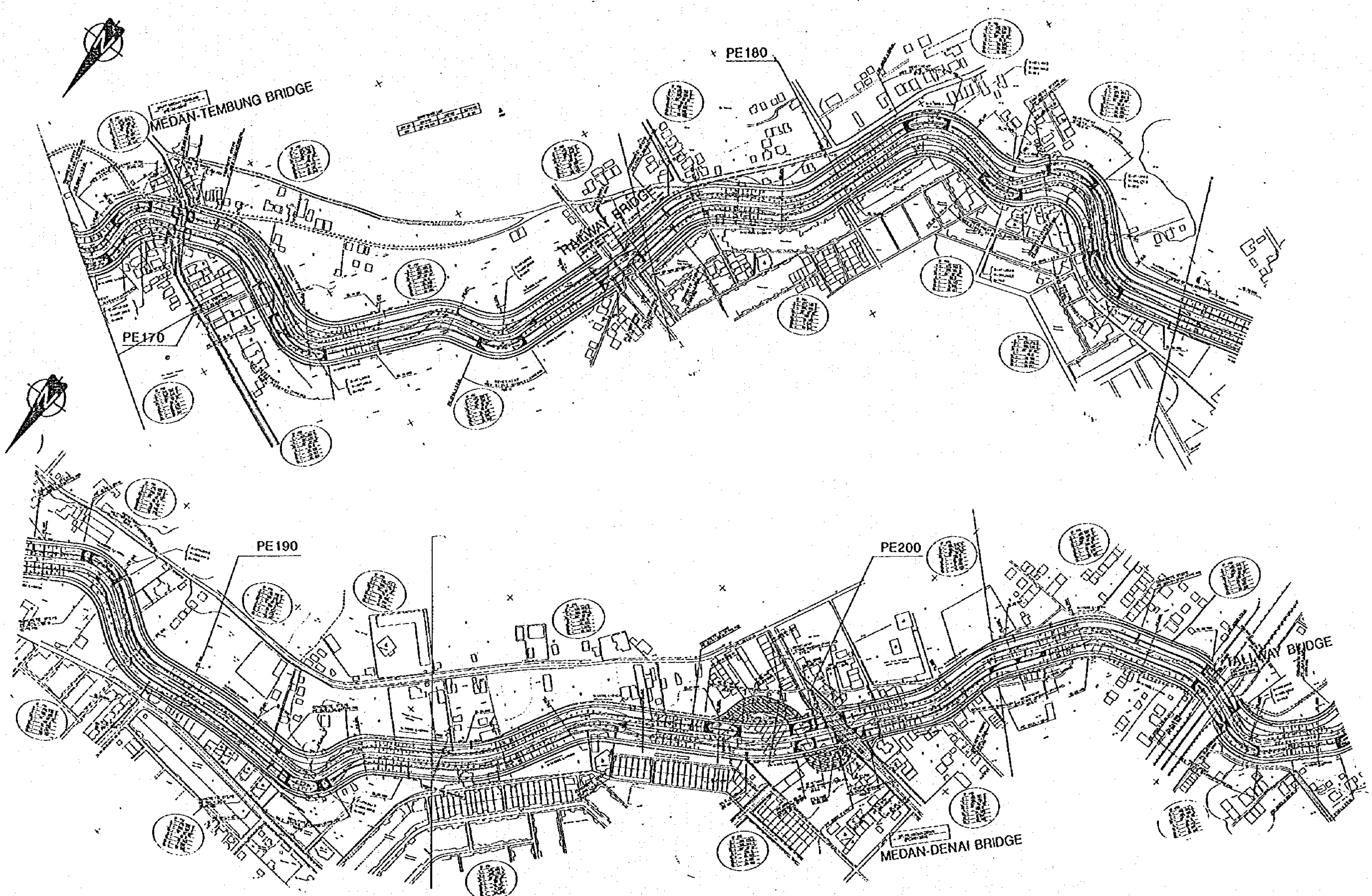
0 50 100 150 200 250m

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	DWG. 6.1.2 (4/8) PLAN OF PERCUT RIVER

6-7

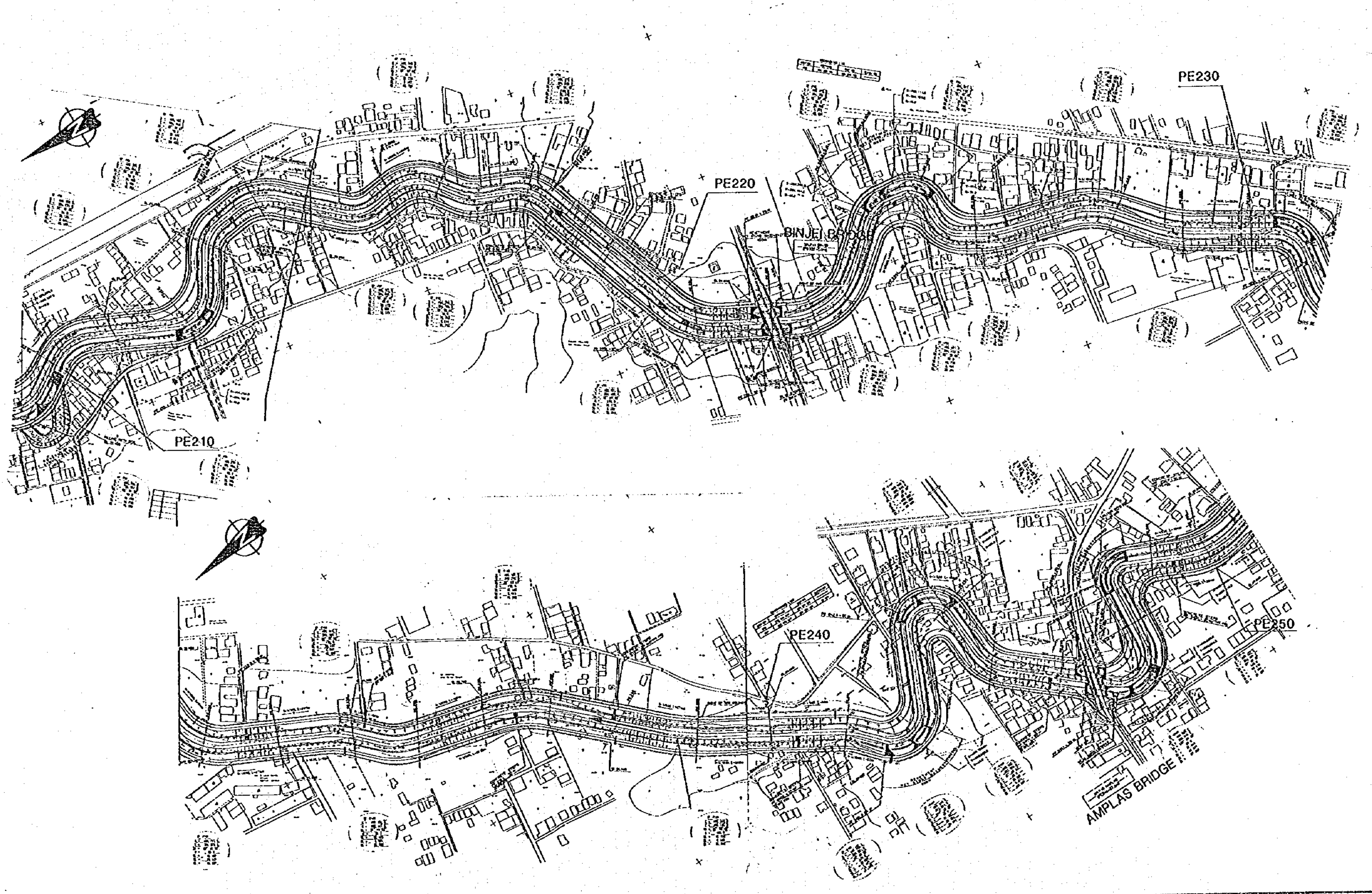


DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	DWG. 6.1.2 (5/8) PLAN OF PERCUT RIVER



SCALE: 1/5,000
0 50 100 150 200 250m

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	DWG. 6.1.2 (6/8) PLAN OF PERCUT RIVER



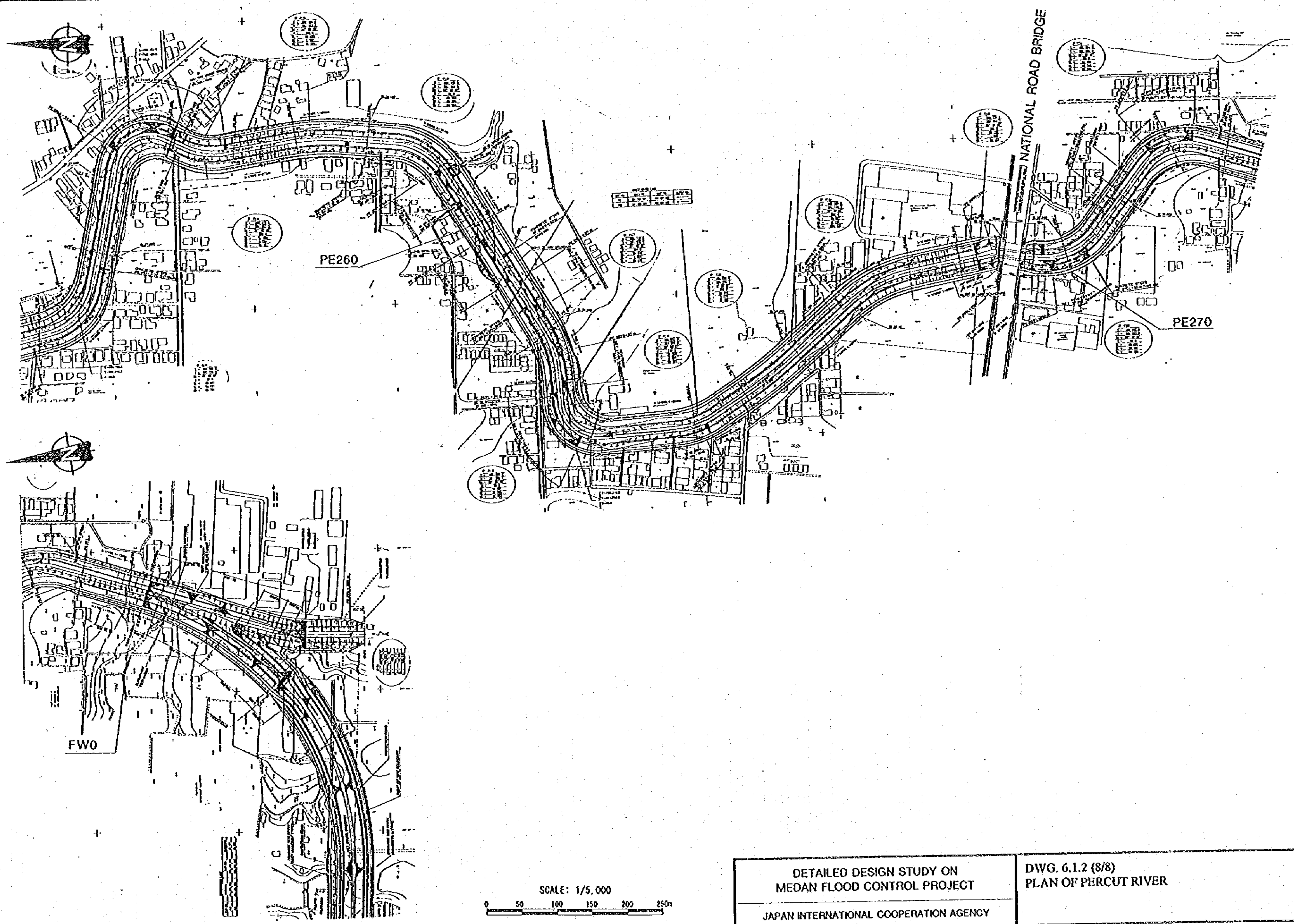
SCALE: 1/5,000

0 50 100 150 200 250m

DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

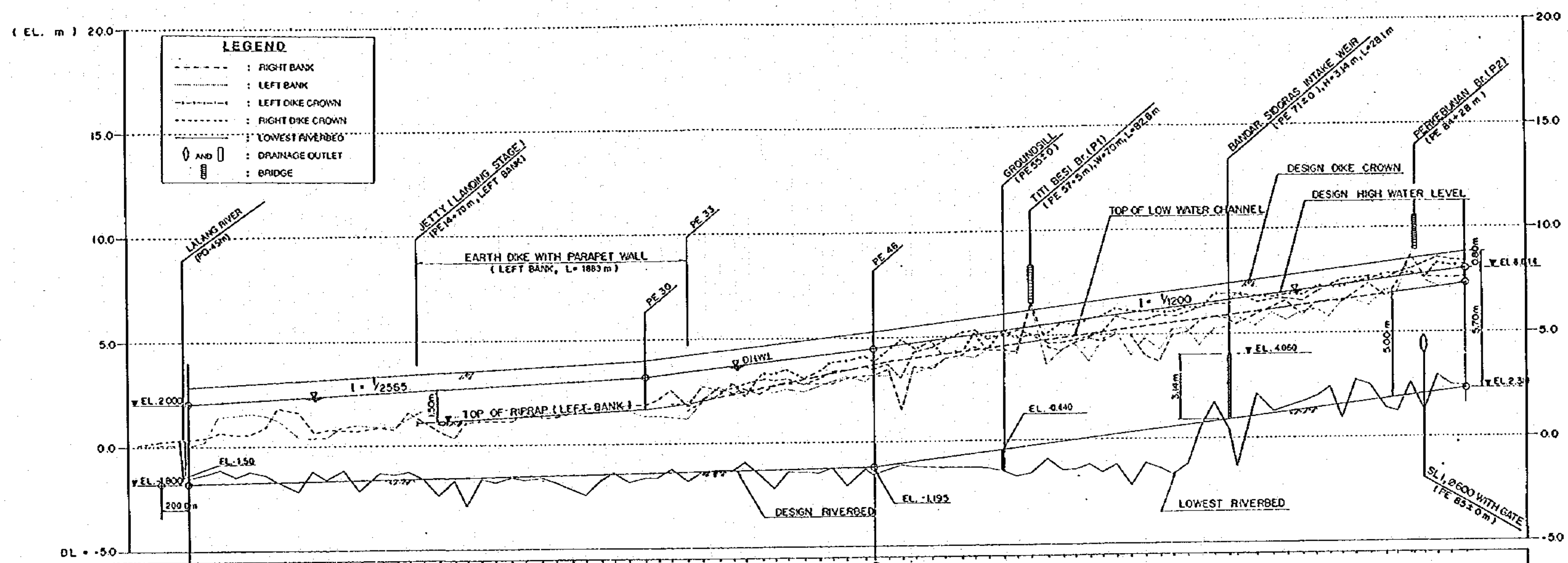
JAPAN INTERNATIONAL COOPERATION AGENCY

DWG. 6.1.2 (7/8)
PLAN OF PERCUT RIVER



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.2 (8/8) PLAN OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	

6-11



GRADIENT OF DESIGN RIVERBED		
(-1.800)	I = 1/8000	(-1.195) I = 1/1200

STATION NO.	DESIGN ELEVATION: DIKE CROWN	DESIGN ELEVATION: HIGH WATER LEVEL	DESIGN ELEVATION: RIVERBED	EXISTING ELEVATION: RIGHT GROUND	EXISTING ELEVATION: LEFT GROUND	EXISTING ELEVATION: LOWEST RIVERBED	DISTANCE: ACCUMULATED (m)	DISTANCE: PARTIAL (m)
PE0	2.800	2.000	-1.800	0.30	0.04	-1.47	0.0	0.00
PE1	2.847	2.047	-1.785	0.45	0.22	-1.34	120.0	120.00
PE2	2.882	2.082	-1.774	0.64	1.40	-1.17	212.0	92.00
PE3	2.928	2.128	-1.759	0.56	1.52	-1.53	327.5	115.50
PE4	2.971	2.171	-1.745	0.57	1.55	-1.26	436.5	109.00
PE5	3.018	2.218	-1.730	0.89	1.43	-1.39	557.5	121.00
PE6	3.049	2.249	-1.720	1.82	1.20	-1.75	639.5	82.00
PE7	3.110	2.310	-1.701	1.60	0.46	-2.18	794.5	115.00
PE8	3.147	2.347	-1.689	0.67	0.36	-1.19	890.5	96.00
PE9	3.186	2.386	-1.676	0.73	0.43	-1.66	989.0	98.50
PE10	3.231	2.431	-1.662	0.74	0.87	-1.18	1107.5	118.50
PE11	3.274	2.474	-1.648	0.74	0.98	-2.15	1215.5	108.00
PE12	3.331	2.531	-1.630	0.93	0.91	-1.34	1363.5	148.00
PE13	3.373	2.573	-1.616	0.80	0.94	-1.42	1468.5	105.00
PE14	3.409	2.609	-1.605	1.32	1.30	-1.27	1563.5	95.00
PE15	3.452	2.652	-1.591	1.20	1.64	-1.53	1671.5	108.00
PE16	3.489	2.689	-1.579	0.74	1.36	-2.43	1765.5	94.00
PE17	3.530	2.730	-1.566	0.37	1.38	-1.65	1871.5	106.00
PE18	3.567	2.767	-1.554	1.08	1.37	-2.91	1965.0	93.50
PE19	3.602	2.802	-1.543	1.17	1.62	-1.62	2055.0	90.00
PE20	3.639	2.839	-1.531	1.12	1.59	-1.79	2152.5	97.50
PE21	3.687	2.887	-1.516	1.10	1.73	-1.54	2275.5	123.00
PE22	3.726	2.926	-1.503	1.60	1.43	-1.73	2372.5	97.00
PE23	3.767	2.967	-1.490	1.35	1.48	-1.61	2479.0	106.50
PE24	3.807	3.007	-1.477	1.34	1.59	-1.80	2581.0	102.00
PE25	3.855	3.055	-1.462	1.47	1.61	-2.16	2704.5	123.50
PE26	3.890	3.090	-1.451	1.75	1.61	-2.40	2795.5	91.00
PE27	3.932	3.132	-1.437	1.69	1.56	-1.67	2902.5	107.00
PE28	3.973	3.173	-1.427	1.72	1.59	-1.35	3006.5	104.00
PE29	4.009	3.209	-1.414	1.91	1.59	-1.82	3107.5	101.00
PE30	4.055	3.255	-1.398	1.87	1.35	-1.59	3218.0	110.50
PE31	4.129	3.329	-1.386	2.12	1.34	-1.56	3314.0	96.00
PE32	4.202	3.402	-1.374	2.57	1.28	-1.20	3408.5	94.50
PE33	4.286	3.486	-1.360	1.78	1.22	-1.82	3516.5	108.00
PE34	4.367	3.567	-1.347	2.09	2.02	-1.36	3622.5	106.00
PE35	4.456	3.656	-1.333	2.63	2.26	-1.32	3738.5	116.00
PE36	4.530	3.730	-1.321	2.37	2.32	-1.28	3833.5	95.00
PE37	4.602	3.802	-1.309	2.55	2.49	-0.91	3927.5	94.00
PE38	4.687	3.887	-1.295	2.37	2.46	-1.58	4037.0	109.50
PE39	4.758	3.958	-1.284	2.69	2.46	-2.19	4130.0	93.00
PE40	4.830	4.030	-1.272	2.81	2.55	-1.40	4223.0	93.00
PE41	4.916	4.116	-1.258	2.86	2.46	-1.41	4333.5	110.50
PE42	4.998	4.198	-1.245	2.83	2.73	-1.44	4441.5	108.00
PE43	5.069	4.269	-1.233	2.85	2.90	-1.19	4532.5	91.00
PE44	5.145	4.345	-1.221	3.06	3.15	-2.12	4631.0	98.50
PE45	5.249	4.449	-1.204	3.15	2.94	-1.31	4765.5	134.50
PE46	5.305	4.505	-1.195	3.20	3.16	-1.56	4838.5	73.00
PE47	5.389	4.589	-1.111	3.45	3.15	-1.30	4939.5	101.00
PE48	5.471	4.671	-1.029	1.62	3.20	-1.11	5037.5	98.00
PE49	5.556	4.756	-0.944	3.55	3.72	-1.20	5139.5	102.00
PE50	5.656	4.856	-0.844	3.50	3.60	-1.22	5259.5	120.00
PE51	5.720	4.920	-0.780	3.88	3.89	-1.18	5336.0	76.50
PE52	5.828	5.028	-0.672	4.09	4.09	-1.21	5466.0	130.00
PE53	5.900	5.100	-0.600	4.30	3.98	-1.20	5552.0	86.00
PE54	5.978	5.178	-0.522	4.36	4.36	-1.27	5646.5	94.50
PE55	6.061	5.261	-0.439	4.31	4.18	-1.37	5746.0	99.50
PE56	6.147	5.347	-0.353	4.21	4.13	-1.63	5849.5	103.50
PE57	6.236	5.436	-0.624	4.99	3.12	-1.54	5955.5	106.00
PE58	6.338	5.538	-0.162	4.45	3.65	-0.90	6078.5	123.00
PE59	6.420	5.620	-0.080	4.26	4.31	-1.42	6177.0	98.50
PE60	6.498	5.698	-0.002	4.69	4.66	-1.36	6270.0	93.00
PE61	6.583	5.783	0.083	4.86	3.72	-1.18	6371.5	101.50
PE62	6.662	5.862	0.162	4.71	4.80	-1.16	6467.0	95.50
PE63	6.745	5.945	0.245	5.02	5.17	-1.18	6566.5	99.50
PE64	6.831	6.031	0.331	4.99	4.01	-2.30	6689.5	103.00
PE65	6.921	6.121	0.421	4.04	4.77	-1.20	6777.5	108.00
PE66	7.005	6.205	0.505	3.77	4.22	-1.41	6678.5	101.00
PE67	7.087	6.287	0.587	5.02	5.21	-1.65	6976.5	98.00
PE68	7.169	6.369	0.669	5.06	5.33	-1.18	7075.0	98.50
PE69	7.251	6.451	0.751	5.62	4.51	0.32	7173.5	98.50
PE70	7.335	6.535	0.835	5.78	5.23	1.68	7274.0	100.50
PE71	7.418	6.618	0.918	5.72	5.33	0.40	7374.0	100.00
PE72	7.460	6.660	0.960	5.50	5.84	-1.39	7424.5	50.50
PE73	7.585	6.785	1.085	5.87	5.43	2.14	7574.5	150.00
PE74	7.677	6.877	1.177	6.25	6.06	1.32	7684.5	110.00
PE75	7.760	6.960	1.260	6.54	5.65	1.48	7784.0	99.50
PE76	7.844	7.044	1.344	5.93	6.03	1.75	7885.5	101.50
PE77	7.927	7.127	1.427	6.46	6.13	1.94	7984.5	99.00
PE78	8.008	7.208	1.508	6.56	5.78	2.41	8081.5	97.00
PE79	8.081	7.281	1.581	6.51	6.46	1.89	8169.5	88.00
PE80	8.155	7.355	1.655	5.88	6.55	2.71	8258.5	89.00
PE81	8.239	7.439	1.739	6.36	6.36	2.56	8359.0	100.50
PE82	8.323	7.523	1.823	6.70	7.08	1.37	8459.5	100.50
PE83	8.402	7.602	1.902	7.31	6.92	1.28	8554.5	95.00
PE84	8.483	7.683	1.983	8.61	8.60	2.67	8651.5	97.00
PE85	8.566	7.766	2.066	7.67	7.49	1.24	8751.5	100.00
PE86	8.645	7.845	2.145	7.67	7.24	3.00	8846.0	94.50
PE87	8.727	7.927	2.227	7.66	7.13	2.48	8944.5	98.50
PE88	8.814	8.014	2.314	7.63	7.51	2.42	9049.5	105.00

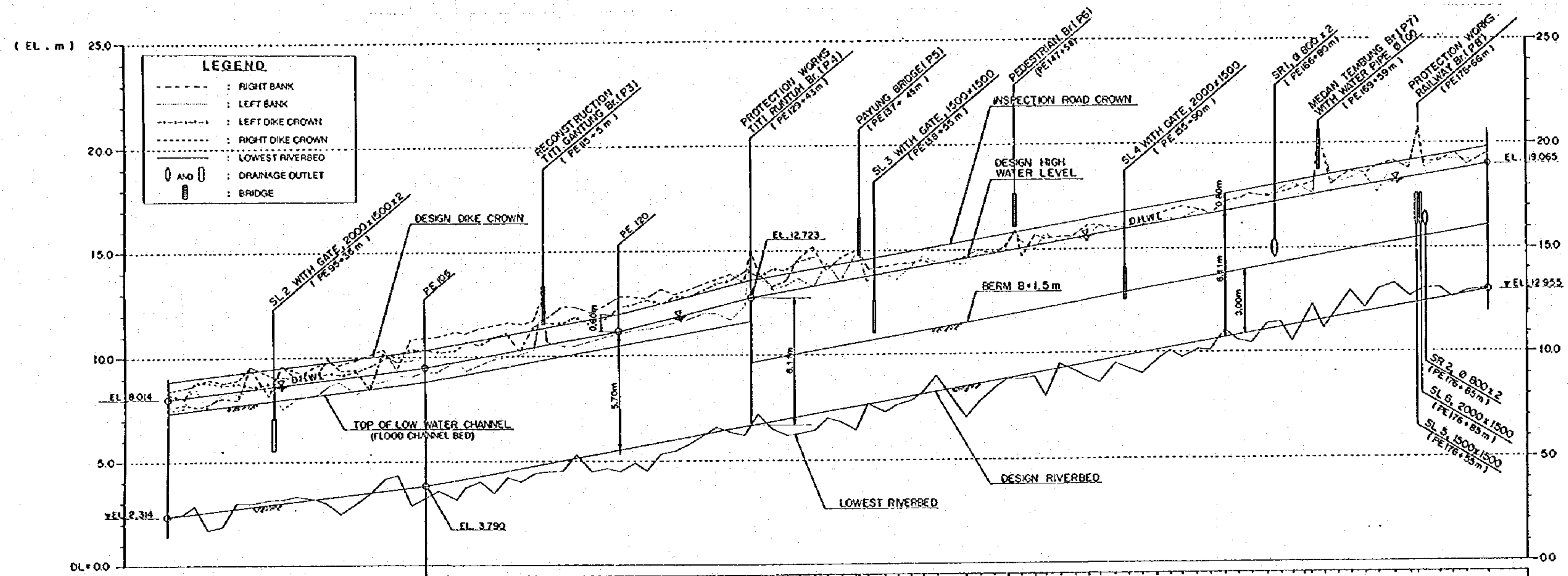
SCALES

VERTICAL: 0 20 40 60 80 100 m — SCALE 1:100

HORIZONTAL: 0 5000 10000 15000 m — SCALE 1:15000

LONGITUDINAL PROFILE OF PERCUT RIVER (1/3)

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.3 (1/3) LONGITUDINAL PROFILE OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



GRADIENT OF DESIGN RIVERBED: 1 : 1/1200 (PE 88 – PE 106, 3.790); 1 : 1/825 (PE 106 – PE 181)

STATION NO.	DESIGN ELEVATION: DIKE/INSPECTION ROAD CROWN	DESIGN ELEVATION: HIGH WATER	DESIGN ELEVATION: RIVERBED	EXISTING ELEVATION: RIGHT GROUND	EXISTING ELEVATION: LEFT GROUND	EXISTING ELEVATION: LOWEST RIVERBED	DISTANCE: ACCUMULATED (m)	DISTANCE: PARTIAL (m)
PE 88	8.814	8.014	2.314	7.63	7.51	2.42	9049.5	0.00
PE 89	8.890	8.090	2.390	7.76	7.61	2.49	9140.0	90.50
PE 90	8.973	8.173	2.473	7.65	8.65	2.88	9240.0	100.00
PE 91	9.055	8.255	2.555	7.73	7.68	1.76	9338.0	98.00
PE 92	9.136	8.336	2.636	8.07	8.27	1.93	9436.0	98.00
PE 93	9.230	8.430	2.730	8.00	8.26	3.00	9548.0	112.00
PE 94	9.302	8.502	2.802	9.51	8.50	2.99	9635.0	87.00
PE 95	9.396	8.596	2.896	8.22	8.50	3.17	9748.0	113.00
PE 96	9.467	8.667	2.967	9.59	7.63	3.19	9832.5	84.50
PE 97	9.548	8.748	3.048	9.07	8.11	3.33	9930.5	98.00
PE 98	9.643	8.843	3.143	9.60	9.27	3.21	10044.0	113.50
PE 99	9.715	8.915	3.215	9.74	8.64	3.03	10130.0	86.00
PE 100	9.797	8.997	3.297	9.68	8.83	2.47	10228.5	98.50
PE 101	9.878	9.078	3.378	9.89	8.31	2.95	10326.5	98.00
PE 102	9.961	9.161	3.461	10.13	8.75	3.48	10425.5	99.00
PE 103	10.044	9.244	3.544	10.39	8.89	4.20	10525.0	99.50
PE 104	10.127	9.327	3.627	9.42	9.17	4.39	10624.5	99.50
PE 105	10.206	9.406	3.706	10.68	9.09	2.89	10719.5	95.00
PE 106	10.290	9.490	3.790	10.82	9.29	3.62	10820.0	100.50
PE 107	10.411	9.611	3.911	11.01	9.29	3.59	10919.5	99.50
PE 108	10.565	9.765	4.065	11.26	9.82	3.21	11046.5	127.00
PE 109	10.649	9.849	4.149	11.16	9.36	3.79	11116.0	69.50
PE 110	10.770	9.970	4.270	11.43	9.60	4.05	11216.0	100.00
PE 111	10.892	10.092	4.392	11.53	9.92	3.49	11317.0	101.00
PE 112	11.012	10.212	4.512	11.67	9.94	4.27	11415.0	98.50
PE 113	11.136	10.336	4.636	11.59	10.11	4.04	11518.0	102.50
PE 114	11.251	10.451	4.751	11.82	10.35	4.44	11613.0	95.00
PE 115	11.370	10.570	4.870	11.87	10.72	4.51	11711.0	98.00
PE 116	11.491	10.691	4.991	12.43	10.55	4.56	11811.0	100.00
PE 117	11.611	10.811	5.111	12.41	10.57	5.29	11909.5	98.50
PE 118	11.737	10.937	5.237	12.17	10.77	4.53	12013.5	104.00
PE 119	11.853	11.053	5.353	12.49	10.94	4.67	12109.5	96.00
PE 120	11.974	11.174	5.474	12.87	11.11	4.52	12209.5	100.00
PE 121	12.142	11.342	5.598	12.89	11.25	4.85	12312.0	102.50
PE 122	12.304	11.504	5.717	12.79	11.30	4.56	12410.0	98.00
PE 123	12.465	11.665	5.836	13.19	11.47	5.33	12508.0	98.00
PE 124	12.636	11.836	5.962	12.97	11.63	5.46	12612.0	104.00
PE 125	12.796	11.996	6.080	13.22	11.78	5.75	12709.5	97.50
PE 126	12.964	12.164	6.204	13.43	12.03	6.20	12811.5	102.00
PE 127	13.113	12.313	6.314	13.67	12.02	6.55	12902.5	91.00
PE 128	13.291	12.491	6.445	13.89	11.77	6.33	13010.5	108.00
PE 129	13.448 / 13.523 / 13.558	12.648 / 12.723 / 12.788	6.561 / 6.613 / 6.678	13.47	12.36	6.16	13106.0	95.50 / 3.00 / 96.50
PE 130				13.94	13.68	7.21	13202.5	
PE 131	13.706	12.908	6.798	13.26	15.16	6.44	13301.5	99.00
PE 132	13.827	13.027	6.917	13.61	13.35	6.20	13399.5	98.00
PE 133	13.946	13.146	7.036	14.62	13.66	6.26	13498.0	98.50
PE 134	14.067	13.267	7.157	15.19	13.27	6.38	13597.5	99.50
PE 135	14.190	13.390	7.280	14.04	14.37	7.01	13699.5	102.00
PE 136	14.303	13.503	7.393	14.68	13.52	6.84	13792.5	93.00
PE 137	14.425	13.625	7.515	14.02	14.02	6.43	13893.0	100.50
PE 138	14.537	13.737	7.627	14.10	13.57	7.70	13985.5	92.50
PE 139	14.667	13.867	7.757	13.98	13.89	7.26	14092.5	107.00
PE 140	14.787	13.987	7.877	14.31	13.60	7.59	14191.5	99.00
PE 141	14.901	14.101	7.991	14.37	14.24	7.80	14285.5	94.00
PE 142	15.007	14.207	8.097	14.55	14.67	8.22	14373.5	88.00
PE 143	15.128	14.328	8.218	14.36	14.44	8.98	14473.5	100.00
PE 144	15.368	14.568	8.458	14.66	14.34	7.00	14671.5	198.00
PE 145	15.488	14.688	8.578	15.00	14.80	7.76	14770.5	99.00
PE 146	15.608	14.808	8.698	14.80	14.87	8.42	14869.5	99.00
PE 147	15.729	14.929	8.819	15.18	15.08	8.63	14969.0	99.50
PE 148	15.847	15.047	8.937	14.62	15.44	8.78	15066.0	97.00
PE 149	15.959	15.159	9.049	15.72	14.97	8.87	15158.5	92.50
PE 150	16.065	15.265	9.155	15.51	15.71	7.96	15246.0	87.50
PE 151	16.177	15.377	9.267	15.51	15.28	9.51	15338.5	92.50
PE 152	16.301	15.501	9.391	15.62	15.61	9.18	15441.0	102.50
PE 153	16.427	15.627	9.517	16.07	15.56	8.94	15545.0	104.00
PE 154	16.542	15.742	9.632	16.09	16.09	8.63	15640.0	95.00
PE 155	16.656	15.856	9.746	15.97	15.83	9.49	15733.0	93.50
PE 156	16.780	15.980	9.870	16.03	15.86	9.26	15836.0	102.50
PE 157	16.895	16.095	9.985	16.38	16.09	9.02	15930.5	94.50
PE 158	17.012	16.212	10.102	16.55	16.38	9.67	16027.5	97.00
PE 159	17.128	16.328	10.218	16.85	16.51	10.08	16123.0	96.00
PE 160	17.245	16.445	10.335	16.98	16.46	9.77	16220.0	96.50
PE 161	17.358	16.558	10.448	16.89	16.78	10.14	16313.0	93.00
PE 162	17.471	16.671	10.561	16.68	16.79	10.04	16406.0	93.00
PE 163	17.586	16.786	10.676	17.23	17.14	11.07	16501.0	95.00
PE 164	17.721	16.921	10.811	17.37	17.33	10.59	16612.0	111.00
PE 165	17.845	17.045	10.935	17.58	17.49	10.45	16715.0	103.00
PE 166	17.958	17.158	11.048	17.50	17.50	11.37	16808.0	93.00
PE 167	18.079	17.279	11.169	17.59	17.83	11.90	16908.0	100.00
PE 168	18.196	17.398	11.288	17.82	18.04	10.50	17006.0	98.00
PE 169	18.299	17.499	11.389	18.10	17.62	12.30	17089.5	83.00
PE 170	18.450	17.650	11.540	17.79	17.95	11.12	17214.0	124.50
PE 171	18.576	17.776	11.666	16.78	18.21	12.78	17318.0	104.00
PE 172	18.696	17.896	11.786	18.61	18.32	12.91	17417.0	99.00
PE 173	18.807	18.007	11.897	18.49	18.51	12.16	17508.5	91.50
PE 174	18.929	18.129	12.019	18.94	17.67	13.00	17609.0	100.50
PE 175	19.042	18.242	12.132	19.13	18.90	13.27	17702.5	93.00
PE 176	19.172	18.372	12.262	18.82	19.00	12.67	17809.5	107.00
PE 177	19.304	18.504	12.394	19.12	18.83	13.02	17918.5	109.00
PE 178	19.419	18.619	12.509	19.14	19.21	13.05	18013.5	95.00
PE 179	19.544	18.744	12.634	19.48	19.24	12.59	18116.5	103.00
PE 180	19.658	18.858	12.748	19.01	19.14	12.91	18210.5	94.00
PE 181	19.865	19.065	12.955	19.47	19.35	13.05	18381.0	170.50

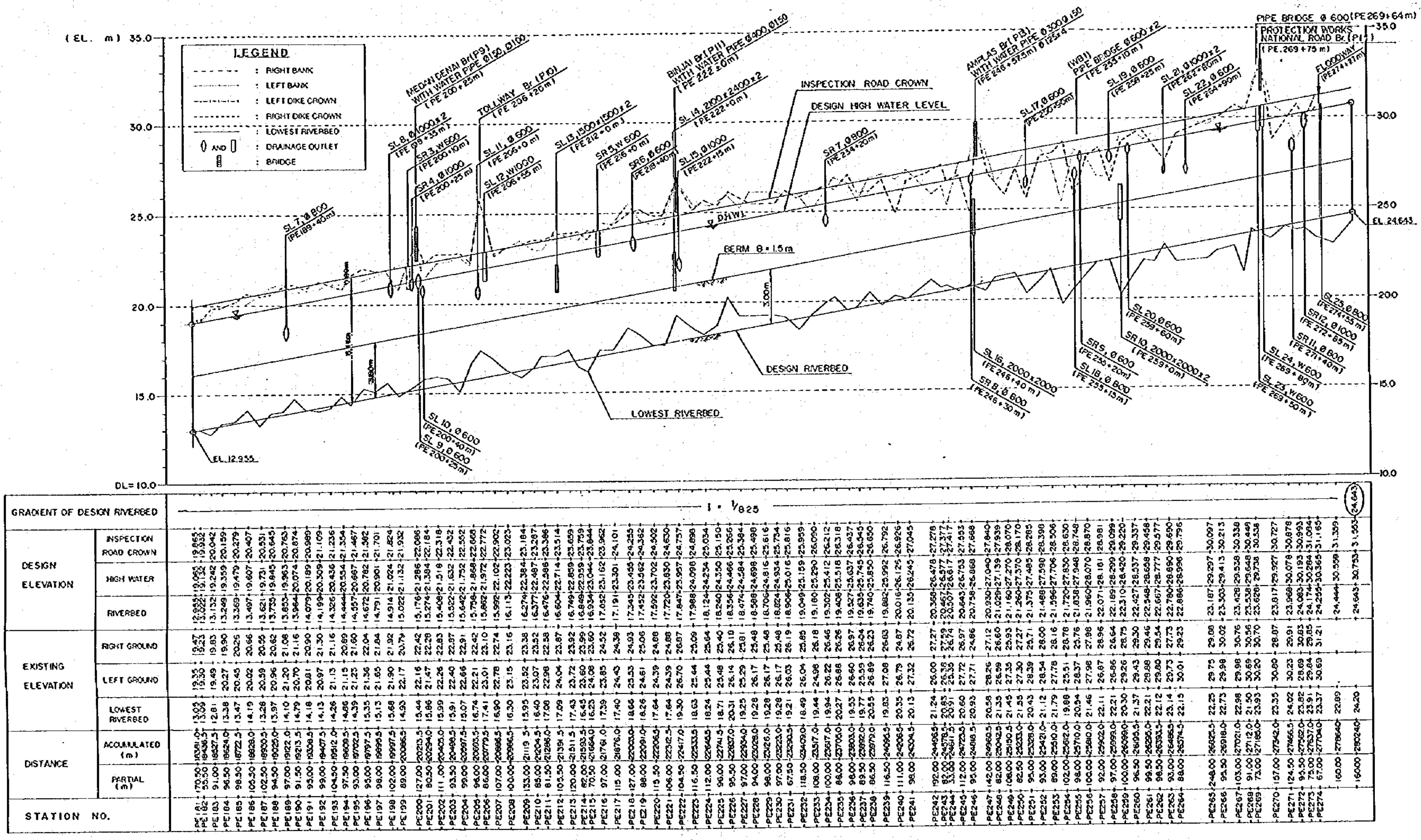
SCALES

VERTICAL 0 20 40 60 80 100 m SCALE 1:100

HORIZONTAL 0 5000 10000 15000 m SCALE 1:15000

LONGITUDINAL PROFILE OF PERCUT RIVER (2/3)

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.3 (2/3) LONGITUDINAL PROFILE OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



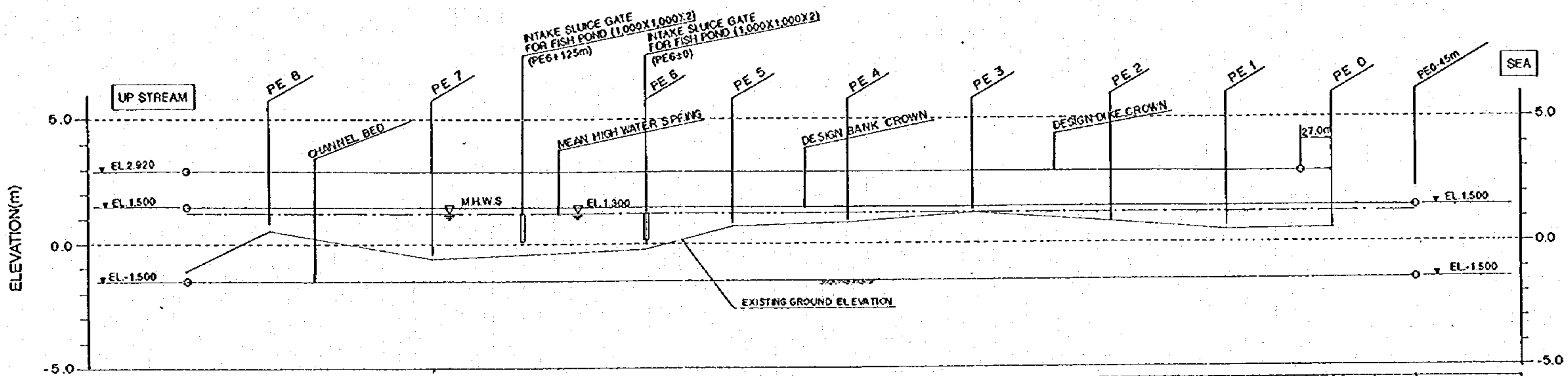
LONGITUDINAL PROFILE OF PERCUT RIVER (3/3)

SCALES

VERTICAL 0 20 40 60 80 100 m SCALE 1:100

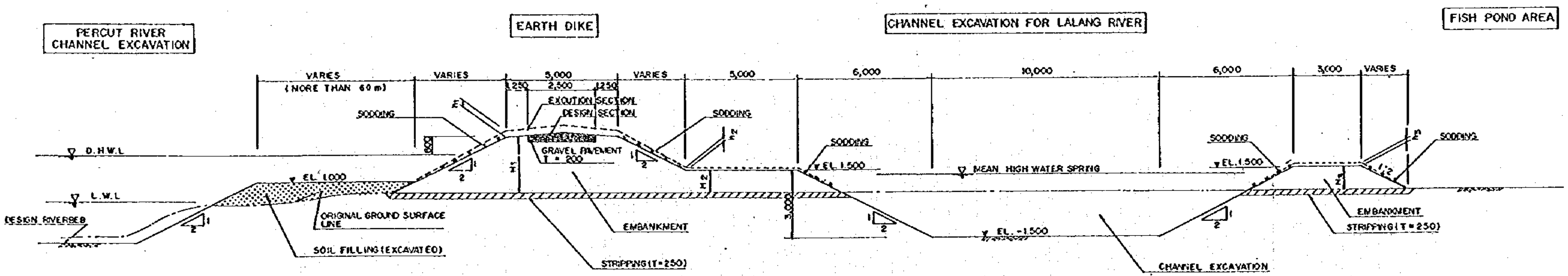
HORIZONTAL 0 500.0 1000.0 1500.0 m SCALE 1:10000

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.3 (3/3) LONGITUDINAL PROFILE OF PERCUT RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



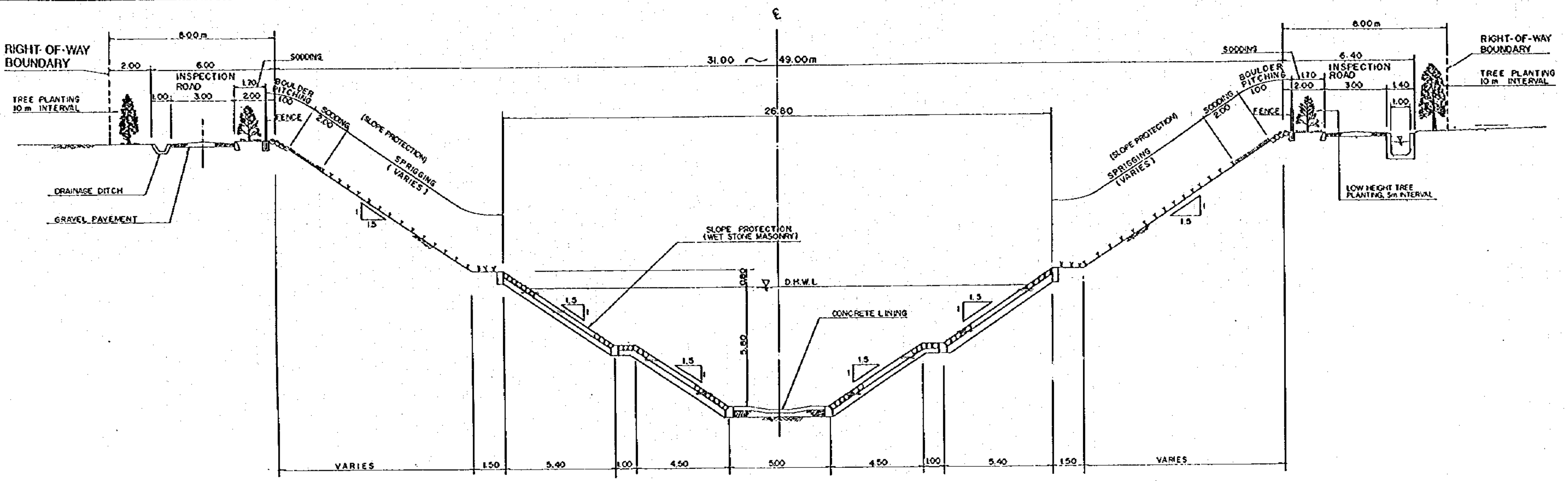
			DC-0	(PE8)	DC-1	DC-2	(PE7)	DC-3	DC-4	(PE6)	DC-5	(PE5)	DC-6	(PE 4)	DC-7	(PE3) DC-8	DC-9	(PE2)	DC-10	(PE 2)	DC-11		(PE0)	DC-12	DC-13
DESIGN ELEVATION	DIKE CROWN		2.920		2.909	2.905		2.893	2.888		2.876		2.863		2.851	2.840	2.831		2.821		2.808	2.804	2.800		
	BANK CROWN		1.500		1.500	1.500		1.500	1.500		1.500		1.500		1.500	1.500	1.500		1.500		1.500			1.500	1.500
	MEAN HIGH WATER SPRING		1.300		1.300	1.300		1.300	1.300		1.300		1.300		1.300	1.300	1.300		1.300		1.300			1.300	1.300
	CHANNEL BED		-1.500		1.500	-1.500		-1.500	-1.500		-1.500		-1.500		-1.500	-1.500	-1.500		-1.500		-1.500			-1.500	-1.500
EXISTING GROUND ELEVATION			-1.109	-0.50			-0.60			-0.25		-0.70		-0.84		1.30		0.83		0.53			0.53		
DISTANCE	ACCUMULATED (m)		0.0		100.0	200.0		300.0	400.0		500.0		600.0		700.0	800.0	900.0		1000.0		1100.0			1200.0	1241.0
	PARTIAL (m)		0.0		100.0	100.0		100.0	100.0		100.0		100.0		100.0	100.0	100.0		100.0		100.0			100.0	41.0
STATION NO.			DC-0	(PE8)	DC-1	DC-2	(PE7)	DC-3	DC-4	(PE6)	DC-5	(PE5)	DC-6	(PE 4)	DC-7	(PE3) DC-8	DC-9	(PE2)	DC-10	(PE 2)	DC-11		(PE0)	DC-12	DC-13

SCALES
VERTICAL 0 2.0 4.0 6.0 8.0 10.0m SCALE 1:100
HORIZONTAL 0 50 100 150 200 250m SCALE 1:2500

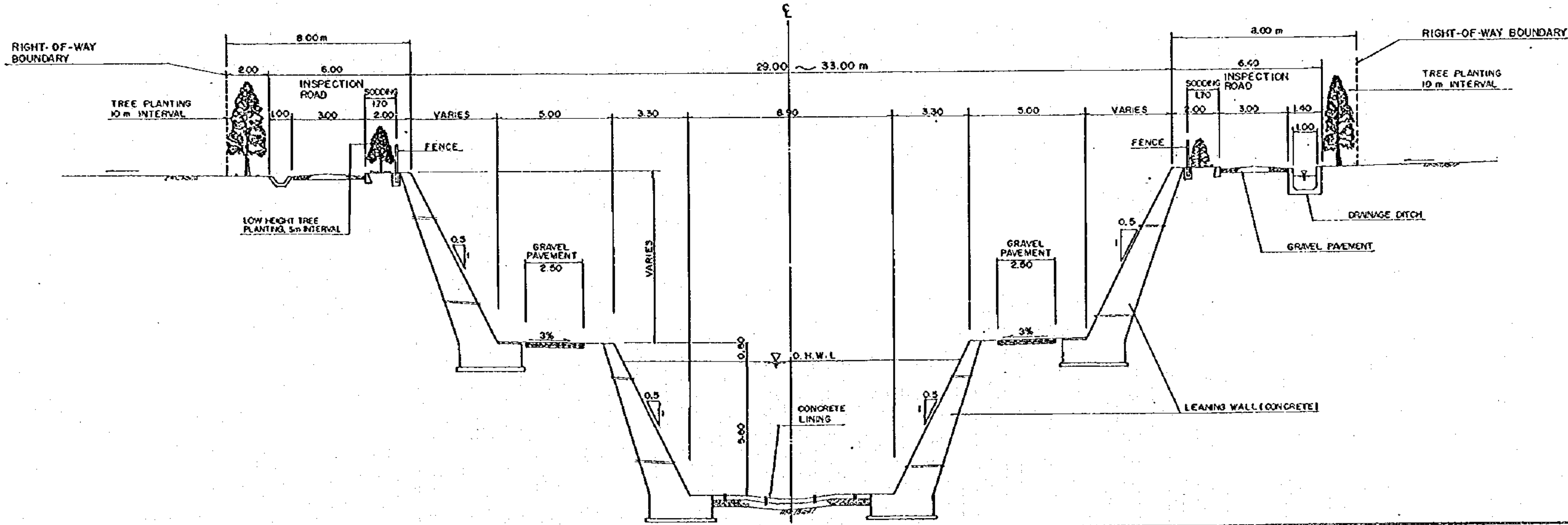


SCALE
0 20 40 60 80 100m
SCALE 1:100

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.4 CHANNEL RELOCATION OF LALANG RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



STANDARD CROSS SECTION OF FLOODWAY (CHANNEL TYPE - I) (UNIT : m)



SCALE :

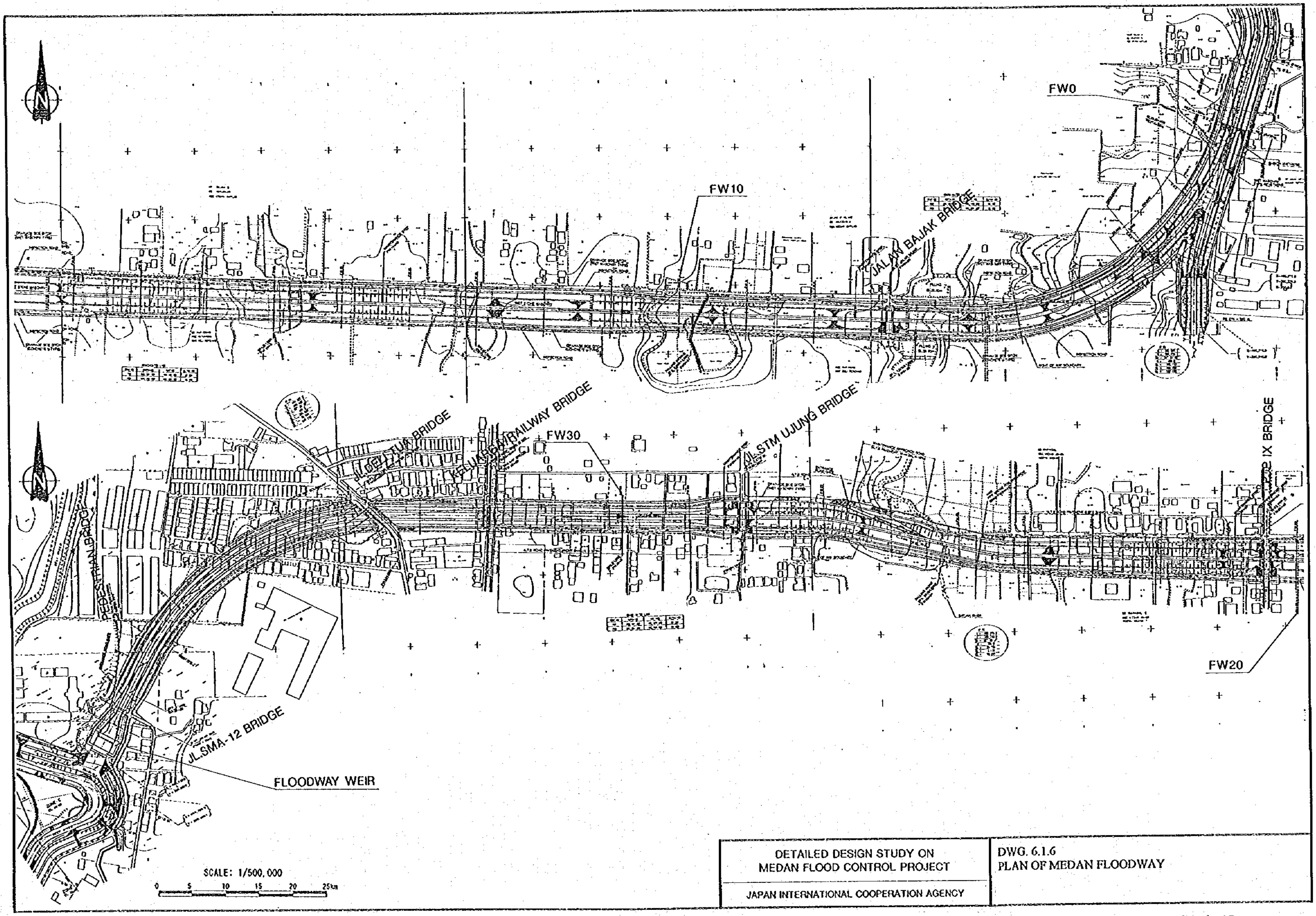
0 20 40 60 80 100m

SCALE 1 : 100

STANDARD CROSS SECTION OF FLOODWAY (CHANNEL TYPE - II)
(UNIT : m)

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.5 STANDARD CROSS SECTION OF MEDAN FLOODWAY
JAPAN INTERNATIONAL COOPERATION AGENCY	

6-16

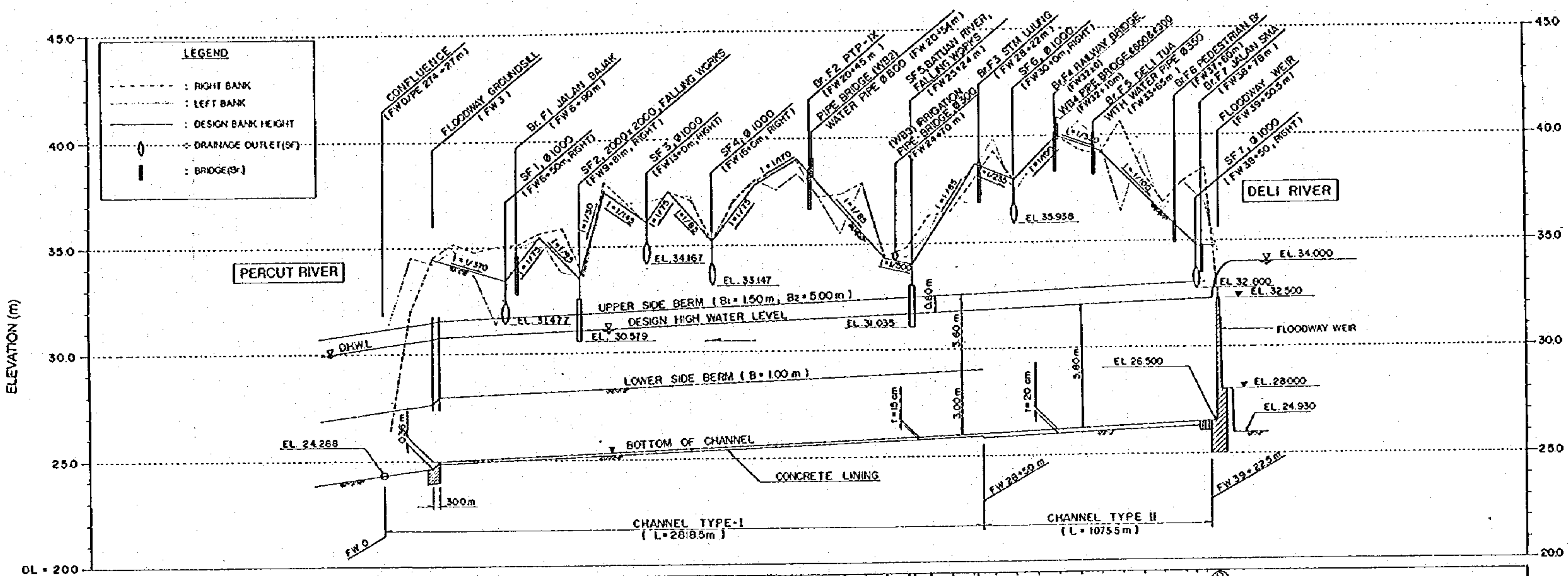


DETAILED DESIGN STUDY ON
MEDAN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

DWG. 6.1.6
PLAN OF MEDAN FLOODWAY

6-17



GRADIENT OF DESIGN CHANNEL BED: I = 1/825 (to 24.570 / 24.930); I = 1/2350 (to 26.500)

STATION NO.	DESIGN ELEVATION: CHANNEL BANK	DESIGN ELEVATION: UPPER SIDE BERM	DESIGN ELEVATION: HIGH WATER LEVEL	DESIGN ELEVATION: BOTTOM OF CHANNEL	EXISTING ELEVATION: RIGHT GROUND	EXISTING ELEVATION: LEFT GROUND	DISTANCE: ACCUMULATED (m)	DISTANCE: PARTIAL (m)
PE274 / FW 0 / FW 1		31.165 / 31.198 / 31.222	30.365 / 30.398 / 30.422	24.255 / 24.288 / 24.312	25.00 / 26.40	30.00 / 31.44	-27.0 / 0.0 / 20.0	-27.0 / 0.0 / 20.0
FW 2		31.352	30.552	24.442	32.00	34.55	127.0	107.0
FW 3	34.491	31.480 / 31.530	30.680 / 30.730	24.570 / 24.930	34.52	34.25	233.0	106.0 (36.8)
FW 4	34.184	31.577	30.777	24.977	35.17	34.90	343.0	110.0
FW 5	33.893	31.623	30.823	25.023	34.77	33.64	450.5	107.5
FW 6	33.612 / 33.477	31.667	30.867	25.067	35.00	31.40	554.5	104.0 (50.0)
FW 7	34.151	31.710	30.910	25.110	35.10	35.00	655.0	100.5
FW 8	35.484	31.752	30.952	25.152	35.60	35.36	755.0	100.0
FW 9	34.432	31.795	30.995	25.195	35.85	33.80	855.0	100.0
FW 10	33.579 / 34.213	31.837	31.037	25.237	33.60	33.57	955.0	(81.8) 100.0
FW 11	37.546	31.880	31.080	25.280	38.00	37.46	1055.0	100.0
FW 12	36.857	31.923	31.123	25.323	37.10	37.00	1155.0	100.0
FW 13	36.167	31.965	31.165	25.365	36.10	37.07	1255.0	100.0
FW 14	37.500	32.008	31.208	25.408	37.50	37.31	1355.0	100.0
FW 15	36.323	32.050	31.250	25.450	37.10	37.29	1455.0	100.0
FW 16	35.147	32.093	31.293	25.493	35.20	34.80	1555.0	100.0
FW 17	36.487	32.136	31.336	25.536	37.05	37.10	1655.5	100.5
FW 18	37.820	32.178	31.378	25.578	37.98	38.05	1755.5	100.0
FW 19	38.414	32.221	31.421	25.621	38.38	37.62	1856.5	101.0
FW 20	38.999	32.263	31.463	25.663	38.92	38.30	1956.0	99.5
FW 21	37.817	32.306	31.506	25.706	37.30	37.25	2056.5	100.5
FW 22	36.634	32.349	31.549	25.749	37.36	35.52	2157.0	100.5
FW 23	35.469	32.391	31.591	25.791	37.84	37.80	2256.0	99.0
FW 24	34.293	32.434	31.634	25.834	34.41	34.28	2356.0	100.0
FW 25	34.083 / 34.035	32.478	31.678	25.878	34.81	34.35	2461.0	105.0 (24.5)
FW 26	35.250	32.522	31.722	25.922	36.32	35.37	2564.0	103.0
FW 27	36.835	32.566	31.766	25.966	36.40	37.73	2667.0	103.0
FW 28	38.395 / 38.704	32.609	31.809	26.009	37.83	38.24	2768.5	101.5 (20.0)
FW 29	38.364	32.652	31.852	26.052	39.10	39.75	2868.5	100.0
FW 30	37.938	32.694	31.894	26.094	37.90	37.35	2968.5	100.0
FW 31	38.943	32.737	31.937	26.137	38.90	38.77	3069.0	100.5
FW 32	39.943	32.780	31.980	26.180	39.92	39.55	3169.0	100.0
FW 33	39.631	32.822	32.022	26.222	39.35	40.64	3269.0	100.0
FW 34	39.315	32.865	32.065	26.265	39.08	39.78	3370.0	101.0
FW 35	38.310	32.908	32.108	26.308	40.60	36.38	3470.5	100.5
FW 36	37.310	32.950	32.150	26.350	38.50	39.28	3570.5	100.0
FW 37	36.300	32.993	32.193	26.393	36.81	36.35	3671.5	101.0
FW 38	35.300 / 34.800	33.036	32.236	26.436	37.80	37.82	3771.5	100.0 (50.0)
FW 39 / FW 39+50.5	34.800 / 34.800	33.079	32.279	26.479 / 26.500	38.44 / 32.32	36.85 / 34.51	3871.5 / 3922.0	100.0 / 50.5

SCALES

VERTICAL: 0 20 40 60 80 100 m — SCALE 1:100

HORIZONTAL: 0 2000 4000 6000 8000 10000m — SCALE 1:10000

LONGITUDINAL PROFILE OF FLOODWAY

DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT	DWG. 6.1.7 LONGITUDINAL PROFILE OF MEDAN FLOODWAY
JAPAN INTERNATIONAL COOPERATION AGENCY	