2-2-2 Basic Plan (Construction Plan / Equipment Plan)

2-2-2-1 Overall Plan

(1) Target and extent of the requested Japanese assistance

① The command area of irrigation under the Japanese assistance

The command area of irrigation by canal shown in Table 2-28 is calculated from the results of reconnaissance survey in Maliana I and topographic map provided by Chinese assistance. Thus, the total target area of the Project is calculated at 1,314 ha. The total command area of 1,314 ha represents the gross area in which the residential lots, roads, waterway etc. are included which is equivalent to about 20% of the total command area, hence the net irrigated command area is around 1,051 ha (= 1,314 ha × 0.8).

Table 2-28 Irrigation areas by canals (ha)

Name of canal	Area irrigated by existing turnout	Area to be irrigated by newly established turnout	Total gross command area	Net irrigation area
Main canal	0	5	5	4
Ramaskora secondary	398	531	929	743
Ritabau secondary	179	201	380	304
Total	**577**	**737**	**1,314**	**1,051**

② Target beneficiary

The targeted irrigated area by village in Maliana I is estimated in Table 2-29 (based from the data provided by Bobonaro district agricultural office and the results of the Baseline survey) with a total of 1,424 households (about 7,400 family members). As concern target farm households, MAFF is providing a list of beneficiary households for the election of board members of WUA, through Bobonaro district agricultural office, in which the number of target households will eventually be about 1,500 (approx. 7,800 family members, as of January, 2006).

Table 2-29 Number of target farm households and landholding

Name of village	Farm household *1) (member per household)	Target command Area (ha)	Unit land holding area (ha/household)
1) Lahomea	542 (4.9)	267	0.49
2) Raifun	272 (4.9)	384	1.41
3) Ritabou	336 (5.4)	407	1.21
4) Odomau	169 (5.1)	103	0.61
5) Holsa	105 (7.0)	153	1.46
Total	**1,424 (5.2 members)**	**1,314**	**0.92**

Source: 1) Bobonaro district administration office (2003)

③ Outline of the Japanese assistance

As for Maliana I irrigation facilities, the Grant Aid components consist of intake facilities, the main canal, secondary canals and building facilities such as storage depot and a gatekeeper's hut. The contents of the major aid component facilities are tabulated in Table 2-30.

Table 2-30 Outline of the request and Japanese assistance

Facility	Outline of the request	Outline of Japanese assistance
1. Intake facilities	1) Rehabilitation and surface protection of raised 0.7 m portion of the fixed weir with steel plate and concrete, 2) Rehabilitation of scouring gate at sediment setting basin, off-take gates along canals etc.	1) Rehabilitation and surface protection of raised 0.7 m portion of the fixed weir with high strength concrete coating, 2) Installation of scouring sluice gates, rehabilitation of intake gate, scouring gate at sediment setting basin and off-take gates etc.
2. Main canal	1) Canal lining extension 1,527m 2) Installation of steel slide gate etc.	1) Canal lining extension 1,527m 2) Installation of steel slide gate etc.
3. Ramaskora secondary canal	1) Canal lining extension 4,650m 2) Installation of steel slide gate etc.	1) Canal lining extension 3,945m 2) Installation of steel slide gate etc.
4. Ritabau secondary canal	1) Canal lining extension 5,250m 2) Installation of steel slide gate etc.	1) Canal lining extension 5,250m 2) Installation of steel slide gate etc.
5. Building facilities	1) Storage for O/M equipment 2) Gate keeper's hut 3) Storage shed 4) Drying floor	1) Construction of storage for O/M equipment 2) Construction of Gate keeper's hut
6. Others	Strengthening of the capacity of WUA	Implementation of soft component plan

(2) Outline of facility plan

The facility plan comprises of the following structures: 1) intake facilities, 2) irrigation canals, 3) wet masonry retaining wall as protection embankment of aqueduct and 4)building facilities are described in Table 2-31 to Table 2-34.

① Intake facility

Table 2-31 Design parameters of the headworks of Maliana I to be rehabilitated

Subject	Scale of facilities etc	Remarks
1) Design discharge at intake	Rainy season: 1.37m^3/sec, Dry season: 0.46m^3/sec	Include 0.015m^3/sec of intake water for domestic water supply
2) Irrigable area	Rainy season: Paddy 1,050 ha, Dry season: Paddy 150 ha, Other crops: 200 ha	
3) Fixed headworks	Type of headwork: Floating type, Elevation of the crest: 254.40 m, Width: 17.10 m, Height: 5.40 m, Length: 8.50 m, Length of downstream side of face: 10.0 m, Maximum thickness of face: 2.1 m, Length of riverbed protection: 12m	Raised by 0.7 m with high strength concrete.
4) Scouring sluice	Width of scouring sluice: 7.40m, Gate type: Manual rack type, Scouring sluice gate: width 3.0m x height 1.5m × 2 gates	
5) Intake structure	Gate type: Manual rack type Intake gate: Width 1.5m × height 1.0m × 2 gates	
6) Sediment settling basin	Sediment settling basin: width 8.0m × length 13.0m Scouring gate: width 1.6m × height 1.5m × 1 gate	
7) Canal intake	Canal intake gate: width 1.8 m × height 1.0 m × 1 gate	
8) Retaining wall	a) Left bank Upstream: Inverse-T type, Height 4.1m×Length 47.5m Midstream: Inverse-T type, Height 4.5m×Length 10.9 m Downstream: Inverse-T type, height 4.5m×Length 25.9 m b) Right bank Upstream: Gravity type, Height 3.0m × Length 20.8 m Midstream: Repair of joints of existing masonry wall, height 2.0～7.8m × length 60.0 m Downstream: Bank protection (dry masonry), height 3.0m×length 23.0 m	Apply embankment and dry masonry to the raised part of the retaining wall.

② Irrigation canal

Table 2-32 Planned elements of the main and secondary canals to be rehabilitated

Name of canal	Main canal	Ramaskora secondary	Ritabau secondary
1) Scale			
Design discharge:	1.37～1.35 m^3/sec	0.96～0.16 m^3/sec	0.39～0.17 m^3/sec
Canal length:	L = 1,527m Existing canal: 1,570m Existing lined section:1,527m	L = 3,945m Existing canal: 1,570m Extension lining: 2,375m	L = 5,250m Existing canal: 2,890m Extension lining:2,360m
2) Typical cross section			
Type of canal:	Open lining canal by wet masonry lining	Open lining canal by wet masonry lining	Open lining canal by wet masonry lining
Width of canal invert: Height of side wall: Width of canal top:	1.60m～5.70m 0.90m～1.80m 1.60m～7.10m	0.40m～1.60m 0.30m～0.80m 1.00m～3.20m	0.40m～1.10m 0.40m～0.80m 0.80m～2.30m
3) Appurtenant structures	Total 25 places	Total 48 places	Total 79 places

③ Plan of bank protection retaining wall for aqueduct

Table 2-33 Design parameters of retaining protection wall of the Aqueduct to be rehabilitated

Subject	Right bank	Left bank
1) Retaining protection wall		
Structure type	Wet masonry	Wet masonry
Extension	72.5m	34.0m
Height	3.0～4.5m	4.5m
2) Block for riverbed foot protection	345m^2	252m^2

④ Building facilities

Table 2-34 Proposed building facilities

Description	Gate keeper's hut	Storage for O/M equipment
1) Location	Upstream side of the left bank of Maliana I headwork	Near Sta. 3+360, station of Ramaskora secondary canal
2) Structure type	One story house of RC beam, block wall, concrete foundation	One story house of RC beam, block wall, concrete foundation
3) Building area	4.2m × 3.5m = 14.7 m^2	10.5m × 6.5m = 68.3 m^2

2-2-2-2 Plan of Facilities

2-2-2-2-1 Intake Facility Planning

(1) Design of fixed weir

The designed cross section of the fixed weir part of intake facility is shown in Figure 2-6.

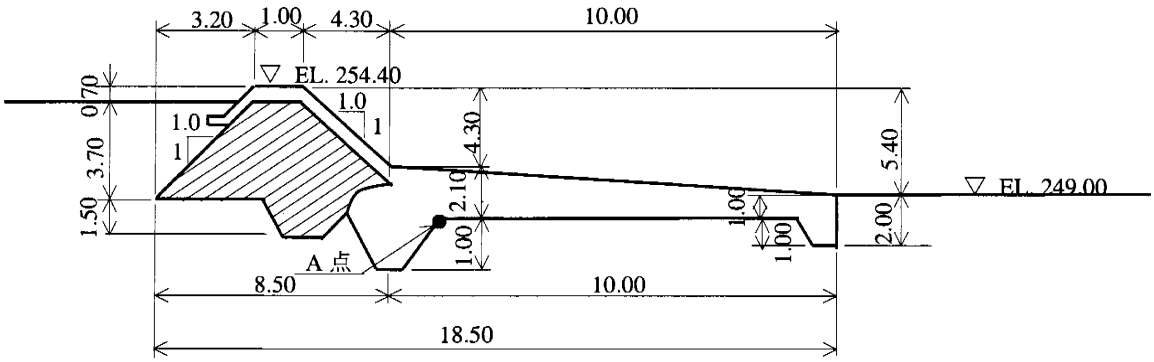


Figure 2-6 Cross section of proposed diversion weir

① Fixed weir body

Both slope gradients of fixed weir are examined to keep the stability of full sediment weir body at full water level and/or a flood. According to examples in Japan, slope gradient for upstream side is vertical and downstream side is 1:1.0. Judging from that the slope gradient is 1:1.0 at both upstream and downstream, existing fixed weir had sufficient safety against external force (inclusive of lateral water pressure and sediment pressure etc. from upstream.

Partial concrete at retaining wall of existing fixed weir has been washed out by floods due to collapse of downstream apron and scouring of downstream riverbed. Its scale is about 2.0 m in width, 2.0 m in depth and 1.0 m in height. The repair of washed out concrete is designed by treatment with high strength concrete at the period of repairing downstream apron.

② Reinforcement work of scouring sluice gate

(a) Design flood discharge

The reinforced scouring sluice gate is designed to withstand against collision of boulders brought about by flood during the targeted flood of 100-year probability. Considering the discharge of 305 m^3/sec obtained in the flood discharge analysis at the review in the WB F/S report the and the discharge of 319 m^3/sec obtained in the flood discharge of observed maximum flood of 100-year reliability, the design flood discharge is set at 310 m^3/sec (probability of 100-year flood), the same as the result of the WB F/S report.

(b) Assumed size of boulders

Velocity of flood flow

With the design flood elevation set at HWL.256.7m after rehabilitation, the relationships among designed level of the intake weir sill, crest and water level are shown in Figure 2-7 (Appendix 5-9 Design of fixed weir, scouring sluice

and bank protection retaining wall, 5-9.3 flood level at the upstream of the intake weir after the rehabilitation). From the following parameters, the velocity of flow at scouring sluice during a flood is calculated at 5.0 m/sec.

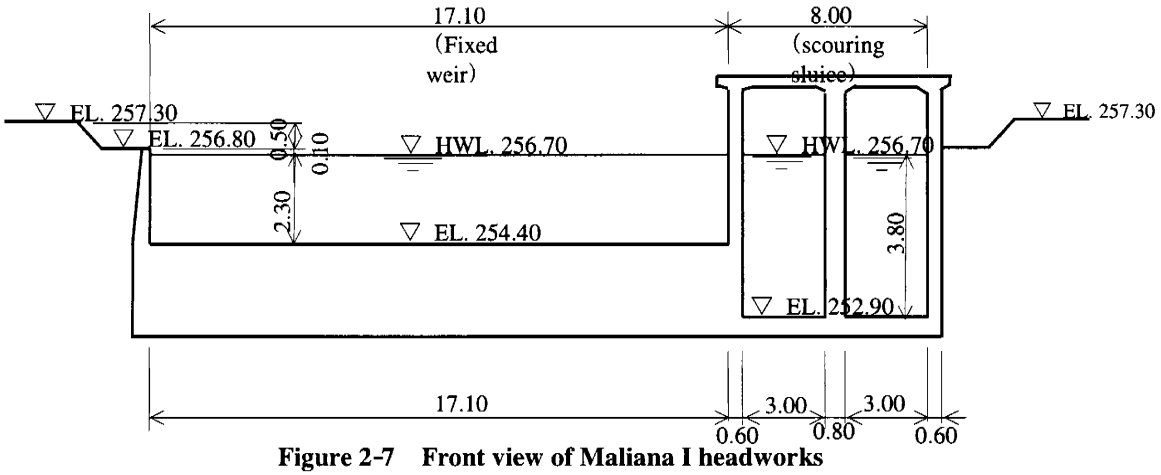


Figure 2-7 Front view of Maliana I headworks

Parameters of scouring sluice gate (Concrete portion)

Water depth	:	hs = HWL. 256.70m − EL.252.90m = 3.80m
Cross-sectional area of flow	:	As = 3.00 × 3.80 × 2 = 22.80m^2
Wetted perimeter	:	Ps = (3.00 + 3.80 × 2) × 2 =21.20m
Hydraulic mean depth	:	Rs = 22.80 / 21.20 = 1.075m
Roughness coefficient	:	n_s = 0.020
River gradient	:	Is = 1 / 100
Velocity of flow	:	Vs = 1/0.020 × 1.075$^{2/3}$ x (1/100)$^{1/2}$ = 5.00m/sec

The size of flowing boulder

The maximum size of flowing boulders is estimated by the following numeric formula.

$D = V^2 / 20 = 5.00^2 / 20 = 1.25m$

where, D : The maximum diameter of boulder

V : flow velocity during flood, V = 5.00m/sec

The maximum diameter of flowing boulders during floods is therefore estimated at around 1.25m.

(c) Impact load of colliding boulders

During a flood, the movement of boulders flowing into scouring sluice before collision against the gate is predicted in a way "The colliding boulders will begin to attenuate its velocity at 0.75m, or 1/2 of the height of the gate, before colliding against the gate."

The mass of a colliding boulder

$$M = \frac{4}{3} \cdot \pi \cdot r^3 \cdot \rho = \frac{4}{3} \times 3.14 \times 0.625^3 \times 2.65 = 2.71 \text{ ton}$$

where, M : Mass of flowing boulder (ton)

r : The radius of boulder r = 1.25 / 2 = 0.625m

ρ : The density of boulder ρ = 2.65 t/m^3

The time required for the movement of boulder from reducing velocity to collision at the gate

$$L = \frac{1}{2} \cdot a \cdot t^2 = \frac{1}{2} \cdot \frac{V_1 - V_2}{t} \cdot t^2$$

$$t = \frac{2 \cdot L}{V_1 - V_2} = \frac{2x0.75}{5.0 - 0.0} = 0.3 \text{ sec}$$

where, t : the time from reducing velocity to collision at the gate (sec)

L : the distance between reducing velocity and the gate L = 1.50 × 0.50 = 0.75m

a : acceleration $a = \frac{V_1 - V_2}{t}$

V_1 : velocity of boulder before collision V_1 = 5.00m/sec

V_2 : velocity of boulder at the collision against the gate V_2 = 0.00m/sec

Impact load of colliding boulder against the gate

$$F \cdot t = M \cdot V_1 - M \cdot V_2$$

$$F = \frac{M \cdot V_1 - M \cdot V_2}{t} = \frac{2.71x5.0 - 2.71x0.0}{0.3} = 45.17 \text{ N}$$

where, t, M, $V_1$and V_2 = the time as defined in (b)

F = Impact of boulder in Newton

(d) The determination of reinforcement work of scouring sluice gate against collision of boulder

From the result of examining reinforcement work of scouring sluice gate against collision of boulder flown by a flood of 100-year probability, the following specification has been determined.

1) The skin plate of the gate : thickness 19mm (12mm as usual)
2) The main beam of the gate : H-section steel H-250 × 250 × 12 × 16
   (as usual : channel-200 × 80 × 7.5 × 11)
3) The main roller: diameter of the roller ϕ 300mm (usually : ϕ 250mm)
4) The main roller axis: diameter of the axis ϕ 75mm (usually : ϕ 50mm)
5) The guide frame: H-section steel H-150 × 75 × 5.5 × 9.5 (as usual : H-125 × 60 × 6 × 8)
6) The total weight of the gate (Sum of the mass of gate, guide frame and operation accessory) : 7 ton (usually 2.9ton)

③ Downstream apron of fixed weir

(a) Length of downstream apron

The downstream apron is designed to prevent scour of downstream riverbed caused by the action of afflux water formed upstream of the fixed weir during occurrence of flood. In this regard, the length of downstream apron is designed following "design criteria of headworks, MoAFF, Japan" (refer to Appendix 5-9 Design of fixed weir and scouring sluice).

(b) Creep length

The creep length along foundation of weir and revetment protection wall is designed to prevent piping of riverbed materials beneath the foundation. The secured creep length is adopted selecting the larger value calculated by (i) Bligh's method or (ii) Lane's method (refer to design criteria of headworks, MoAFF in Japan).

In this calculation, maximum difference in water level between upstream and downstream is based on the assumption that downstream water depth is 0 on the safe side. Also, to reduce uplift pressure, weep hole is set up at the cut-off at the end of downstream apron. Therefore, creep length doesn't include that of cut-off at downstream end.

(c) Thickness of downstream apron

The thickness of downstream apron is calculated from the formula regarding balance of uplift (refer to design criteria of headworks).

④ Riverbed protection of fixed weir

(a) Riverbed protection length

The riprap protection is provided in addition to downstream apron, because there is risk of scour at downstream riverbed by overflow from fixed weir. In this installation, the length of riverbed protection is designed after "design criteria of headworks, MoAFF, Japan".

(b) Size of Riprap

The size of riprap must bear with enough weight and resistance to keep stability against water flow. The study team designs weight of a riprap block as per the design criteria of headworks, MoAFF, Japan).

⑤ Design Parameter of Fixed Weir

From the design results of fixed weir, the design parameters are determined as in Table 2-35 (refer to Appendix 5-9 design of fixed weir and scouring sluice).

Table 2-35 Design parameters of proposed fixed weir

Design item	Design condition	Required parameter	Design parameter	Note
1.Fixed weir body	Weir body height: H = 4.3m	Slope gradient Upstream: vertical Downstream: 1:1.0	Slope gradient Upstream: 1:1.0 Downstream: 1:1.0	· It's the same as that of existing weir referring to examples in Japan.
2.Apron length	Dam up height: H=5.4m Bligh efficiency (gravel): C = 4	Required length : la = 5.57m	Design length : la =10.0m	· Creep length is secured · Fit into apron length of scouring sluice
3.Creep length	Dam up height: H = 5.4m Bligh: C = 4 Lane: C' = 2.5	Bligh : S = 21.60m Lane : L = 13.50m	Bligh : S = 27.20m Lane : L = 14.87m	· Creep length is designed by Lane method
4.Downstream apron thickness	Water level difference : ⊿H = 5.4m Head loss: Hf = 3.41m	Required thickness : ta =1.97m	Design thickness : ta = 2.10m	· Necessary thickness to uplift is secured · Fit into thickness of scouring sluice
5.Riprap length	Flood discharge : q = 11.22m^3/s/m Dam up height: H = 5.4m	Required length : L = 10.86m	Design length : L = 12.0m	· 4 lines × @ 3.0m
6.Riprap block	Velocity: V = 5.25m/sec Impact area: A = 1.35m^2/block	Cast-in-place cross concrete block Required weight : W = 7.16ton	Cast-in-place cross concrete block Design weight : W = 8.75 ton	· Select blocks are locally procured · Block : 2.7m (width) × 2.7m (length) × 1.0m (height)

(2) Design of scouring sluice and revetment retaining wall

① Width of scouring sluice

The width of scouring sluice is decided assuming the velocity of about 0.4 m/sec at taking in ordinary water level of rainy season (about 2.0m^3/sec).

② Longitudinal slope of scouring sluice

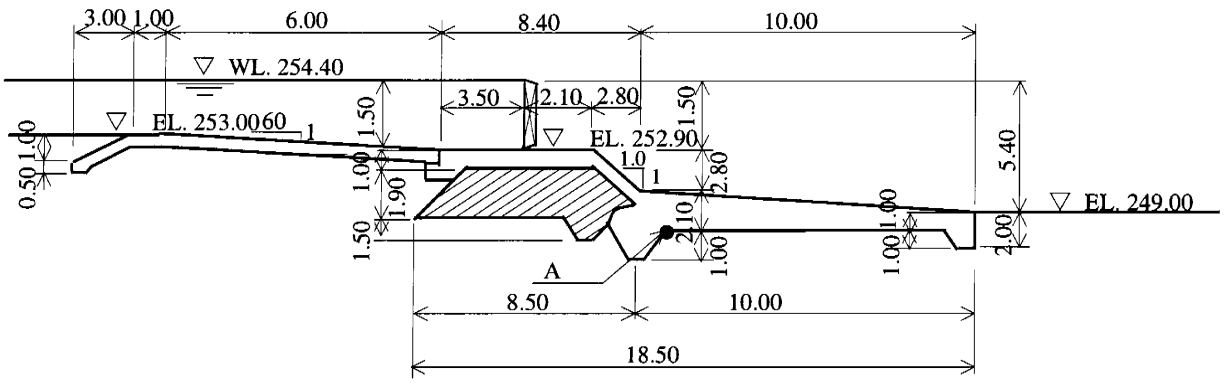


Figure 2-8 Cross section of proposed scouring sluice

Flow in scouring sluice at ordinary discharge is supercritical flow. Scouring sluice is designed so that target maximum grain (d_{max} = 40 mm) can be washed out at full gate operation. In this design, longitudinal slope of scouring sluice must be made equal to or steeper than the existing downstream slope of river.

③ Downstream apron of scouring sluice

(a) Length of downstream apron

The downstream apron is constructed for preventing scouring of downstream riverbed, because there is risk of scour at downstream riverbed by overflow water of scouring sluice. And, the length of downstream apron is designed referring to "design criteria of headworks, MoAFF in Japan" (refer to Appendix 5-9 design of fixed weir and scouring sluice).

(b) Creep length of scouring sluice

To protect against piping, creep length along foundation of weir and back of revetment protection wall must be secured. The larger value calculated by (i) Bligh method or (ii) Lane method is adopted for securing creep length (refer to design criteria of headwork MoAFF in Japan). In this design, the maximum difference of water level between upstream and downstream is calculated assuming that downstream water depth is 0 on the safe side. Also, to reduce uplift pressure, weep hole is set up at the cut-off at the end of downstream apron. Therefore, creep length doesn't include the cut-off at the downstream end.

(c) Downstream apron thickness of scouring sluice

The thickness of downstream apron is calculated from the formula regarding balance of uplift pressure (refer to design criteria of headworks, MoAFF in Japan).

④ Riprap of scouring sluice

(a) Riprap length

The riprap is installed in addition to downstream apron, because there is risk of scour at downstream riverbed by overflown water of scouring sluice. In this case, the length of riprap is designed referring to "design criteria of headworks, MoAFF in Japan".

(b) Riprap block

The riprap block must bear resistance and stability against water flow. The study team designed weight of one riprap block (refer to design criteria of headworks, MoAFF in Japan).

⑤ Design parameter of scouring sluice

From the design result of scouring sluice, design parameters are decided as in Table 2-36 (refer to Appendix 5-9 Design of fixed weir and scouring sluice).

Table 2-36 Design parameters of proposed scouring sluice

Design item	Design condition	Required parameter	Design parameter	Note
1.Width of scouring sluice	Grain size: d = above 1mm Discharge: Q = 2.0m^3/sec Settling velocity : V = 0.4m/sec	Required width: B = 5.6m	Designed width: B = 6.0m	· Scouring sluice gate: 3.0m x 1.5m (2 sets)
2.Lengitudinal slope	Maximum grain size: d=40mm Sand removal discharge: Q = 2.0m^3/sec Sand removal velocity: V = 0.89m/sec	Required slope: I = 1/109	Designed slope: I = 1/60	· Existing riverbed slope of downstream: Fit into 1/60
3.Apron length	Dam up height: H = 5.4m Bligh efficiency (gravel):C=4	Required length: la = 8.37m	Designed length: la =10.0m	· Secure creep length
4.Creep length	Intake water height: H = 5.4m Bligh efficiency: C = 4 Lane efficiency: C' = 2.5	Bligh: S = 21.60m Lane: L = 13.50m	Bligh: S = 26.40m Lane: L = 14.07m	· Design creep length by Lane method
5.Thickness of downstream apron	Water level difference: ⊿H=5.4m Head loss: Hf = 3.35m	Available thickness: ta =2.02m	Designed thickness : ta = 2.10m	· Secure necessary thickness to uplift
6.Riprap length	Flood discharge: q=19.97m^3/s/m Dam up height: H = 5.4m	Required length: L = 26.85m	Designed length: L = 27.0m	· 9 lines × @ 3.0m
7.Riprap block	Velocity: V = 5.25m/sec Impact area: A = 1.35m^2/block	Crossing type concrete block Required weight: W = 7.16 ton	Crossing type concrete block Designed weight: W = 8.5 ton	· Blocks are procured locally · Block: 2.7m (width) x 2.7m (length) x 1.0m (height)

⑥ Durability of scouring sluice pier and gate

(a) Scouring sluice pier

The concrete of scouring sluice pier constructed in rapid stream has a risk of damage by sediment flow mixing boulder during flood. By adopting "High strength concrete construction method" for surface protection work, the durability of scouring sluice pier can be secured.

(b) Scouring sluice gate

Numerous examples of the scouring sluice gate constructed in rapid stream exist in Japan. The main trouble of the gate is caused by the presence of boulder in rapid river flow during flood.

At the diversion weir for irrigation, the sluice gate can be kept full open because no intake is needed during flood. It follows that the gate is never damaged as long as it is operated to keep it open during flood (as mentioned in the regulation of gate operation).

In preparation for miss-operation of gate during flood, the gate leaf (skin plate, main beam, roller and roller axis) subject to damage shall be designed considering tolerable protection works against impact of boulder.

⑦ Riprap and retaining wall

Bank protection retaining wall need to be raised by 0.5m based on the design flood elevation HWL.256.7m and the

following hydraulic conditions.

(a) Hydraulic conditions

Design flood discharge :	Q = 310m^3/sec (100-year flood)
Length of fixed weir :	L_1 = 17.1m
Width of scouring sluice :	L_2 = 3.0m × 2 sets

(b) Flood level of upstream side

Assumed flood water level :	HWL. 256.70m
Overflow discharge of fixed weir :	Q_1 = 192.0m^3/sec
Scouring sluice flow :	Q_2 = 119.8m^3/sec
Total flow discharge :	Q = 192.0 + 119.8 = 311.8m^3/sec ≒ 310m^3/sec

Based on the above, flood level of upstream after repair of diversion weir is set at HWL. 256.70m.

(c) Raising height of protection wall

The raising height of both left and right banks is decided as follows.

Crest elevation of dike= Design flood level + Protection wall freeboard
= HWL. 256.70m + 0.60m
= EL. 257.30m

Raising height of wall = Design protection wall crest elevation + Existing riprap crest elevation
= EL. 257.30m □ EL. 256.80m
= 0.50m

(3) Design of intake, sediment settling basin, and canal intake work

① Intake

(a) Intake sill level

At intake, almost all the sediments in the scouring sluice consist of bed load (sediment that rolls or bounds along riverbed). Taking this into consideration, the intake sill level is designed to be 0.70m higher than sill level of the scouring sluice, (half of the depth in scouring sluice of 1.40m), to prevent inflow of sediment into the intake structure.

- Intake sill = EL. 252.90m + 0.70m = EL. 253.60m

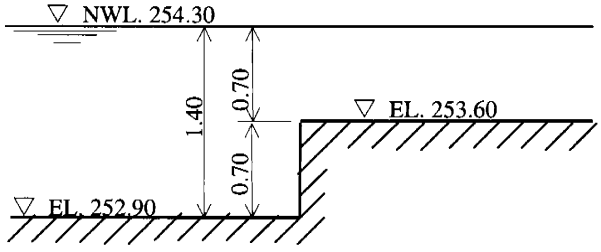


Figure 2-9 Intake sill level

(b) Intake velocity

The standard intake velocity should be kept in a range 0.6 - 1.0 m/sec to prevent inflow of sediment to the intake structure.

- Inflow velocity = 0.6 to 1.0m/sec

(c) Intake width

The intake width is calculated by the following formula, considering the inflow depth calibrated from intake sill level and the designed intake level as well as intake velocity.

$$B = Q / (h_1 \cdot V) = 1.37 / (0.70 \times (0.6 \text{ to } 1.0)) = 1.96 \text{ to } 3.26 \text{ m}$$

Where, B : Intake width (m)

Q : Design intake discharge: Q = 1.37 m^3/sec

h_1 : Inflow water depth: h_1 = NWL. 254.30m □ EL. 253.60m = 0.70m

V : Inflow velocity: V = 0.60 to 1.0 m/sec

Although the intake width ranges from 1.96m to 3.26m, it is designed at 3.0 m so that the intake velocity can be maintained at low level, assuming the case that the gate can hardly be operated during the night in Bulobo River. In addition, the regulating gate is needed for flood protection at intake. The flood-regulating gate is designed as 1.5m W × 1.0 m H × 2 sets of gate leaf (4-side back sealing slide gate) in order to make the operation easier.

② Sediment settling basin

(a) Hydraulic conditions

The hydraulic conditions of sediment basin are as follows.

- Design discharge : Q = 1.37m^3/sec
- Target grain size : d = 0.5 - 40.0 mm (the grain diameter of 10 ～ 100% filtered is adopted from the results of geological survey and grain size analysis of riverbed materials)
- Velocity in sediment basin : V = 0.4 m/sec, by rough estimation
- Water depth in sediment basin : h = 0.6m, roughly estimated water depth of main canal

(b) Examination of existing sediment settling basin

Hydraulic conditions of existing sediment basin

- Effective width : B = 6.0m
  (existing width is 12.0m, but, effective width is about 6.0m due to drift current)
- Water depth : h = 0.6m, roughly estimated from water depth of main canal,
- Target grain size : d = 0.5～40.0mm (the grain diameter of 10～100% filtered is adopted from geological survey and grain size analysis of riverbed materials)

- Velocity in basin : V = 1.37 / (6.0 × 0.60) = 0.38 m/sec
- Critical settling velocity : Vg = 0.049 m/sec (velocity to minimum grain size $d_{min.}$ = 0.6mm)

Sedimentation ditch length of existing settling basin

The length of sedimentation ditch is calculated by the following formula.

$L = K \cdot h/Vg \cdot V = (1.5 \sim 2.0) \times 0.60/0.049 \times 0.38 = 7.0 \sim 9.3$ m < existing length : 13.0m

where, L : Sedimentation ditch length (m)
K : Safety coefficient: K = 1.5～2.0
h : Effective water depth: h = 0.60m
Vg : Critical settling velocity: Vg = 0.049m/sec (minimum diameter : $d_{min.}$ = 0.5mm)
V : Velocity in basin: V = 0.38m/sec

Therefore, the sedimentation ditch length of 13m at the existing sediment basin has sufficient sediment function.

③ Canal intake

(a) Hydraulic design conditions and hydraulic profile

Hydraulic design conditions

1) Design intake discharge : Q = 1.37 m^3/sec
2) Design headwater level : NWL. 254.30 m
3) Design intake width : W = 1.50 × 2 + 0.60 = 3.60 m
4) Intake sill level : EL. 253.60 m
5) Hydraulic condition of beginning point of main canal :

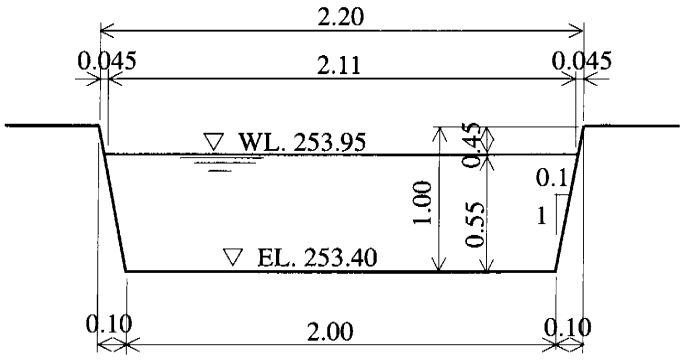


Figure 2-10 Cross section of beginning point of Main canal (Sta. 0 + 030)

(b) Hydraulic profile

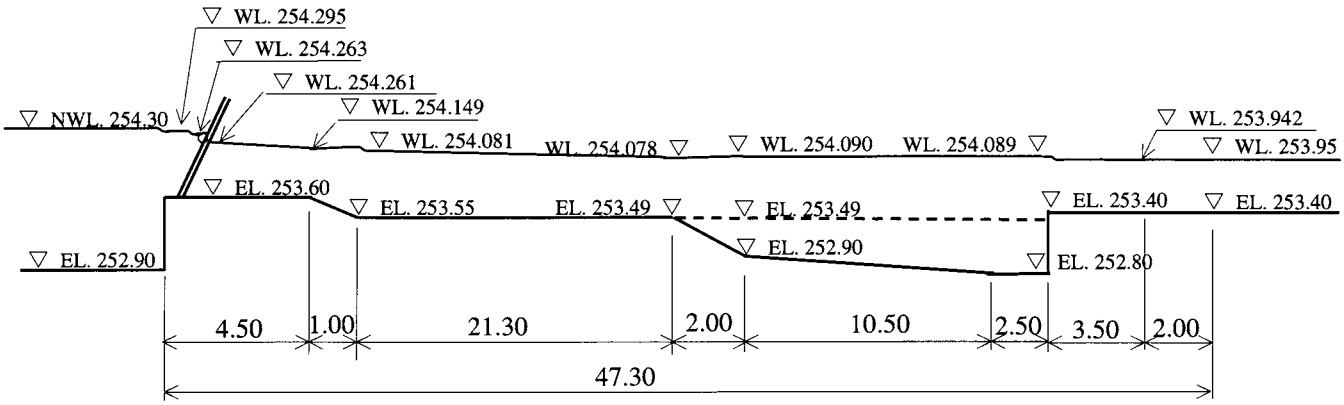


Figure 2-11 Hydraulic profile of intake and sediment settling basin

(c) Hydraulic computation

The water level decline where located at intake (inflow, step, friction, pier, and screen), link canal (bend, link canal), sediment settling basin (inlet, friction), and canal intake work (inflow, transition) is as shown in Table 2-37 (reference 5-10 "design of canal intake works").

Table 2-37 Hydraulic water level decline

Design item	Design conditions	Water level decline	Elevation after decline	Note
1.Inside of scouring sluice	Intake discharge : Q=1.37m^3/sec Water depth in scouring sluice : h = 1.40m Approaching velocity : V = 0.0m/sec	—	Design headwater level : NWL.254.300m	· Approaching velocity is disregarded
2.Water level decline by intake inflow	Water depth after inflow : h = 1.395m Velocity after inflow : V = 0.27m/sec	Water level decline : 0.005m	Water level after inflow : WL.254.295m	· Shape of intake : rectangular & circle · Inflow coefficient of head loss : fc = 0.2
3.Water level decline by step	Water depth after passing step : h = 0.676m Velocity after passing step : V = 0.56m/sec	Water level decline : 0.019m	Water level after passing step : WL.254.276m	· Ratio of flow area : A_2/A_1 = 0.48 · Coefficient of head loss : f = 0.44
4.Water level decline by pier	Water depth after passing pier : h = 0.663m Velocity after passing pier : V = 0.69m/sec	Water level decline : 0.013m	Water level after passing pier : WL.254.263m	· Shape of pier : Circle · Coefficient of head loss : C = 0.92
5.Water level decline by screen	Water depth after passing screen : h = 0.661m Velocity after passing screen : V = 0.69m/sec	Water level decline : 0.100m	Water level after passing screen : WL.254.163m	· Shape of screen : rectangular & circle · Coefficient of head loss : fr = 0.09
6.Water level decline by intake friction	Water depth of downstream end : h = 0.549m Velocity of downstream end : V = 0.83m/sec	Water level decline : 0.014m	Water level of downstream end at intake : WL.254.149m	· Mean gradient : I = 0.000575
7.Water level decline by intake bend	Water depth of downstream end : h = 0.531m Velocity of downstream end : V = 0.81m/sec	Water level decline : 0.068m	Water level of upstream end at link canal : WL.254.081m	· Bend angle : 90° · Coefficient of head loss : fb = 1.0
8.Water level decline by link canal	Water depth of downstream end : h = 0.588m Velocity of downstream end : V = 0.73m/sec	Water level decline : 0.003m	Water level of downstream end at link canal : WL.254.078m	· Mean gradient : I = 0.000436
9.Water level decline by inlet portion of sediment basin	Water depth of upstream end : h = 0.600m Velocity of upstream end : V = 0.29m/sec	Water level decline : -0.012m	Water level of upstream end at sediment basin : WL.254.090m	· Expansion of cross section · Coefficient of head loss : ft= 0.50
10.Water level decline by friction of settling basin	Water depth of downstream end : h = 0.639m Velocity of downstream end : V = 0.27m/sec	Water level decline : 0.001m	Water level of downstream end at sediment basin : WL.254.089m	· Mean gradient : I = 0.000073
11.Water level decline at inlet of canal intake	Water depth after inflow : h = 0.542m Velocity after inflow : V = 1.40m/sec	Water level decline : -0.147m	Water level after inflow : WL.253.942m	· Shape of intake : Angle · Coefficient of loss : ft = 0.50
12.Water level decline by transition	Water depth of main canal : h = 0.550m Velocity of main canal : V = 1.27m/sec	Water level decline : -0.008m	Water level of upstream end at sediment basin : WL.254.090m	· Expansion of cross section · Coefficient of loss : ft = 0.20
13.Total water level decline		Total of water level decline : 0.350m		

2-2-2-2-2 Irrigation Canal Facility Planning

(1) Design conditions of irrigation canal

① Design discharge of irrigation canal

The maximum irrigation water is required in puddling period of rainy season that irrigation area expanded to the maximum. Design discharge of irrigation canal in this period is decided as total of puddling water for 1,050 ha paddy field and requirement for water supply.

1) Main canal : 1.37～1.35 m^3/sec
2) Ramaskora secondary canal : 0.96～0.16 m^3/sec
3) Ritabau secondary canal : 0.39～0.17 m^3/sec

② Mean velocity formula

The mean velocity of irrigation canal is calculated by Manning's formula.

$$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$$

$$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$$

where, V : Mean velocity (m/sec)

n : Roughness coefficient

Aqueduct steel or concrete canal :	0.015
Mortar finished flume canal :	0.020
Wet masonry lining canal :	0.025
Earth canal (clayey loam) :	0.030
Earth canal (grass canal) :	0.035

R : Hydraulic mean depth (m)

I : Canal slope

③ Allowable maximum and minimum velocity

The allowable maximum velocity is decided in consideration of the durability of irrigation canal lining. Besides, allowable minimum velocity is decided in consideration of velocity that refrains from sedimentation in the irrigation canal and overgrowth of submerged plant that may affects water flow shown in Table 2-38.

Table 2-38 Allowable maximum and minimum velocity

Lining type	Allowable min. velocity (m/sec)	Allowable max. velocity (m/sec)
Earth canal (loam)	0.70	0.70
Wet masonry canal	0.70	2.50
Concrete canal	0.70	3.00
Steel canal	0.70	4.50

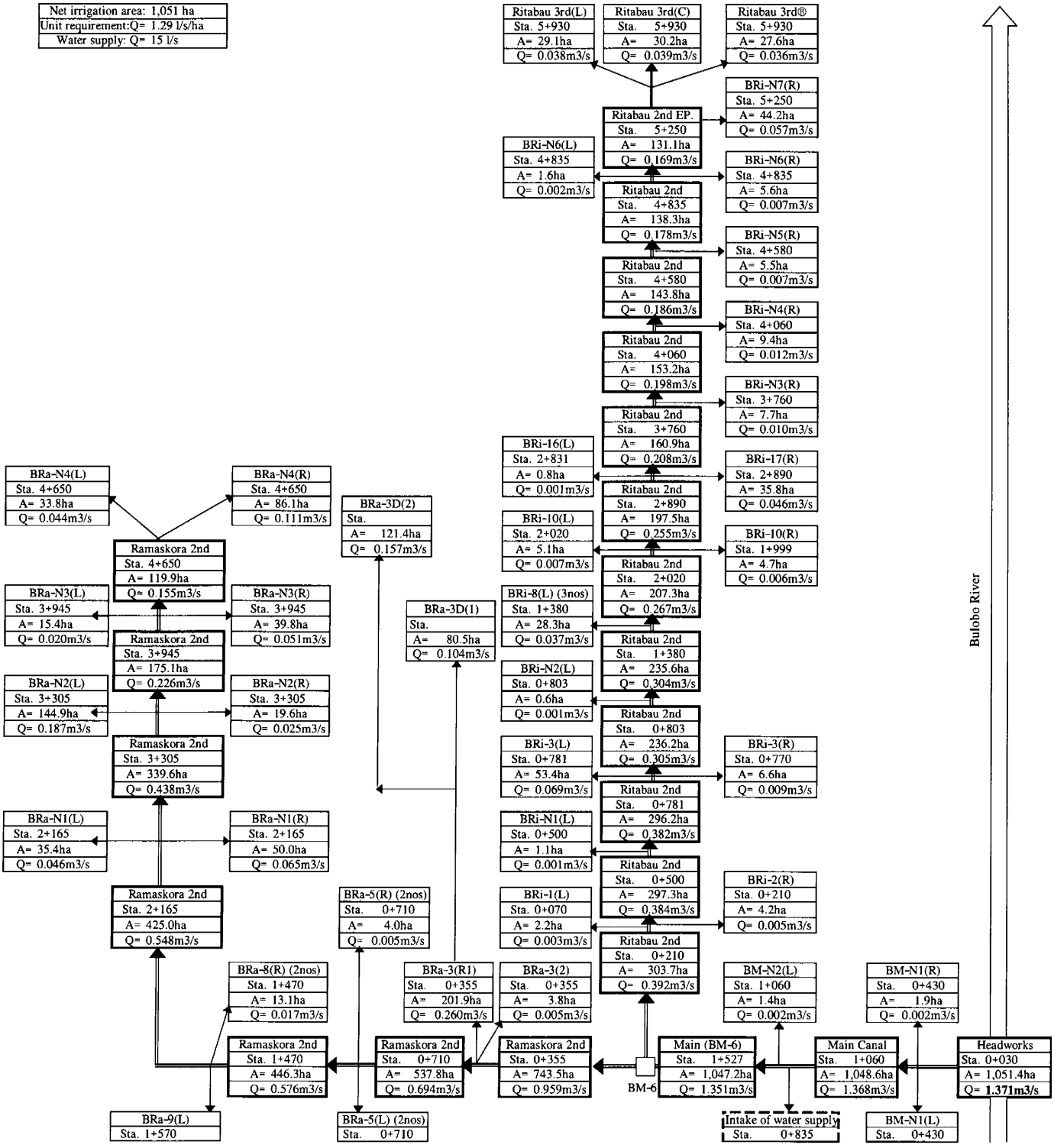


Figure 2-12 Irrigation water distribution plan at peak season (rainy season: 1st half of Feb.)

(1) Main canal

The dimension of proposed main canal is given in Table 2-39, in line with the principles of rehabilitating length of canals, lining method and rehabilitating appurtenant facilities of irrigation canals.

Table 2-39 Design parameters of proposed Main canal

Item		Facilities scale etc.
1) Facility scale	Design discharge: Length:	Q_{max} = 1.37～1.35 m^3/sec L = 1,527m (All sections : lining canal)
2) Standard cross section	Canal type: Canal Bottom width: Side wall height: Crest width:	Wet masonry lining trapezoidal open 1.60m - 5.70m 0.90m - 1.80m 1.60m - 7.10m
3) Related structure	Aqueduct bridge: Side ditch spillway: Sand removal facility: Turnout: Small-scale turnout: Drop structure: Cross drain work: Drainage inlet: Concrete bridge: Concrete foot bridge: Wooden foot bridge: Washing basin:	1 place(W: 1.60m × H: 1.80m × L: 40.00m) 1 place (W: 2.10m × H: 1.00m × L: 2.50m) 1 place (W: 1.00m × H: 1.00m × 2 sets) 1 place (W: 1.00m × H: 0.80m × 2sets) 4 places (PipeD100 - 300mm) 2 places (H: 0.75 - 0.90m × W: 1.6 - 2.1m) 4 places (cross pipe, D1,000 mm × 1 - 2 sets) 1 place (W: 1.00m × H: 0.7m) 1 bridge (W: 2.5m × L: 3.0m) 1 bridge (W: 0.5m × L: 4.5m) 7 bridges (W: 0.3 - 1.0m × L: 2.5 - 4.5m) 12 places (L: 1.0 - 4.5m × ⊿H: 0.3 - 0.45m × 1 - 3 steps)

(2) Secondary canal

① Ramaskora secondary canal

The dimension of proposed Ramaskora secondary canal is indicated in Table 2-40 in accordance with the principles of rehabilitating length of canals, of lining method and of rehabilitating appurtenant facilities of irrigation canals.

Table 2-40 Design parameters of proposed Ramaskora secondary canal

Item	Facilities scale etc.	
1) Facility scale	Design discharge : Length : Existing lining section : Proposed lining section :	Q_{max}= 0.96 - 0.16 m^3/sec L = 3,945m 1,570m 2,375m
2) Standard cross section	Canal type : Bottom width : Side wall height : Crest width :	Wet masonry lining trapezoidal open canal 0.40m - 1.60m 0.30m - 0.80m 1.00m - 3.20m
3) Related structure	Turnout : Small-scale turnout : Drop structure : Cross drain work : Drainage inlet : Concrete bridge : Farm road bridge : Wooden foot bridge : Washing basin :	14 places 8 places 2 places (⊿H: 1.2 - 1.4m × W: 0.9 - 2.1m) 1 place (cross pipe, ϕ 1,000 mm × 1 set) 1 place (W: 0.5m × H: 0.8m) 13 bridges (W: 1.9 - 7.5m × L: 2.0 - 4.0m) 1 bridge (W: 5m × L: 0.8m) 31 bridges(W: 0.3 - 2.5m x L: 2.5 - 3.5m) 27 places (L: 0.8 - 7.0m × ⊿H: 0.2～0.45m × 1 - 5 steps)

② Ritabau secondary canal

The dimension of proposed Ritabau secondary canal is given in Table 2-41.

Table 2-41 Design parameters of proposed Ritabau secondary canal

Item	Facilities scale etc.	
1) Facility scale	Design discharge :	Q_{max} = 0.39 - 0.17 m^3/sec
	Length :	L = 5,250m
	Existing lining section :	2,890m
	Proposed lining section :	2,360m
2) Standard cross section	Canal type :	Wet masonry lining trapezoidal open canal
	Bottom width :	0.40m - 1.10m
	Side wall height :	0.40m - 0.80m
	Crest width :	0.80m - 2.30m
3) Related structure	Turnout :	15 places
	Small-scale turnout :	11 places
	Chute work :	1 place (W: 1.0m x H: 1.0m × L: 47.5m)
	Drop structure :	17 places (⊿H: 0.3 - 1.6m × W: 0.7 - 1.0m)
	Drainage inlet :	5 places (W: 0.1 -0.6m × H: 0.4 -0.7m x L: 5.0m)
	Concrete bridge :	13 bridges (W: 1.5 - 6.0m × L: 2.0 - 4.0m)
	Wooden foot bridge :	81 bridges (W: 0.3 - 2.6m × L: 2.0 - 3.5m)
	Washing basin :	27 places (L: 1.0 - 2.3m x ⊿H: 0.2 - 0.35m x 1 - 3 steps)

(3) Appurtenant facilities of irrigation canal

The related facilities to the above-tabulated irrigation canals needed to be refit or to be repaired are compiled in Table 2-42.

Table 2-42 Appurtenant facilities of irrigation canal

Related facility	Number of Places				Rehabilitation or repair
	Main canal	Ramaskora secondary canal	Ritabau secondary canal	Total	
1. Turnout	1	13	15	29	Rehabilitation the whole
2. Small-scale turnout	4	0	1	5	Rehabilitation partially
	0	8	10	18	Rehabilitation all or new
3. Drop structure	2	2	17	21	Rehabilitation the whole
4. Side ditch spillway	1	0	0	1	Repair partially
5. Washing basin	12	24	27	63	Repair the whole
6. Sand removal facility	1	0	0	1	Rehabilitation the whole
7. Chute work	0	0	1	1	Repair partially
8. Cross drain work	4	1	0	5	Rehabilitation partially
9. Concrete bridge	0	0	1	1	Rehabilitation the whole
	0	0	7	7	Repair partially

2-2-2-2-3 Design of Wet Masonry Protection Wall for Aqueduct

In compliance with the policies of rehabilitating wet masonry protection wall of the Aqueduct, the wall will be refitted as follows:

(1) Wet masonry protection wall of right bank

The design parameters of proposed wet masonry protection wall of right bank is shown in Table 2-43.

Table 2-43 Design parameters of proposed Aqueduct -Wet masonry protection wall at right bank

Item	Facilities scale etc.				Total
	Upstream	Midstream	Downstream (Upper level)	Downstream (Lower level)	
1)Riprap and retaining wall					
Structure type	Wet masonry (refit)	Wet masonry (existing)	Wet masonry (refit)	Wet masonry (new construction)	Wet masonry work
Length	17.0m	7.5m	22.0m	26.0m	72.5m
Height	4.5m	4.5m	4.5m	3.0m	—
Slope gradient	1 : 0.5	1 : 0.5	1 : 0.5	1 : 0.5	—
2)Riverbed protection					
Structure type	Crossing type concrete block	Crossing type concrete block	Crossing type concrete block	Crossing type concrete block	—
Each block size	2.7m×2.7m×1.0m	2.7m×2.7m×1.0m	2.7m×2.7m×1.0m	2.7m×2.7m×1.0m	—
Length/ Width	17.0m × 6.0m	7.5m × 6.0m	18.0m × 3.0m	24m × 6.0m	—

(2) Wet masonry protection wall of left bank

The design parameters of proposed wet masonry protection wall of left bank is shown in Table 2-44.

Table 2-44 Design parameters of proposed Aqueduct -Wet masonry protection wall at left bank-

Item	Facilities scale etc.	Total
1)Riprap and retaining wall		
Structure type	Wet masonry (New construction)	Wet masonry (New construction)
Length	34.0m	34.0m
Height	4.5m	—
Slope gradient	1 : 1.0	—
2)Riverbed protection		
Structure type	Crossing type concrete block	Crossing type concrete block
Each block size	2.7m×2.7m×1.0m	2.7m×2.7m×1.0m
Length / Width	42.0m × 6.0m	42.0m × 6.0m

2-2-2-2-4 Building Facility Planning

(1) Gate keeper's hut

The design parameters of proposed gatekeeper's hut is shown in Table 2-45.

Table 2-45 Design parameters of proposed Gate keeper's hut

Item	Facility scale etc.	Note
1) Location	Upstream side of left band of Maliana I weir	・Left bank just upstream of weir is proper for gate operation and land reservation is easy
2) Structure type	1-storied RC column-beam structure, wall block, concrete foundation	・Adopted structure type had many achievements in the country
3) Total building area	4.2m × 3.5m = 14.7m^2	・Space for gate administrators are able to resident in day time
4) Gate administrator's room	3.0m × 3.5m = 10.5m^2	・Space for installation of a simple bed, a desk and two chair
5) Lavatory	1.2m × 3.5m = 4.2m^2	・Space for change of clothes

(2) Storage for O/M equipment

The dimension of proposed storage for O/M equipment is given in Table 2-46.

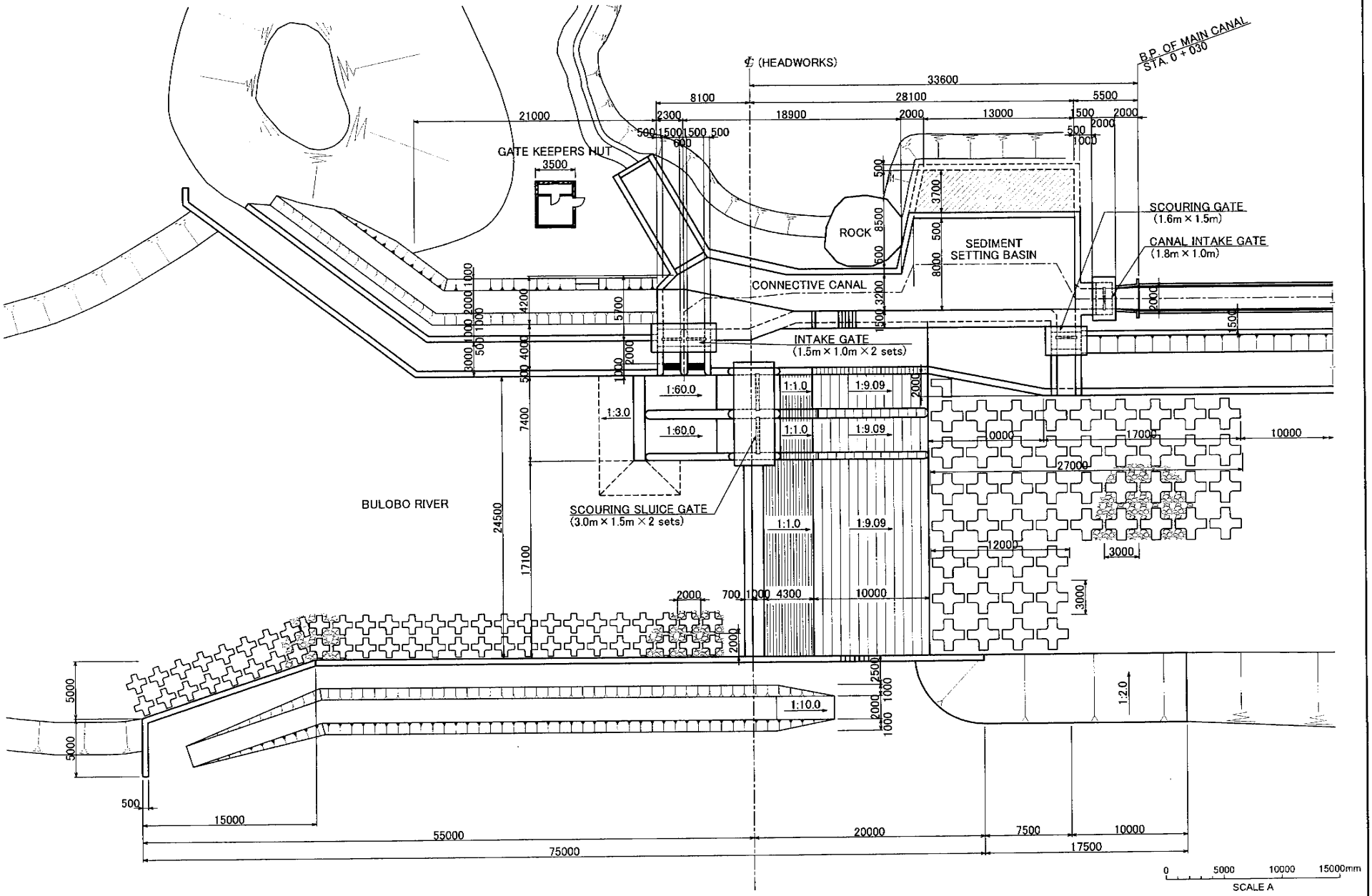
Table 2-46 Dimension of proposed storage for O/M equipment

Item	Facilities scale etc.	Note
1) Location	Ramaskora secondary canal (vicinity of Sta. 3+360 point)	・Site was selected where land is readily available, locating at almost the center of the irrigation area with easy access from existing road
2) Structure type	1-storied RC column-beam structure, wall block, concrete foundation	・Adopted a structure type with many other achieved performances in this country
3) Total building area	10.5m × 6.5m = 68.25 m^2	・Meeting room, lavatory, store and corridor are laid out to accommodate about 30 members
4) Meeting room	6.5m × 4.0m = 26.0 m^2	・About 30 members of WUA are able to assemble
5) Equipment and materials storage room	5.0m × 4.0m = 20.0 m^2	・Space for holding 65 gate handles and 44 stop logs
6) Data storage room	3.5m x× 2.5m = 8.75 m^2	・Space for storing and inspecting the data of manual etc.
7) Lavatory	1.5m × 1.5m = 2.25 m^2	・Space for change of clothes
8) Store	1.5m × 4.0m = 6.0 m^2	・Space for keeping materials/tool for the maintenance of gate etc.
9) Corridor	1.5m × 2.5m = 3.75 m^2	・1.5 m wide, as a standard width where passers can readily pass each other

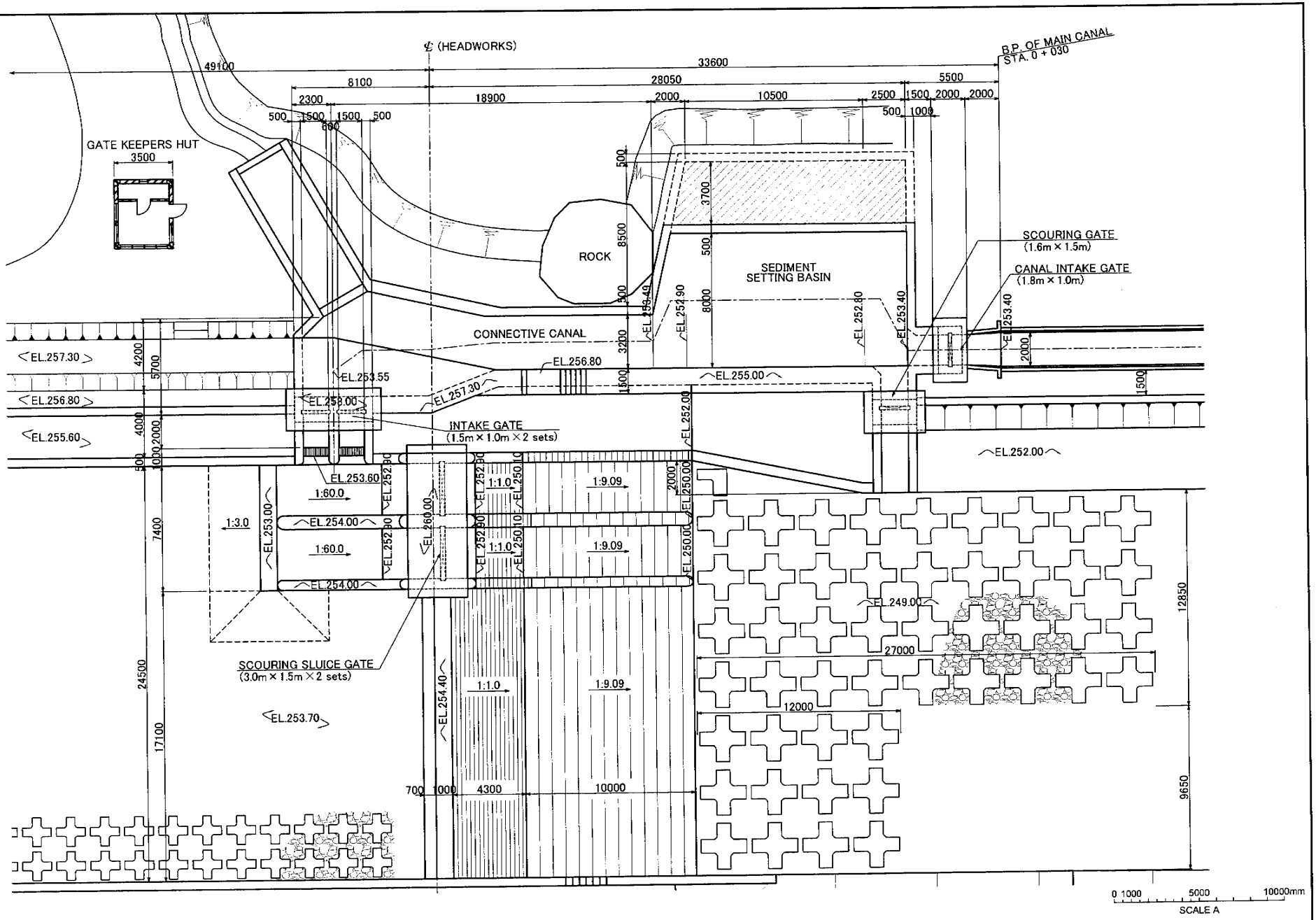
2-2-3 Basic Design Drawing

Table 2-47 List of drawings

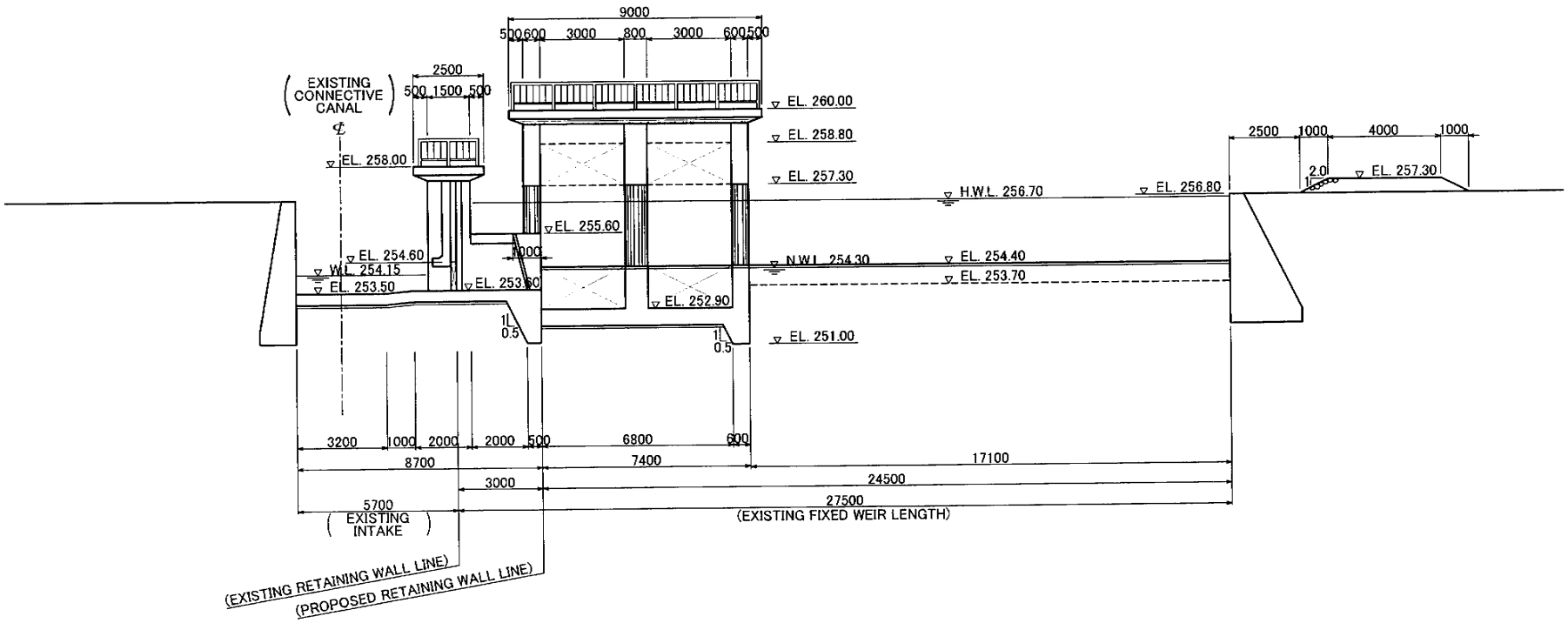
Drawing No.	Title of Drawing
DWG-A	Headworks – General Plan
DWG-B	Headworks – Detailed Plan
DWG-C	Headworks – Elevation
DWG-D	Headworks – Longitudinal Profile of Scouring Sluice and Typical Cross Section of Fixed Weir
DWG-E	Main Canal – Plan and Longitudinal Profile (1/3)
DWG-F	Main Canal – Plan and Longitudinal Profile (2/3)
DWG-G	Main Canal – Plan and Longitudinal Profile (3/3)
DWG-H	Main Canal – Typical Cross Section
DWG-I	Main Canal – Plan of Scouring Gate
DWG-J	Main Canal – Structural Sections of Canal Scouring Gate
DWG-K	Main Canal – Plan of Turnout
DWG-L	Main Canal – Structural Sections of Turnout
DWG-M	Main Canal – Structural Sections of Drop Structure
DWG-N	Aqueduct – Structural Sections of Wet Masonry Protection Wall
DWG-O	Storage for O/M Equipment – Structural Sections



DWG-A : HEADWORKS – GENERAL PLAN

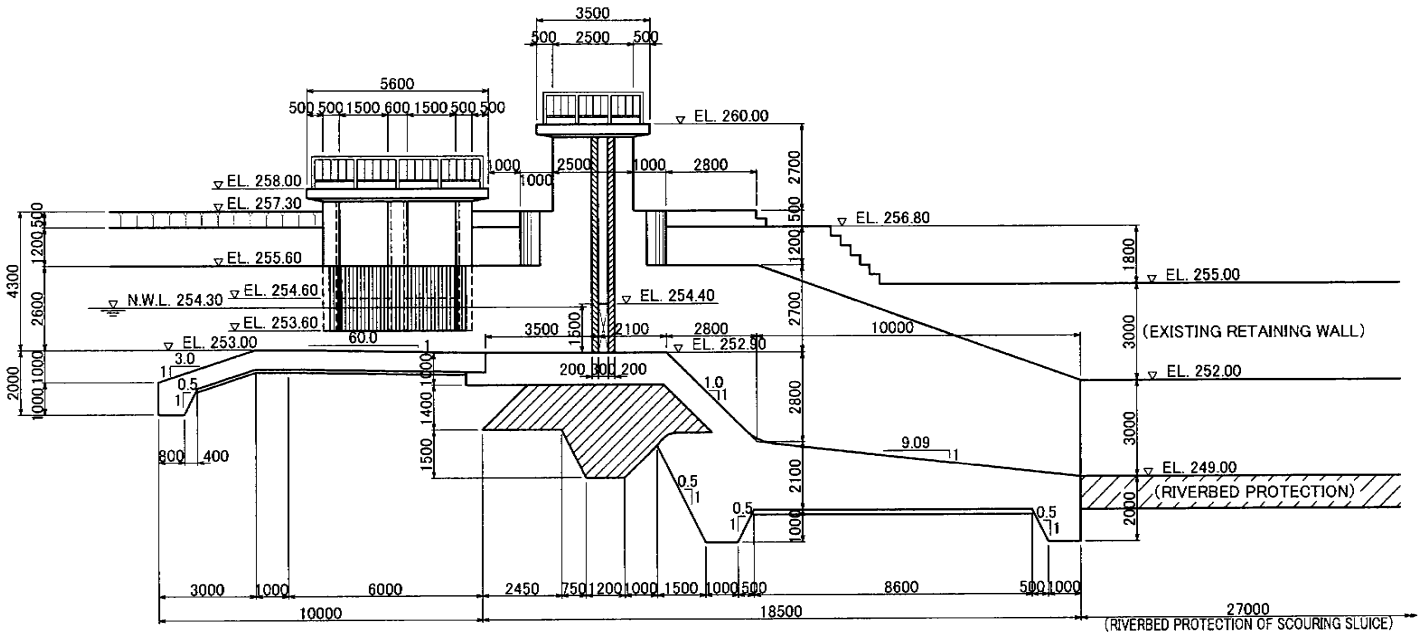


DWG-B : HEADWORKS - DETAILED PLAN

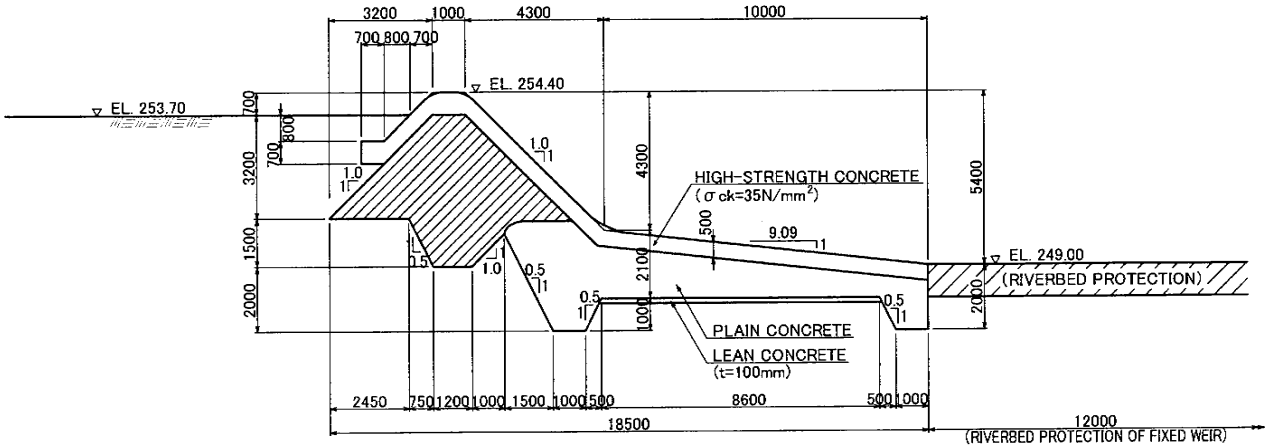


0 1000 2500 5000 7500mm
SCALE A

DWG-C : HEADWORKS - ELEVATION



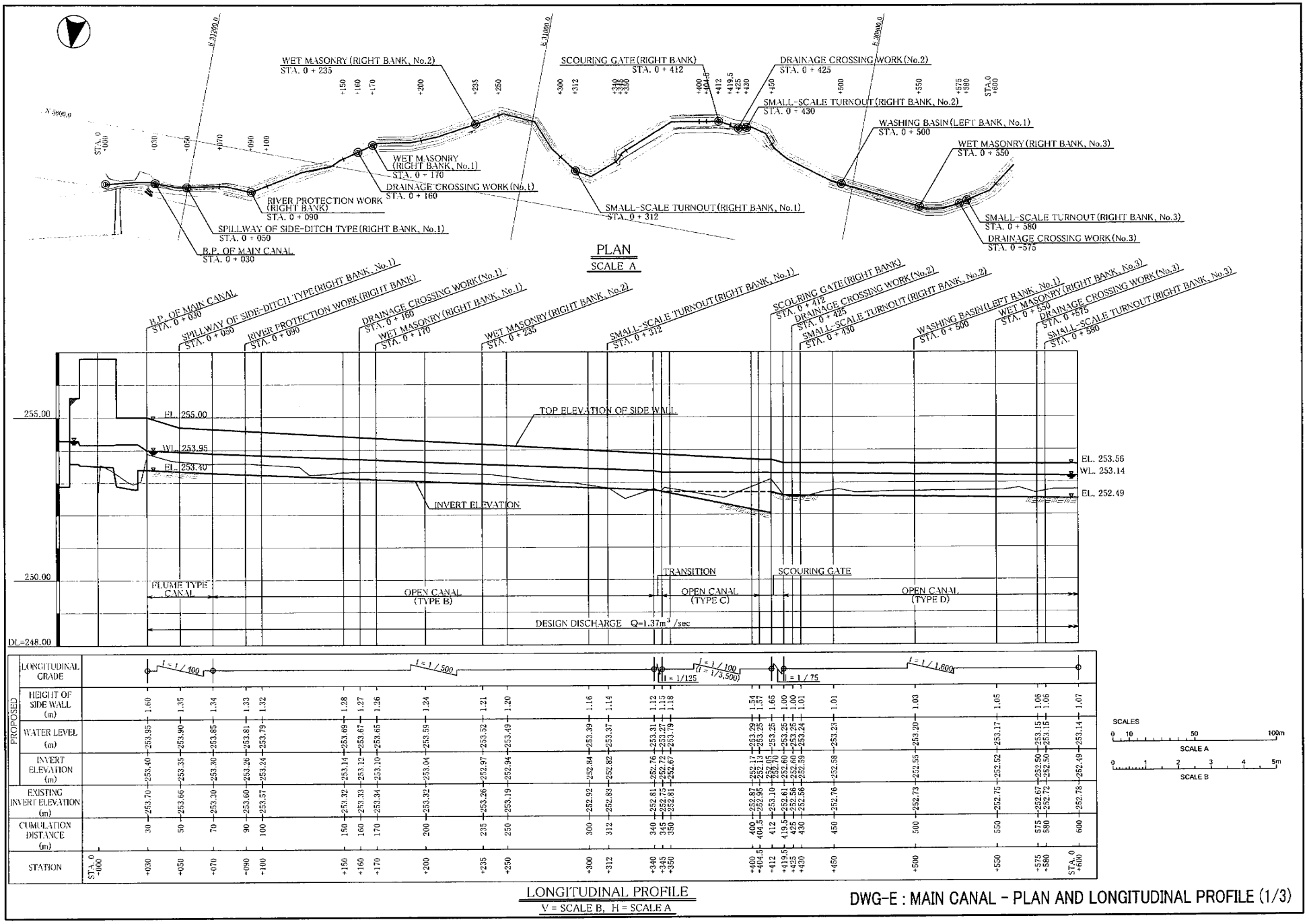
LONGITUDINAL PROFILE OF SCOURING SLUICE



TYPICAL CROSS SECTION OF FIXED WEIR

0 1000 2500 5000 7500mm
SCALE A

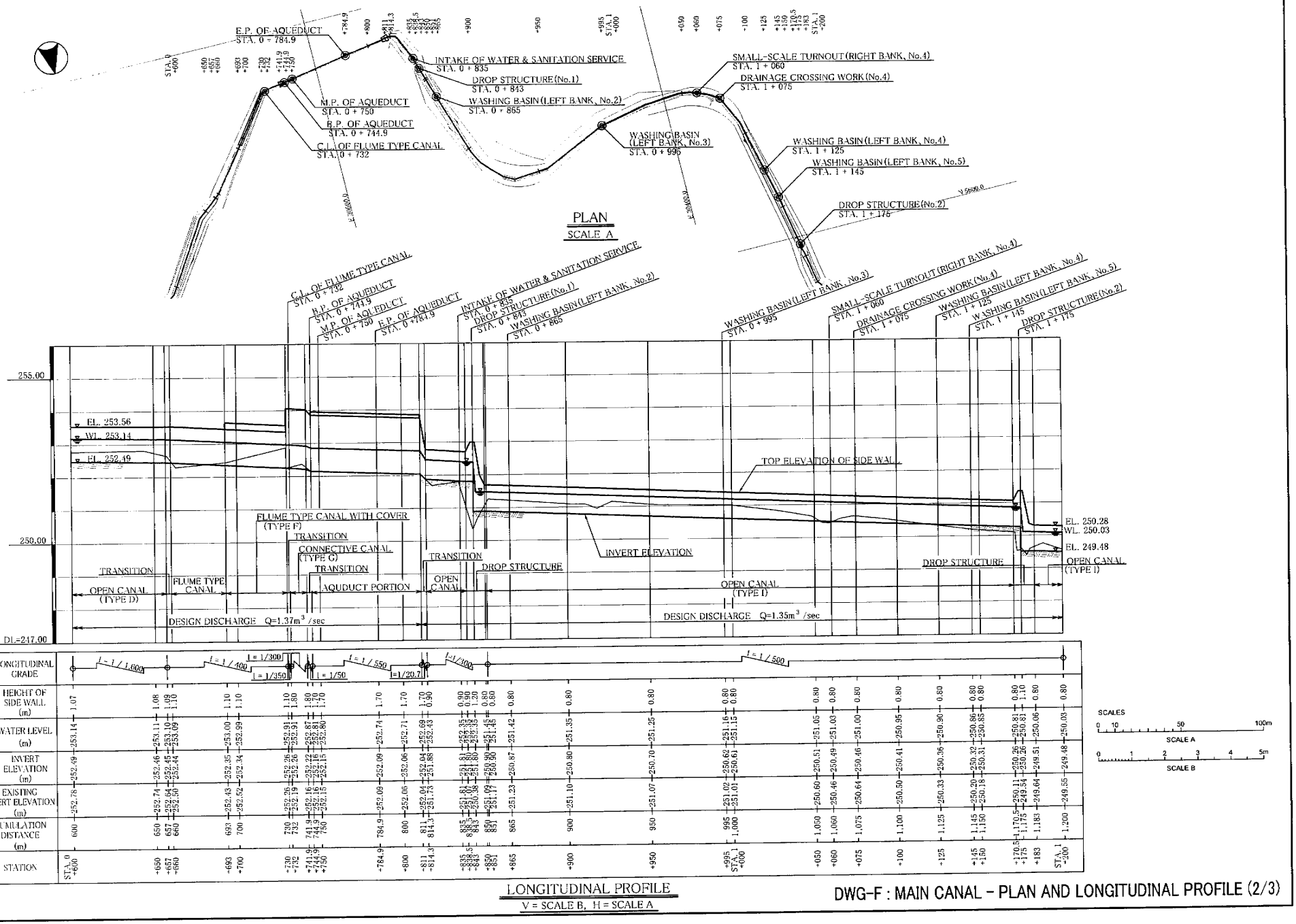
DWG-D : HEADWORKS - LONGITUDINAL PROFILE OF SCOURING SLUICE AND TYPICAL CROSS SECTION OF FIXED WEIR



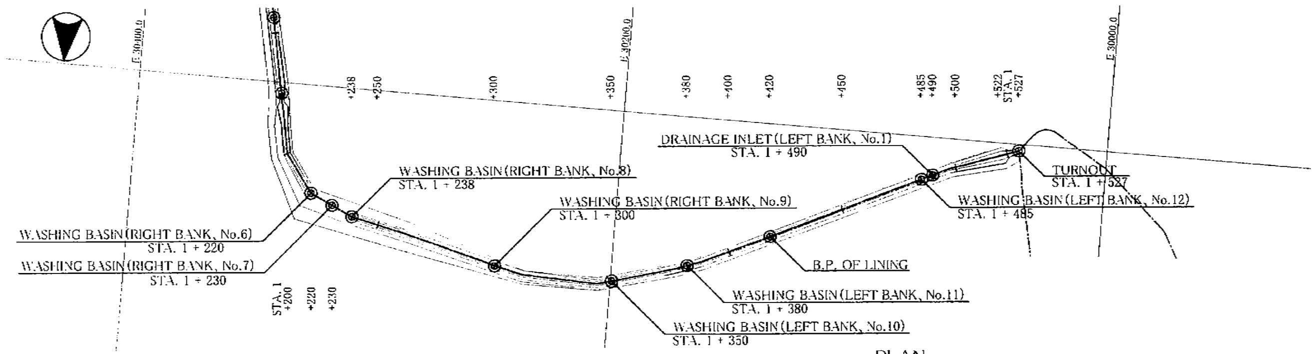
LONGITUDINAL PROFILE

V = SCALE B, H = SCALE A

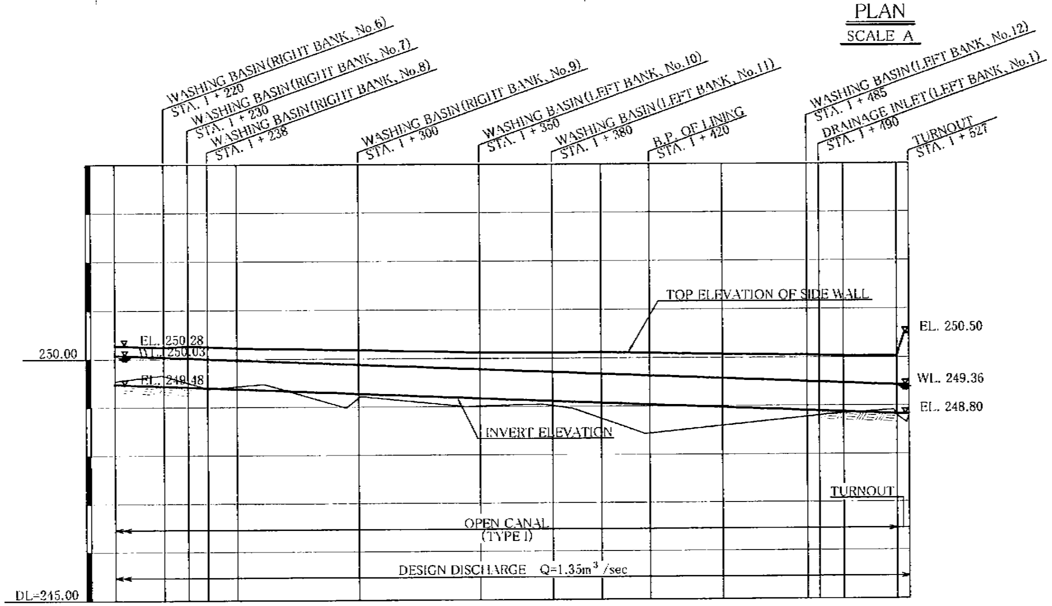
DWG-E : MAIN CANAL - PLAN AND LONGITUDINAL PROFILE (1/3)



DWG-F : MAIN CANAL - PLAN AND LONGITUDINAL PROFILE (2/3)

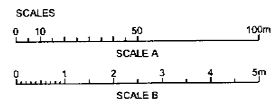


PLAN
SCALE A

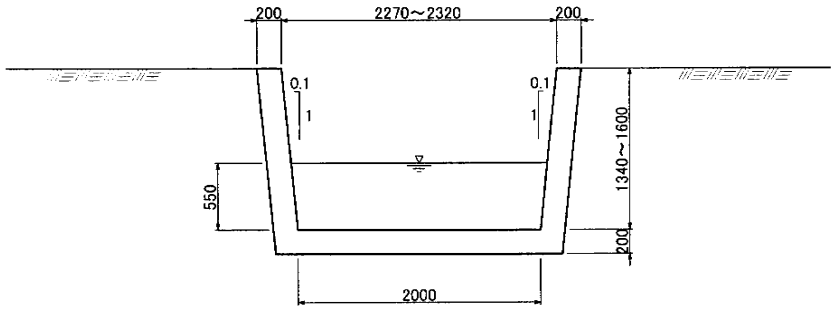


	LONGITUDINAL GRADE	I = 1 / 500														I=1/167	
PROPOSED	HEIGHT OF SIDE WALL (m)	0.80	0.80	0.85	0.85	0.85	0.90	0.95	1.00	1.05	1.05	1.10	1.15	1.15	1.15	1.20	1.70
	WATER LEVEL (m)	250.03	249.99	249.97	249.95	249.93	249.83	249.73	249.67	249.63	249.59	249.53	249.46	249.45	249.43	249.39	249.36
	INVERT ELEVATION (m)	249.48	249.44	249.42	249.40	249.38	249.28	249.18	249.12	249.08	249.04	248.98	248.91	248.90	248.87	248.83	248.80
	EXISTING INVERT ELEVATION (m)	249.55	249.66	249.51	249.39	249.43	249.19	249.01	249.02	248.75	248.44	248.59	248.77	248.80	248.84	248.82	248.81
	CUMULATION DISTANCE (m)	1,200	1,220	1,230	1,238	1,250	1,300	1,350	1,380	1,400	1,420	1,450	1,485	1,490	1,500	1,522	1,527
	STATION	STA.1 +200	+220	+230	+238	+250	+300	+350	+380	+400	+420	+450	+485	+490	+500	+522	STA.1 +527

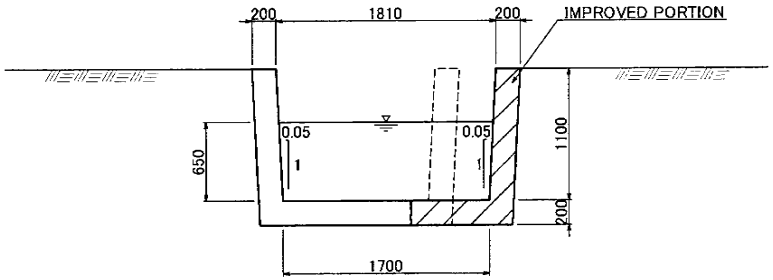
LONGITUDINAL PROFILE
V = SCALE B, H = SCALE A



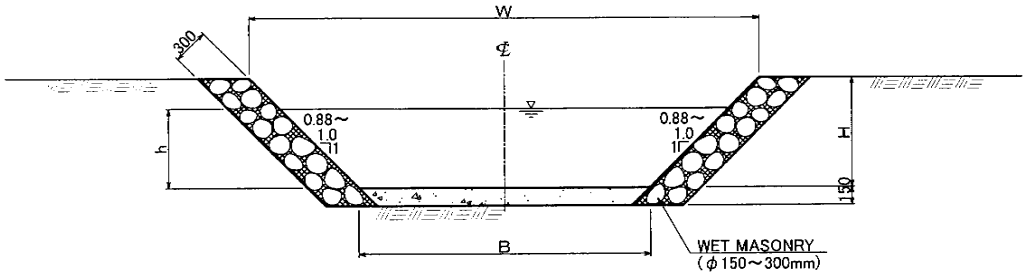
DWG-G : MAIN CANAL – PLAN AND LONGITUDINAL PROFILE (3/3)



TYPICAL CROSS SECTION OF FLUME TYPE CANAL(TYPE A)

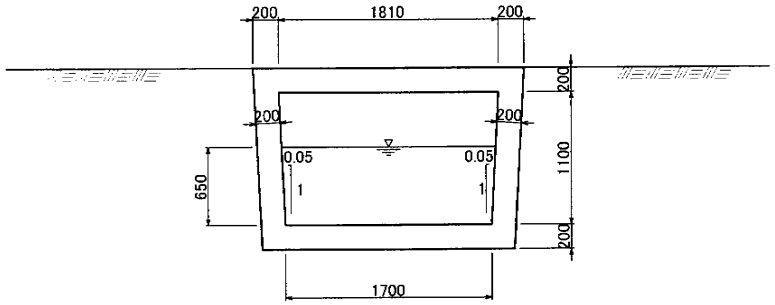


TYPICAL CROSS SECTION OF EXPANDED FLUME TYPE CANAL(TYPE E)

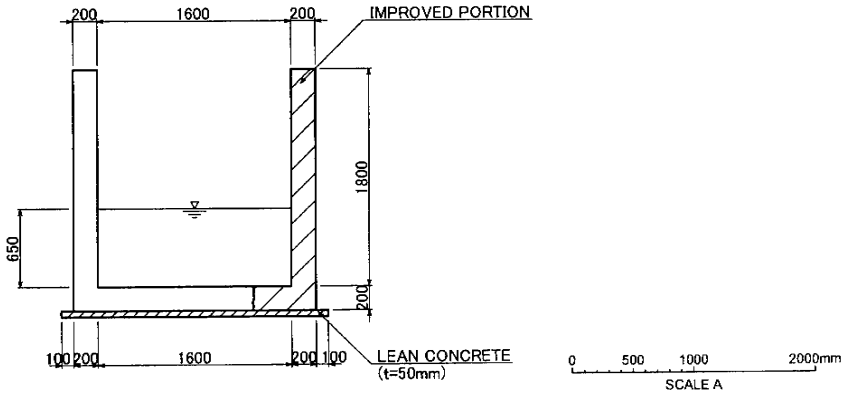


TYPICAL CROSS SECTION OF OPEN CANAL

TYPE	STATION	WIDTH OF CANAL INVERT B	WIDTH OF CANAL TOP W	HEIGHT OF SIDE WALL H	WATER DEPTH h
TYPE B	STA.0+070 ~ STA.0+340	2100	4340~4780	1120~1340	550
TYPE C	STA.0+345 ~ STA.0+404.5	5700	7720~8460	1150~1570	550
TYPE D	STA.0+419.5 ~ STA.0+657	2900	4900~5080	1000~1090	650
TYPE H	STA.0+814.3 ~ STA.0+838.5	1600	3400	900	550
TYPE I	STA.0+851 ~ STA.1+522	2100	3700~4500	800~1200	550

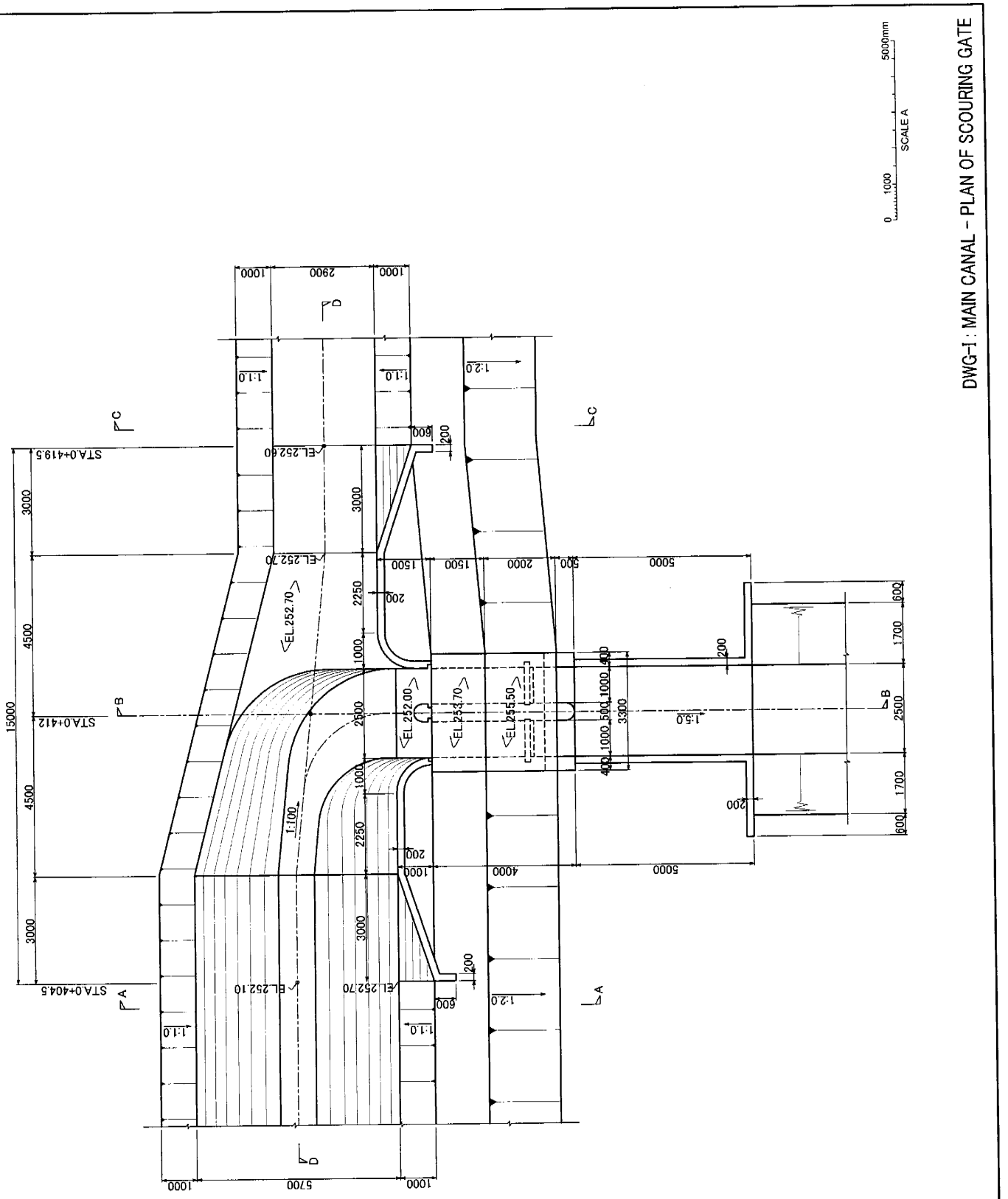


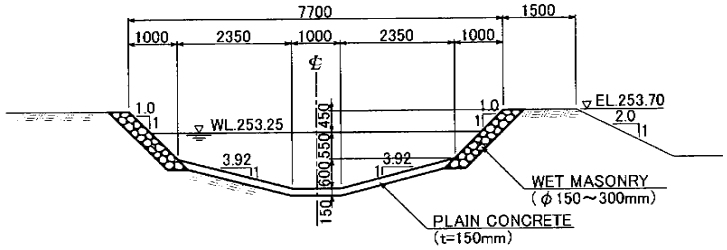
TYPICAL CROSS SECTION OF FLUME TYPE CANAL WITH COVER (TYPE F)



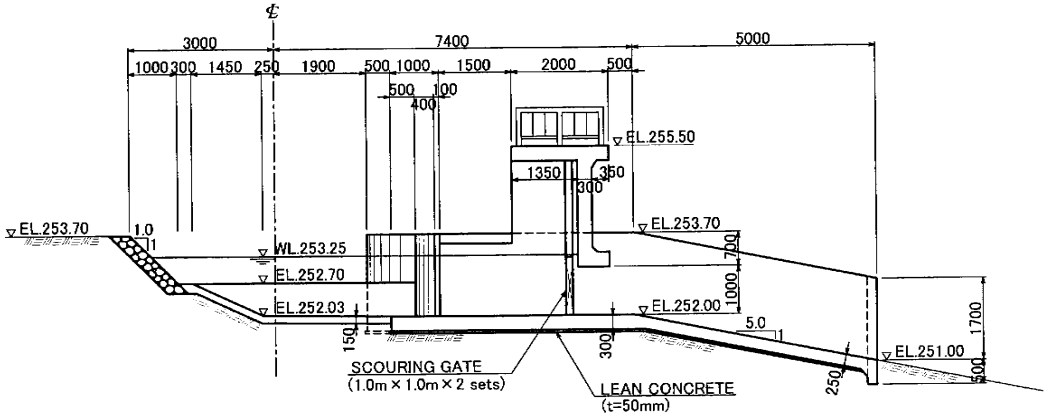
TYPICAL CROSS SECTION OF CONNECTIVE CANAL(TYPE G)

DWG-H : MAIN CANAL - TYPICAL CROSS SECTION

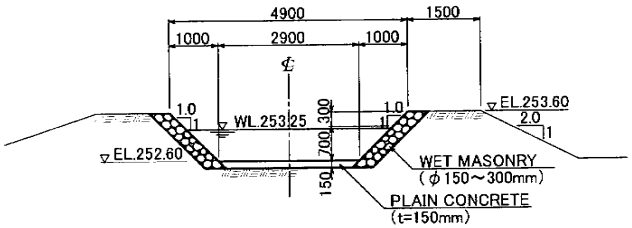

DWG-1 : MAIN CANAL – PLAN OF SCOURING GATE
SCALE A
0
1000
5000mm
STA 0+419.5
STA 0+412
STA 0+404.5
EL.252.60
EL.252.70
EL.252.10
EL.252.00
EL.253.70
EL.255.50
1:1.0
1:2.0
1:5.0
1:100
15000
4500
3000
2250
2600
1000
600
200
1500
2000
5000
4000
2900
5700
1700
2500
400
500
300



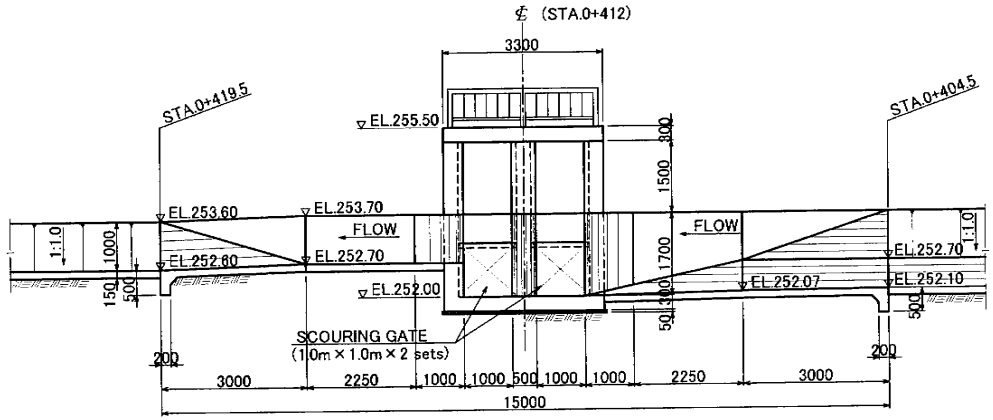
SECTION A-A



SECTION B-B



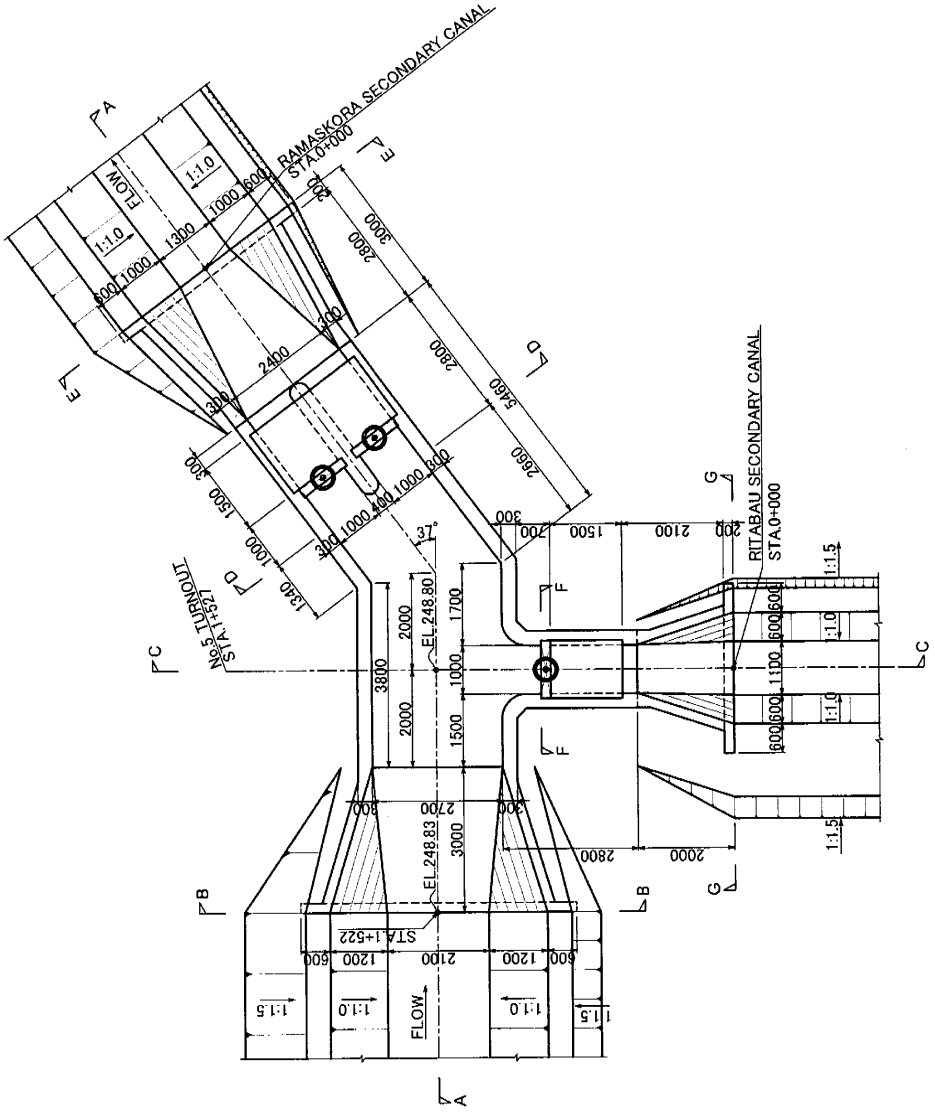
SECTION C-C



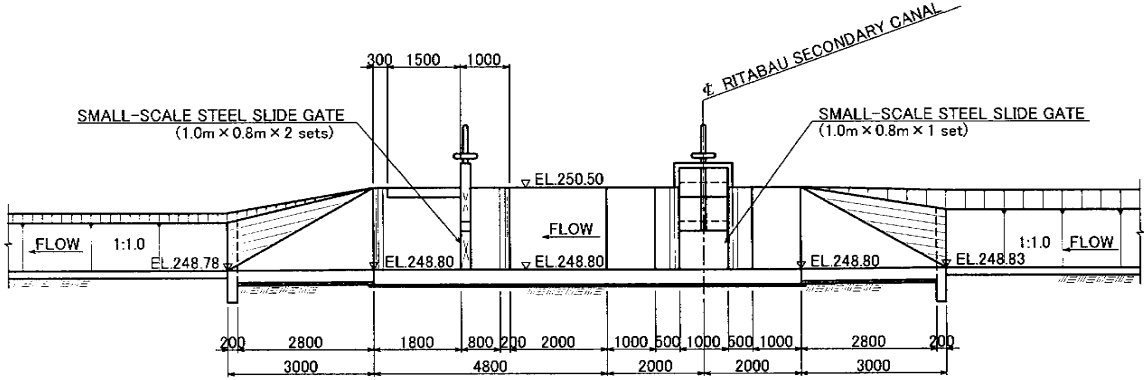
SECTION D-D

0 1000 5000mm
SCALE A

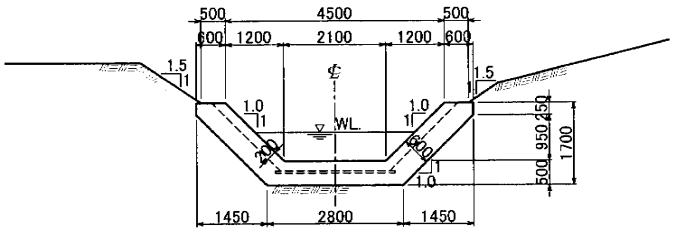
DWG-J : MAIN - STRUCTURAL SECTIONS OF CANAL SCOURING GATE



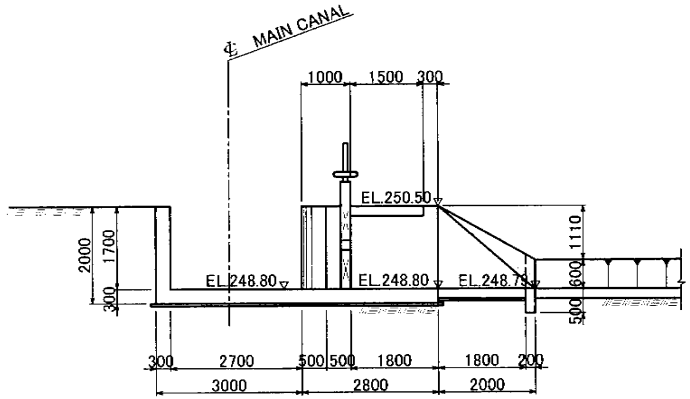
DWG-K : MAIN CANAL – PLAN OF TURNOUT



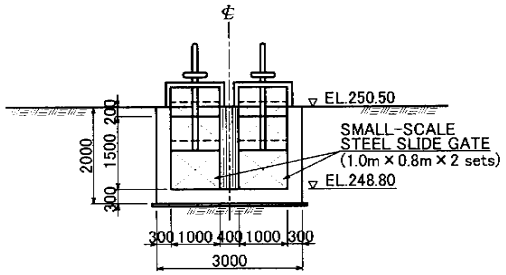
SECTION A-A



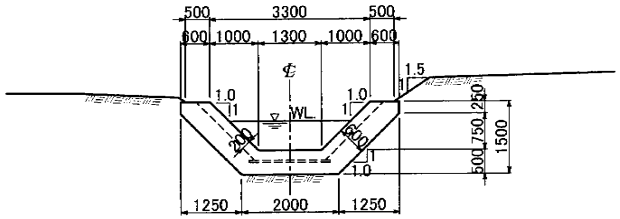
SECTION B-B



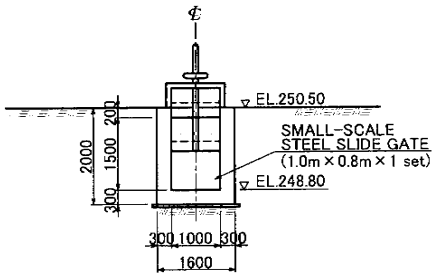
SECTION C-C



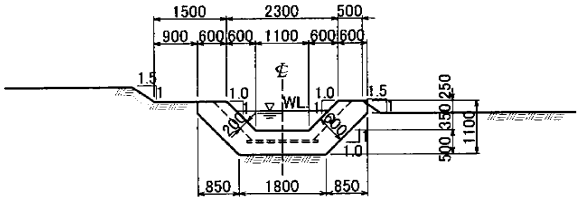
SECTION D-D



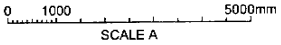
SECTION E-E



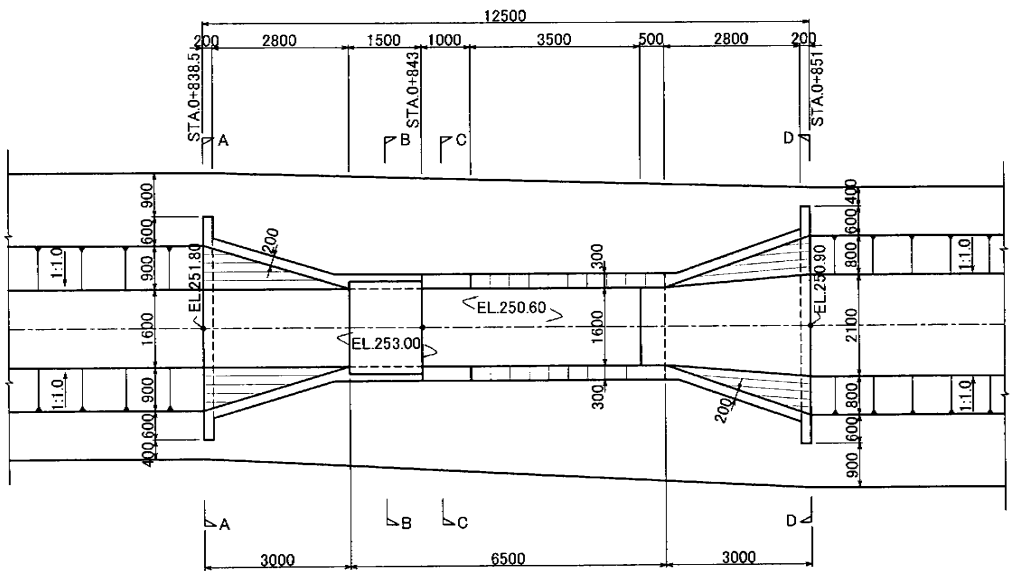
SECTION F-F



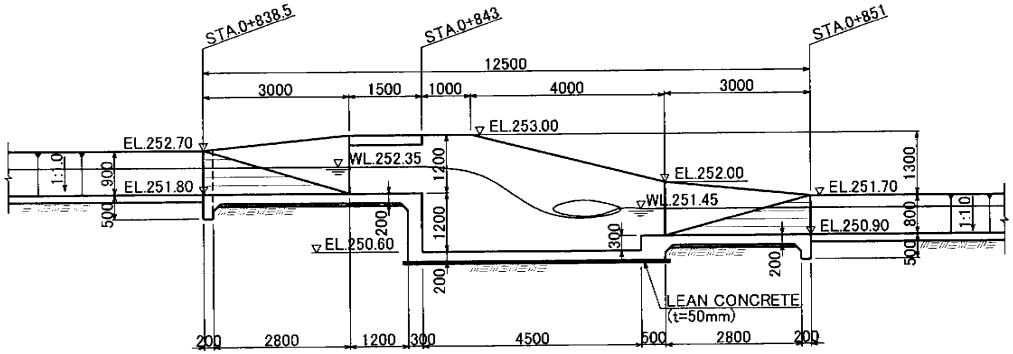
SECTION G-G



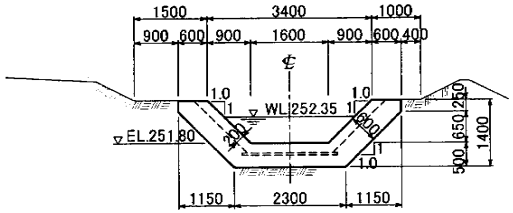
DWG-L : MAIN CANAL - STRUCTURAL SECTIONS OF TURNOUT



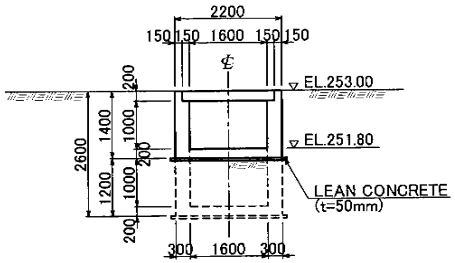
PLAN



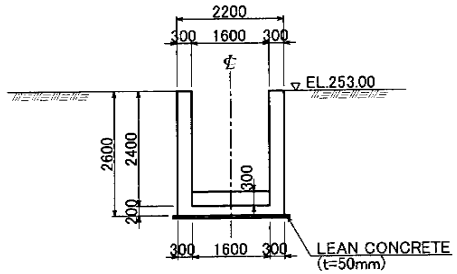
LONGITUDINAL PROFILE



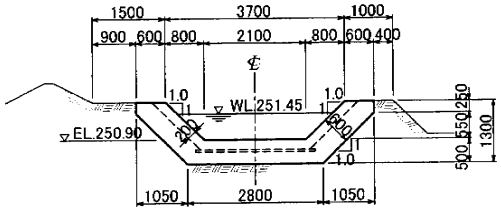
SECTION A-A



SECTION B-B



SECTION C-C

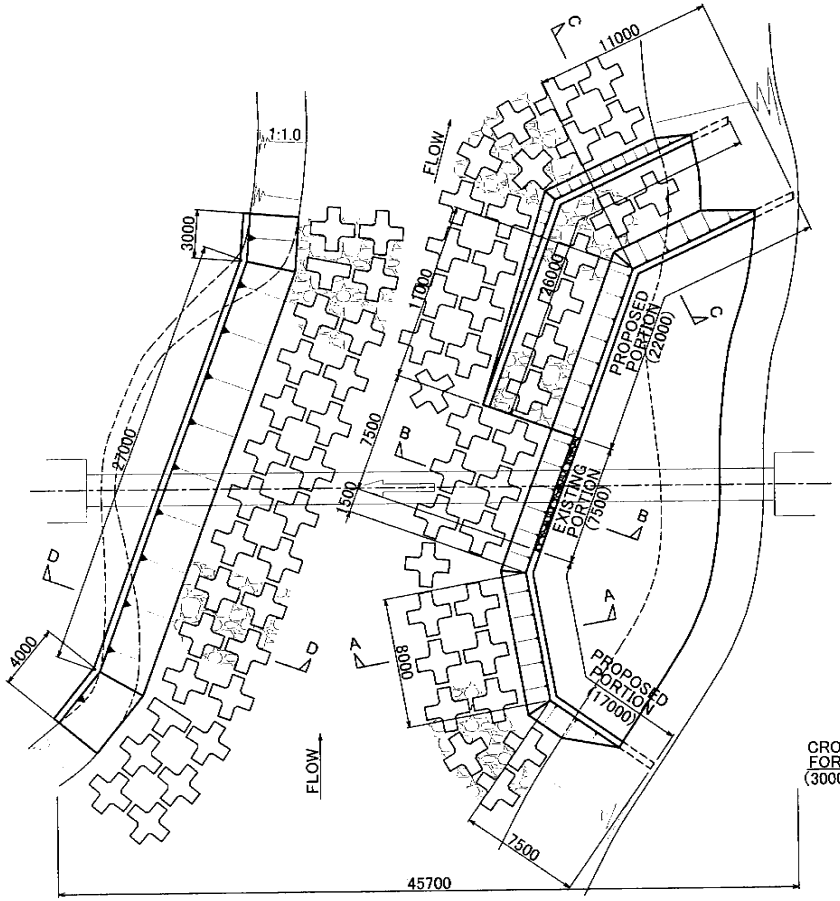


SECTION D-D

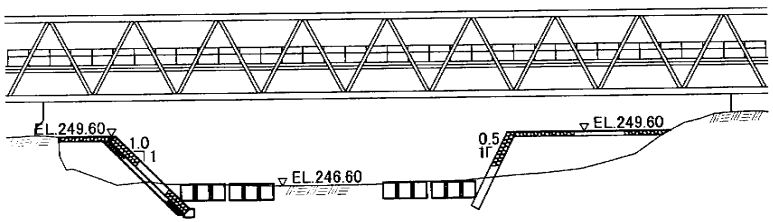
0 1000 5000mm

SCALE A

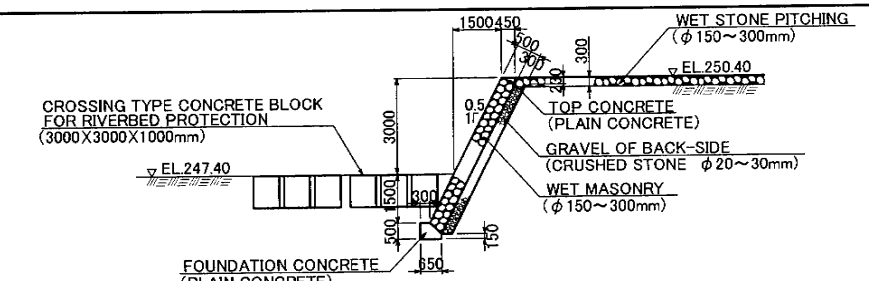
DWG-M : MAIN CANAL – STRUCTURAL SECTIONS OF DROP STRUCTURE



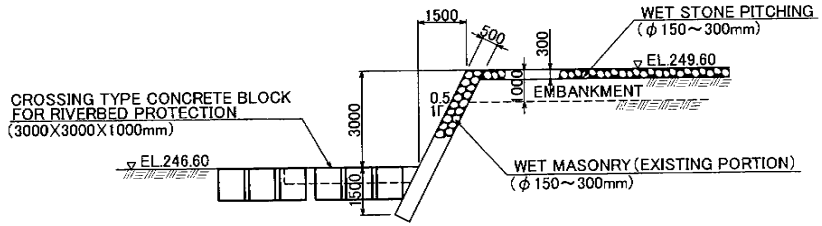
PLAN
SCALE A



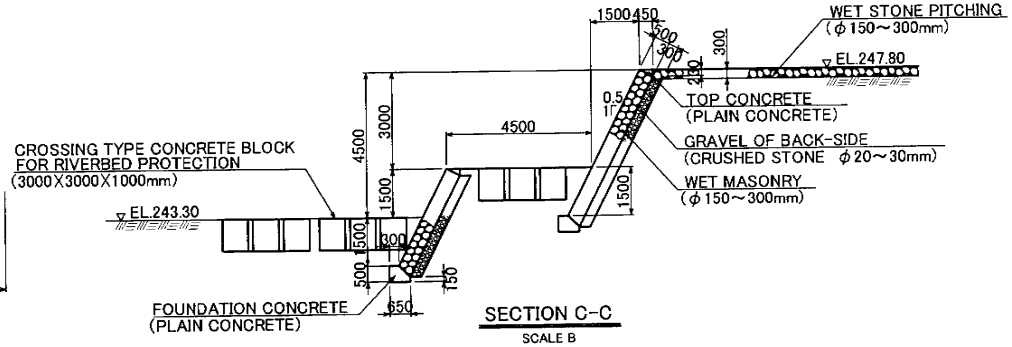
ELEVATION
SCALE A



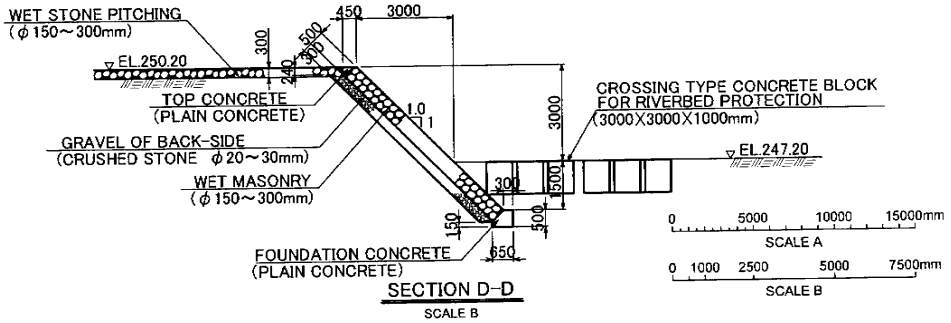
SECTION A-A
SCALE B



SECTION B-B
SCALE B



SECTION C-C
SCALE B

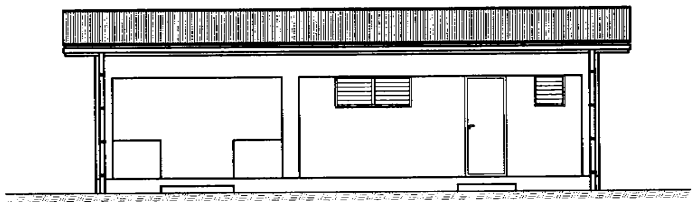


SECTION D-D
SCALE B

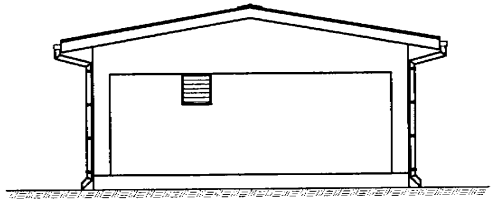
0 5000 10000 15000mm
SCALE A

0 1000 2500 5000 7500mm
SCALE B

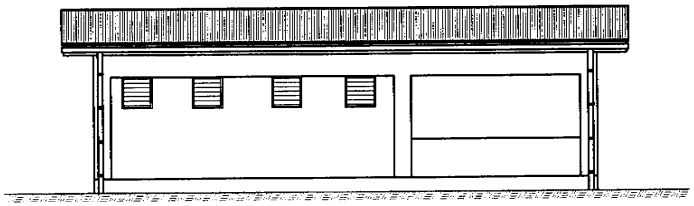
DWG-N : AQUEDUCT - STRUCTURAL SECTIONS OF WET MASONRY PROTECTION WALL



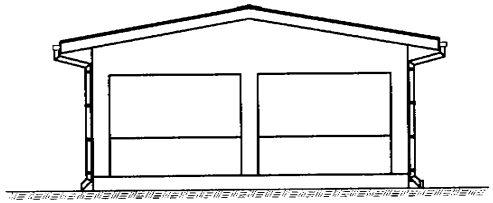
FRONT VIEW ELEVATION



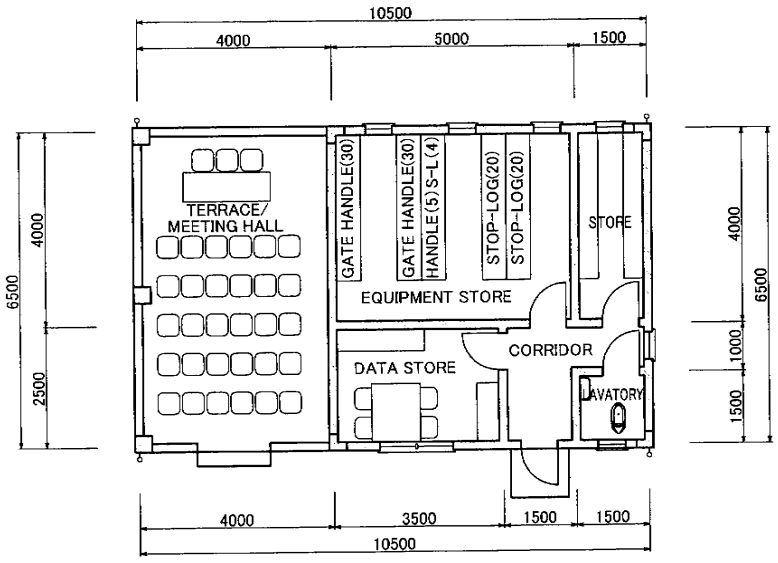
RIGHT SIDE VIEW ELEVATION



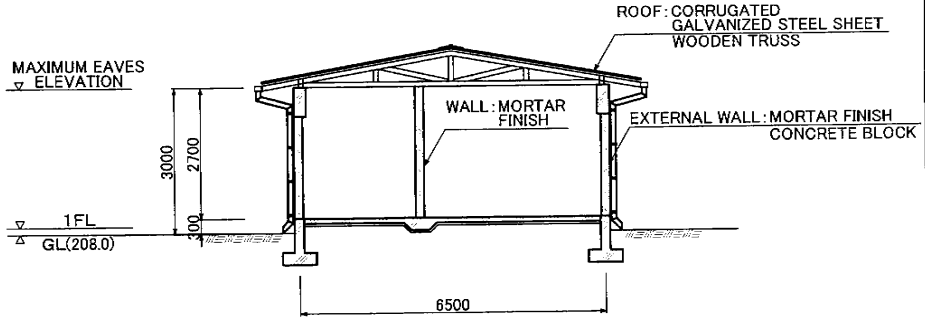
BACK VIEW ELEVATION



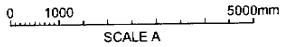
LEFT SIDE VIEW ELEVATION



PLAN



SECTION



DWG-O : STORAGE FOR O/M EQUIPMENT - STRUCTURAL SECTIONS

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The Project has objectives of rehabilitating irrigation facilities of Maliana I in Bobonaro district including intake and canals, as well of procuring and installing steel gates including scouring sluice of intake weir, intake gate, scouring gate of sediment settling basin, turnout gates and diversion at irrigation canals etc. MAFF is the responsible organization for project implementation, while Bobonaro District Agricultural Office takes charge of implementation at the site. Since the Project is an engineering constructing scheme, a lump sum and representative subcontract system shall be employed.

Construction equipment and materials such as construction machinery including steel gates shall be procured from Timor-Leste, Japan and a third country, Indonesia. Local constructors shall be employed in implementing civil works and gate installation, while Japanese engineers will be dispatched to take charge of schedule and quality control. Also, civil engineers, architectural engineers and those of machinery, electric facility and land survey will be dispatched from the third country.

2-2-4-2 Implementation Conditions

(1) Extraction of aggregate and stone materials for the Project

Prior to starting construction works, a permit from the government of Timor-Leste is required to extract gravel for concrete aggregate at riverbeds. The Ministry of Traffic and Common Public Works issues permission from the standpoint of flood control/river training and the Secretary of State for Environmental Coordination, Terrestrial Ordering and Physical Development (SSECTOPD), and Department of Forest and Water Resources of MAFF is in charge for the royalty of quarry. In addition, it needs to explain the gravel-extraction plan to nearby autonomous authorities and residents to ask for their consent to the plan.

(2) Compensation for standing trees and lands

The project needs to compensate for standing trees and lands for acquiring lands for temporary works and additional lands necessary for improvement design. Based on the basic design and detailed design studies, the Timor-Leste side must complete the necessary compensation and acquire necessary lands prior to construction works

(3) Interruption of supply for irrigation water and domestic water

In this project, due attention should be done to minimize disturbance of farming activities of Timor-Leste people in order to accomplish the project efficiently. However, the authority of Timor-Leste is required to coordinate all the stakeholders on the following matters; The supply of irrigation water is planned to terminate at the end of April. After the completion of construction works, water distribution is resumed from December. During the period from May to November water distribution for both irrigation and domestic use will completely be interrupted. It is therefore required for the authority to coordinate among all the stakeholders so that they can be prepared to do farming activities without water, and also they can manage to secure domestic water from other sources during this interrupted period.

(4) Procurement control of such equipment / materials as steel gates

With regard to procurement of steel gates to be installed at intake facilities and irrigation canals, the parts of gates are imported from Japan and they are msnufactured and assembled in such third countries as Indonesia. As the implementation of the Project is scheduled within a single dry season from May to October, procurement control is prerequisite so that construction machinery and equipment / materials can smoothly and properly be procured and delivered, taking particular importance on the installation of steel gates that affects the completion of construction works.

2-2-4-3 Scope of Works

(1) Demarcation of works

Table 2-48 shows the demarcation of works between Japan and Timor-Leste sides for the implementation of the Project.

Table 2-48 Demarcation of works for the Project implementation

Item	Japan side	Timor-Leste side
1) Construction of architectural facilities (Access roads, storage depot for equipment accommodation)	Site creation, access road construction, construction of storage depot for equipment accommodation, and gate keepers hut	To secure all lands required, including standing trees and land compensation. To provide furniture and appliances for architectural facilities
2) Improvement of irrigation infrastructure	Construction of irrigation infrastructure	ditto
3) Widening canals	Widening and improvement of canals	ditto
4) Maintenance roads built along with canals	Construction of maintenance roads	ditto
5) Construction work of the aqueduct-bridge bank protection	Construction of bank protection structures, construction & removal of temporary work yards and access roads	ditto
6) Temporary works (material depot, temporary building, temporary road, diversion canal)	Embankment, shaping and rehabilitation of lands required for temporary works. Construction and removal of material depot, temporary building, temporary road, diversion canal.	To secure all lands required (private lands, nationally-owned land) including standing trees and land compensation.
7) Temporary roads and work sites for canal improvement (along with both sides of canal)	Construction and rehabilitation of temporary roads and work sites	ditto
8) Gates, fences	Construction of gates and fences of architectural facilities	-
9) Proposed portion of tertiary canals	Basic plan and design	Construction of the proposed portion of tertiary canals
10) Irrigation water	-	During the interruption period of irrigation water delivery from the beginning of May to the end of November, take an alternative water delivery measures if /when necessary.
11) Water supply	Construction and removal of temporary water intake facilities (the water is construction purpose, and river water or groundwater is used.) Water supply system in architectural facilities	To take alternative measures to water cut-off due to construction work. Construction of water supply system to architectural facilities from outside water sources.
12) Electric supply	Installation and removal of construction-purpose private electric power generators. Electrical works in architectural facilities.	Electrical works to architectural facilities from an outside source.
13) Communication facilities / equipment	Installation and removal construction-purpose temporary communication facilities / equipment.	Installation of communication equipment in architectural facilities and communication lines to O&M facilities from outside
14) Sewarage systems	Sewarage systems in architectural facilities	Sewarage systems around architectural facilities and connection to public sewage systems
15) Bank account Opening and payment charge	-	AP advice charge. Payment charge
16) Import custom clearance of products	Air or sea transportation cost from Japan / the third country to an airport or seaport of Timor-Leste, and transport cost from the port of discharging to the project site.	Procedures of duty exemption at the port of discharging for products imported, and assistance for import custom clearance.
17) Duty and tax imposed on products and services	-	To exempt Japanese from duty and tax imposed on products and services
18) Proper use and O&M of facilities improved	-	Proper use and O&M of facilities improved by this grant aid.
19) Soft components plan	Dispatch of experts of gate operation for water control, and provision of materials and equipment necessary for instruction.	Establishment and management of WUAs, IWMD WUA advisors, people in charge of WUAs, DIO staff, marino & gate operators (2), cadres of WUA (4) and other applicants

(2) Procurement plan of materials and equipment

The demarcation of procurement is shown in Table 2-49.

Table 2-49 Demarcation of procurement

Item	Demarcation			Basis of demarcation	Remarks
	Timor -Leste	Japan	Third country		
1. Materials for construction					
1) Steel members (H-section steel, angle, etc)		○		Cost & quality	
2) Reinforcing bars*			○	Cost & quality	Indonesia
3) Cement			○	Cost & quality	Indonesia
4) Fine aggregate &coarse aggregate	○			Cost & quality	
5) Admixture	○			Cost & quality	
6) Stone	○			Cost & quality	
7) Wood / timbers	○			Cost & quality	
8) Plywood			○	Cost & quality	Indonesia
9) Steel scaffold & scaffold board		○		Small quantity	
10) Materials for form		○		Small quantity	
11) Brick	○			Cost & quality	
12) Steel grating cover & handrail			○	Cost & quality	Indonesia
13) Water stop & joint filler		○		Small quantity	
14) Glass tile & wooden door	○			Cost & quality	
15) Steel door & aluminum sliding door			○	Unprocurable in Timor-Leste	Indonesia
16) Materials for interior works & waterproof material of roof	○			Cost & quality	
17) Electric cables & pipes for water supply	○			Cost & quality	
18) Gasoline, diesel oil and oil	○			Cost & quality	
19) Steel gates (headworks, scouring sluice)			○	Cost & quality	Parts made in Japan, assembled in Indonesia.
20) Steel gates (turnouts, diversion facilities)			○	Cost & quality	
2. Construction machinery					
1) Heavy machinery for excavation and loading	○			Short-term use	Rented at/near the construction site
2) Trucks / dump trucks	○			Short-term use	
3) Passenger vehicles & 4x4 vehicles	○			Short-term use	
4) Cranes, etc	○			Short-term use	
5) Compactors and rollers (embankment / pavement)	○			Short-term use	
6) Concrete plant	○			Short-term use	Rented at/near the construction site, 15m^3/h
7) Concrete mixer truck (3~4.5m^3)	○			Short-term use	Rented at/near the construction site
8) Concrete vibrator	○			Short-term use	
9) Concrete breaker	○			Short-term use	
10) Water pump (diameter: 100 and 200mm)		○		Unprocurable in Timor-Leste	
11) Generator (45 to 150 KVA)		○		Unprocurable in Timor-Leste	
12) Generator (2 or 5 KVA)		○		Unprocurable in Timor-Leste	
13) Reinforcing bar cutters and benders	○			Short-term use	Rented at/near the construction site

Remarks) *The quality standards of procurable Indonesia-made reinforcing bars are ASTM40[300] and ASTM60[420], which are equivalent to SD295 and SD390 of Japanese standards.

2-2-4-4 Consultant Supervision

(1) Terms of references of consultants, personnel plan

① Personnel plan for design and construction control

The Terms of References of consultants in the stage of implementation design are given as follows: The planned personnel consists of 8 staff including a chief engineer who summarizes overall multi-disciplinary designs, two(2) engineers in charge of hydraulic structures / detailed design (D/D), an engineer in charge of machinery maintenance, an architectural engineer, an engineer in charge of estimation and procurements, an engineer in charge of tender documents and a cartographer in charge of detailed drawings.

1) Site survey required for D/D and detailed design,
2) Review and revision of estimates performed in the Basic design, and
3) Provision of detailed drawings and tender documents, etc.

② Construction control

The services by consultants in construction control include the below-listed items. In this supervising system, a construction controller is responsible for overall supervision, and he appoints a permanent controller in charge of the overall construction management throughout the implementing period. Besides, he also appoints those who supervise on particular spots, an engineer for machinery installation who inspects installation and adjustment tests of gates and an inspector who witness the completion inspection at the completion of the construction works. These 4 engineers are dispatched from Japan. In addition, as supporting personnel to the above-mentioned consultants, it is planned to dispatch 2 assistant engineers from the third countries.

1) Deputized actions for bidding procedures, witness to bidding evaluation and contract negotiations, consultations with the implementor,
2) Approval of implementation drawings and provision of standard specifications of gates,
3) Management of schedule, quality and safety during construction works,
4) Inspection of installation of steel gates, and
5) Inspections of completed work items, on the completion of contracted works, on defects warranting etc.

(2) Plan and system of construction supervision

The construction work is designed to accomplish planned improvement of existing irrigation infrastructure within a single dry period, by fully mobilizing construction machinery, materials and equipment. Installation of steel gates procured from outside Timor-Leste is critical and implemented under careful supervision, work progress control and quality control.

In this connection, the project establishes a site management office and a dormitory in Maliana town or near the site to administer the overall rehabilitation works, procuring the existing private house on a rental basis in order to smoothly establish an implementation system for a short-period completion. Also, the project has a liaison office functioning liaison and coordination between each of rehabilitation sites and the parties concerned in Dili including related government offices of Timor-Leste, responsible offices of implementation, permanent

representative office of JICA in Timor-Leste and Embassy of Japan, as well for procurement of equipment and materials in Dili.

(3) Plan of security control

The Bobonaro district area where Maliana town lies is adjacent to Indonesia, and the area between highway and the international border to Indonesia is forbidden to enter in the vicinity of Bolobo town. The public security is good and stable because UN Peace Keeping Forces (PKF) has been stationed in the north of Maliana town and UN and Timor-Leste police forces are deployed in the town. Cell phones will be prepared to secure the emergency communication means. As a route for retreating, a national highway is available, going to southward to reach Suai town, or to northward to reach the capital, Dili city. As for medical care, there is a hospital with four English-speaking doctors (Timor-Lesteese and Russian) for medical treatment for non-serious diseases or injury. In the case of serious sickness, it can be treated in a hospital in Dili city or the patients can be sent by air to Darwin, Australia, or Singapore for cutting-edge medical treatment.

2-2-4-5 Quality Control Plan

Quality control of construction materials such as concrete shall be performed in a laboratory built in near the construction site, where hired local or third-country civil engineers plus local staff are stationed for conducting tests. Local or third-country civil engineers in charge of construction works are stationed in each site for checking product quality and dimensions, while Japanese engineers in charge of overall work progress and quality control are staffed to each engineering block as shown in Table 3-50.

Table 3-50 Contents of quality control

Type of work	Item	Methodology
1. Cutting and filling	Slope gradient, degree of compaction	Naked eye inspection, measurement of size, height etc., tests on particle size distribution, site consolidation
2. Concrete	Materials (stones and aggregates)	Particle size tests, measurement of specific gravity
	Cement	Inspection on quality guaranteeing documents
	Concrete filling	Slump, air content, water / cement ratio
	Strength of concrete	Methods of curing, compression strength test, crack
3. Works with form	Location of installing forms	Location of fixing, location identification method
4. Reinforcing works	Strength of reinforcing bar, distribution	Stretching strength, inspection on distribution of bars
5. Wet masonry	Stone materials, mortar	Size of quarry materials, mixing proportion of sand/ cement
6. Installing steel-gates	Accuracy of installation, functions	Measurement of installed position, operational tests
7. Finished structures	Size of completed structures	Measurement of completed structure's size, photographing
8. Environment	Environment management plan (EMP)	Check on the observance of EMP

2-2-4-6 Procurement Plan

Considering the significance of quality and durability, manufacturers in the third countries will design steel gates based on the basic design provided by the consultant, will procure parts of steel gates from Japan and assemble them. Likewise, such equipment and materials that would be difficult to procure in Timor-Leste or in the third countries as shape steel, scaffold materials and water stop will be procured in Japan. As to the procurement of construction machinery, those that are available in Timor-Leste on rental basis such as transport, carriage vehicles, cranes and concrete agitator trucks will be procured in Timor-Leste except for time-consuming machinery for procurement such as submersible pumps and generators.

2-2-4-7 Implementation Schedule

Major construction work involving headworks in the Bulobo River and canals is scheduled to implement during dry season ranging May to November to stop irrigation water, during which construction resources will concentrated so that efficient rehabilitation of the intake weir and canal structures can be completed (see next page 2-87, Figure 2-13 Project implementation schedule).

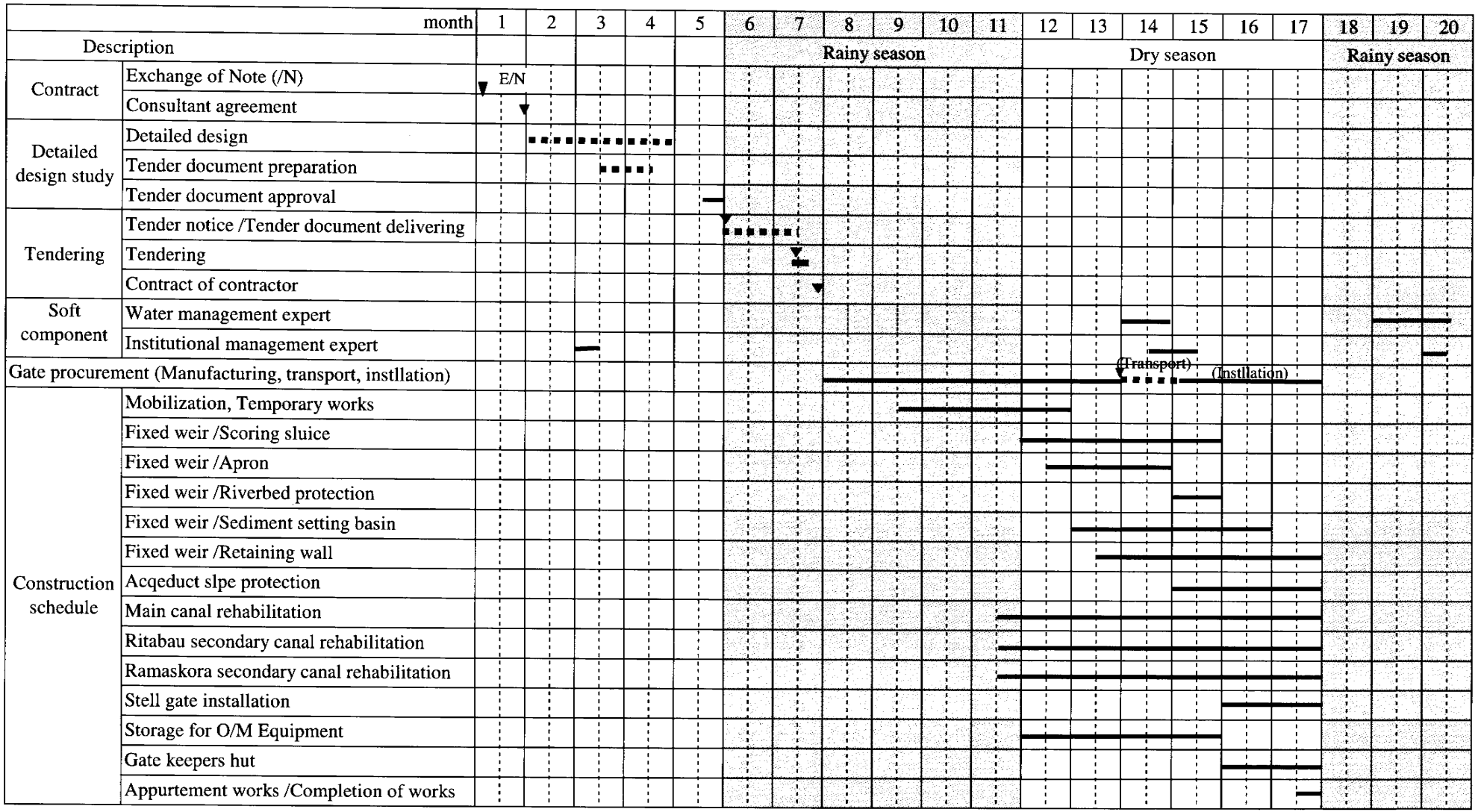


Figure 2-13 Project implementation schedule

2-3 Obligations of the Government of Timor-Leste

(1) Land acquisition and compensation for the Project

As the land acquisition should be promoted with the prior decision on the clearance of the procedure by Timor-Leste before the implementation of this project, the following procedure shall be asked through MAFF for land acquisition to be taken by implementing agency.

1) To establish a coordinated organization consisting of the representatives from beneficiary farmers in the area concerned, MAFF, agencies related to the land acquisition / expropriation and regional agencies concerned (district and sub-district).
2) To confirm the pursuance of the basic agreement between the implementating agency and the representatives of residents obtained during the Basic Design Study, then to secure the land acquisition with the final confirmation by individual agreement to be valid between the implementation agency and the individual land users/owners during the Detailed Design Study.
3) As for the expense for land acquisition (by compensation), it will be planned to clearly design and define the borders of acquired areas and sizes and to clarify the incidence of compensation on land acquisition maps (location, area, etc) on the completion of Detailed design study in order to facilitate compensation measures for the losses / damages of lands and crops.

Moreover, it will be requested that Timor-Leste should pay attention to the following in acquiring land for the works of the Project;

1) In case of felling trees and deforestation, compensation should be done for losses incurred, including the cost for planting /tending incurred so far and expected future profits.
2) As for the road expantion, the design like alternative sectional shape of road should be considered in order not to affect the residential areas. In case of construction of the work yards such as temporary road facilities, etc. on the land other than public property, a necessary rent must be appropriated.

For costs borne by the Government of Timor-Leste on land acquisition for project implementation, the following forms of expenses for compensation are anticipated.

1) Compensation for the land acquisition and the felling of existing trees for widening of irrigation canals,
2) Fees for land rental for temporary work yard of temporary canal works for intake weir and temporary roads,
3) Fees for land rental for temporary work yard of protection wall works for aqueduct and temporary roads,
4) Costs of land compensation concerning the lands for constructing architectural facilities including storage depot for accommodating equipment, gatekeeper's hut and access roads and
5) Construction costs for newly introduced tertiary canals (actual expense does not occur because real works are covered by contributed labor by the beneficiary volunteers) etc.

(2) Considerations for land acquisition

According to the information from local authorities and communities around the site as well as the examples from

other implemented projects, the following issues should be considered for land acquisition:

1) Though the basic agreements of the land use have been obtained at the workshops held during the field survey for Basic design study, it is essential that the Government of Timor-Leste should confirm the details of land use and compensation, and complete the procedures to be cleared before the project implementation, according to the designed plan on compensation for possible losses of agricultural crops and deforestation,

2) Offices responsible for the Project hsould enlighten the beneficiaries in the site by telling them that the Project would bring the direct benefits to them, and to smoothly discuss so that they can enter into the agreements, transfer of the land acquired/expropriated and compensating the losses of beneficiary residents, representatives, land-users /owners in the sites in cooperation with the central government agencies and rural authorities.

3) They should make efforts to increase the employment opportunities within the beneficiaries and in realizing land acquisition in a smoother way.

(3) Permission for the collection of river stone materials

In order to obtain the permission of collecting river stone materials and royalty exemption, the implementating agency should clear the following procedures, referring to the procedures of the past and on-going irrigation projects.

1) To obtain the permission from concerning agencies for collection of river stone materials,
2) To obtain the permission from the Ministry of Traffic and Common Public Works (MTCPW) on the aspect of river training/protection,
3) To obtain the permission from the Department in charge of Environmental Assessment of Public Development (SSECTOPD) with regard to environment,
4) To obtain the right of quarry works from of Forestry and Water Resources Department of MAFF, and
5) To explain the project details to the municipalities and communities in and around the site, and to obtain their consents.

2-4 Project Operation Plan

2-4-1 Operation and Maintenance System and Staffing

In the Project, MAFF plans to provide subsidies to the operation and maintenance as per the "Policy for WUA and O/M of irrigation facilities (draft)". However, actual operation and maintenance of irrigation facilities will be handed over to WUA to be organized. In this transfer, MAFF provides training and monitoring on fortification of managing WUA and O/M of the transferred facilities through Bobonaro office of IWMD and district administration office. The assumed O/M system and staffing is presented in Figure 2-14.

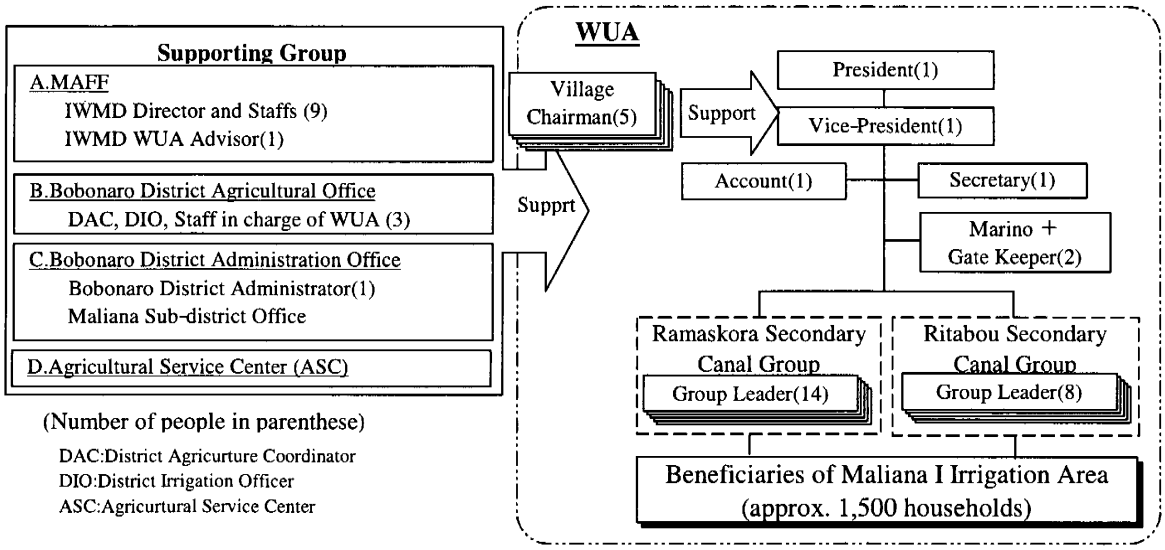


Figure 2-14 Operation and maintenance system and staff arrangement

2-4-2 Contents of Operation and Maintenance Works

The operation and maintenance consists of operation of WUA, instruction and monitoring of cadres on the use of intake facilities, water management and gate operation for WUA and gatekeepers by MAFF, diversion works, O/M of gates, repairing of facilities, dredging of canals etc. by beneficiary farmers and group leaders, as tabulated in Table 2-51.

Table 2-51 Contents of O/M works

Item	Content of practices	Demarcation
A. Operation of WUA	4 managerial cadres are responsible for the operation of WUA	Beneficiary
B. Instructions / monitoring of water management and gate operation	DIO and O/M coordinators under MAFF will give training and monitoring on the use of facilities for the initial 10 years.	MAFF
C. Diversion practices at intake facilities, main canal and secondary ones	2 gatekeepers and 22 group leaders practice the operation of gates at intake facilities and canal diversion gates	Beneficiary
D. O/M of gates (Intake facilities: 8 leafs of gates) (diversion works: 65 leafs of gates)	1) lubricant injection: lubrication with grease is made once a year at gate spindles (axis of rolling up the gates)	Beneficiary
	2) recoating painting: gates are repainted for recoating once in 7 years but gates are grouped into 3 years term	Beneficiary
	3) water-sealing rubber: water sealing rubber is exchanged once in 15 years but gates are grouped into 3-year-term groups	Beneficiary
E. Facility Compensation cost (riprap works, bank protection and slope surface of banks)	Intake facilities, riprap floor at aqueduct, masonry bank protection retaining wall and masonry coated slope of main / secondary canals are checked once a year and repairings are made whenever necessary parts are found	Beneficiary
F. Routine works for O/M	Sediment evacuation works in sediment settling basin, canal dredging works, sediment removal from intake, weeding in canals are done in routine works	Beneficiary (labor portion)