5-3-4. Topography, Geology and Construction Material

a) Topography

i) General

Bohol island, which is located in the Central Visayas, covers an area of 3,932 km^2. It is bounded on the north by the Camotes Sea, and on the south by the Mindanao Sea.

Bohol is a broad southward plunging syncline with the major axis trending northeast-southwest. At the northern, central and southern portion of the island, undulating to high rolling sedimentary and calcareous hills and plains cover approximately 70 percent of the island.

The famous chocolate hills in Carmen, karst plain in Cortez, high rolling hills and ridges in Sevilla, Anda Peninsula, Sanguangan Mountain, and undulating sedimentary rocks from Buenavista to San Miguel are some of the formation that dominates the lithologic units. Extensive conglomerate occurs at Tubigon, pure limestone in Balilihane, limy shale in Batuan. Limstone of different ages exhibits karstic topography and are sometimes structurally arranged by NE-SW faults. Sierra Bullones limestone at Mount Mayana reached a height of 827 meters. Low rolling diorite, metamorphic, and ultrabasic hills are sometimes associated with high and steep volcanic hills, covering approximately 25 percent of the island, which are exposed in the northeastern and northwestern part of the island. Agglomerate rises as a plateau at the central part of the island.

Southwest of Ubay, gently rolling hills consisting of diorite and andesite are overlain by the steep Malibalibod hill. The damsite and the irrigation area in this project

area are constituted sediment rock originating from surrounding volcanic rock, and have formed lower rolling hills.

ii) Topography of the project area

The proposed Capayas dam site is located about 6km southwest of Ubay Poblacion in the northern part of Bohol island. The topography of the project area is characterized by low rolling to hilly surface undulation, which itself is characterized by extensive sequence of sedimentary formation mainly siltstone, mudstone, sandstone and conglomerate. The boundary of the area is well defined by a sudden change of low to high topography, which consists of volcanic or sedimentary rocks.

Capayas dam is planned in low and gently rolling hills (EL 35 - 25m) having a dip to the north, and this area is surrounded by mountain with an elevation of less than 100m. The slope of abutment is approximately 1: 20. The topography of the damsite is formed by Bayang river.

Bayang river obtains water from Mount Malibalibod (EL=425m) in the vicinity of the southeastern part of the damsite. The catchment area of 13.1 km^2 is surrounded by volcanic hills. The river traverses from the damsite toward northwest and joins the Soon river at about 5.5 km. The river then runs about 7.7km, and flows into The Camotes sea in the vicinity of Mandawa.

b) Geology

i) General

Bohol province consists of igneous rock on the eastern and western portion of the island with a vast expansion of

sedimentary rock in the center called the Carmen formation, a very extensive well-bedded sequence of sandstone, shale, mudstone/siltstone. Common material of these features are volcanic rocks accumulated from the weathering of surrounding country rocks. Intrusive and extrusive igneous rocks represent about 30 percent of the rock types in the province, particularly in the northeastern part of the island. Uplifted reef limestone facies of considerable height later fringed the core of mainland Bohol. Sedimentary rocks occupy almost 70 percent of the island. There are 7 sedimentary formations and 5 volcanic hills.

Sedimentary rocks are calape limestone (Cl), Ilihan shale (Is), Wahing Formation (Wf), Carmen Formation (Cf), Sierra Bullone limestone (Sbl), Maribjoc Formation (Mf) and Alluvium (Al).

Volcanic rocks are Alicia Schist (As), Ubay volucanics (Ub), Boctol Serpentinite (Bs), Talibon Diorite, and Jetafe Porphyry (Td).

A comparison of the geologic age and geological map of the area is shown in Figure A-5-6 in the Appendix.

ii) Geology of project area

The project area was totally overlain by Carmen Formation (CF), an inter-bed of sedimentary clastics, chiefly sandstone, shale and siltstone. The clastic materials that constitute the sequence are primarily volcanic in nature originating from igneous flanks of the surrounding volcanic rocks. The beddings of sedimentary rock on the project area are almost flat lying (Dip and Strike is N10° E 20° NW) to sub-horizontally stratified. Sandstone bedding is medium-grained and moderately undulated grayish to light gray in color. Shale and siltstone beddings are grayish in color, fine-grained relatively friable and brittle when dry, very

soft when wet and susceptible to weathering when exposed to surface condition. Water enhances the slaking property of these materials.

Outcrops are observed on river bank, however, soil mantle blankets the whole area covering the underlying formation. Soil type is predominantly clay to silty clay with admixture of uncomplete weathered materials with an average thickness of 2 to 3 meters. Soil in the project area is a prevalent product of in-situ weathering of the underlying formation.

Andesite and diorite are distributed upstream of the damsite, and are called Ubay volcanics and Tolibon diorite. Fresh rock is outcropped in the river and creek bed. But the ground surface should be gravel clay or clay.

A geological map of the damsite and reservoir area is shown in Figure A-5-7 in the Appendix.

c) Boring Investigation

Site investigations were carried out at a total of 6 boreholes, 3 boreholes during the feasibility study of Phase II (1985), 3 boreholes in the basic design stage in 1989.

CDH-1 (L=18m)	Left abutment :	Examination of bearing and water permeability in the dam-base and decision of cut-off depth.
CDH-2 (L=30m)	right abutment :	"
CDH-3 (L=15m)	right abutment :	"
CDH-4 (L=30m)	spillway:	Examination of bearing and water permeability in the structure, and decision of cut-off depth.
CDH-5 (L=40m)	left abutment :	Examination of bearing and water permeability in the dambase, and decision of cut-off depth.
CDH-6 (L=30m)	spillway:	Examination of bearing and water permeability in the structure, and decision of cut-off depth.

A location map of the damsite and the reservoir is shown in Figure A-5-7, and the geological profile of the dam axis is shown in the Drawing.

i) Core Boring

The borehole loggings are shown in Figure A-5-8 in the Appendix.

According to the result of boring investigation along the dam axis, the dam foundation is mainly composed of soft sedimentary rocks consisting of interbedded siltstone, mudstone, sandstone, and conglomerate. The dip and strike of the outcrop at the riverbed is N 10° E 20° NW. The base rock along the dam axis is considered to incline toward the right abutment gently, and the conglomerate in the riverbed and CDH-3 (13 to 15m) is the same layer. The overburden or weathered layer to be removed in the dam construction is a thin layer 4 to 6 m below the ground surface. The foundation of the damsite can give more than 70% cost-recovery, though as R.Q.D is 0 to 90%.

The weathered rock layer corresponds with the D to CL class, but CL to CM class consist of trash and agglomerate.

The base rock forming the foundation of the dam body is almost fresh and massive, even if it is one of soft rocks with assumed unconfined compression strength of less than 100 kg/cm^2. The foundation rock mentioned above presents no problem when a fill-type dam is constructed. From engineering point of view, this foundation rock has enough capacity to construct a dam with height of 20 m.

ii) Standard Penetration Test

Standard penetration tests are carried out in CDH-4 CDH-6, where the incidental structure stands on the spillway.

According to the result of the penetration test, the overburden and weathered layer of about two meters has an N-value of less than 50, but the layer of D to CL class has an N-value of more than 50. Since the cut-off line is 4 to 6 m below the surface, it was confirmed that the foundation rock has a good bearing capacity.

iii) Permeability Test

Permeability tests are carried out at all boreholes to confirm the water permeability. According to the results of CDH-2, 4, and 6, the permeability in 9 to 10 m depths is less than 10 Lugeon value. But the other boreholes (CDH-1, 3, 5) indicate more than 10 Lugeon Vale. These results suggest that water will leak from the packer and then from the gravelly clay and weather rock. Fresh rock indicates an impervious layer with the same result as in CDH-2, 4, 6. Water permeability of the depths layer presents no problems, because the layer of this area dips to downstream. But as the surface of base rock is semi-pervious to pervious, foundation treatment will be necessary.

d) Test Pit Investigation

Test pit investigations were conducted at the dam abutment and reservoir area. The location of test pits is shown in Figure A-5-6, and the test pit loggings are shown in Figure A-5-7 in the Appendix.

According to the result of the test pits, sedimentary rocks are also distributed in the reservoir area similar to the damsite. The overburden has a 0.3 to 0.5 m layer and extremely weathered rock has about 2 m layer. The deeper rock changes into consolidation rock with moderately to slightly weathering.

e) Investigation Material

The location of the borrow area and the quarry site is shown in Figure A-5-9, and the investigation materials are listed in Table A-5-11 in the Appendix.

i) Earth Material

The earth material will be obtained mainly from the borrow area in the reservoir. The material is mainly composed of sand clay and silt containing moderately to extremely weathered fragment and gravel. The material which ranges from 1 - 2 m in thickness is extensively distributed in this area. The earth material is about 700,000 m^3, which is sufficient to construct a dam.

ii) Filter and Concrete Aggregate

Ilay river, Kinanoan river and Hinlayaban river were selected as proposed quarry sites under Phase II F/S study. Based on the result of the reexamination, aggregate from those rivers cannot be gathered due to other on-going dam construction and poor quality and quantity of aggregates for Capayas dam. Therefore, Guinsularan river is proposed as the aggregate site.

iii) Riprap and Rock Material

Dagohoy quarry was planned for riprap and rock material during F/S of Phase II. However, the Forest Bureau prohibits quarrying in order to prevent environmental destruction of the forest. Therefore (1) Hill upstream of the damsite (2) Capayas

upstream (Lumangog) (3) Ilaya river (4) Nagasnas Hill (5) Abihilan were investigated. There are two prospective quarries, one is basaltic rock in Nagasnas Hill, and the other is andesitic rock in Lumangog of Capayas upsteam. However, there is no road to Lumangog, therefore, Nagasnas Hill located 10 km from the damsite, would be the most suitable for the quarry.

iv) Material

Capayas quarry will be used in producing road material. Capayas Quarry located upstream of the damsite had been used for national roads.

f) Result of Laboratory Tests

Laboratory tests for earth material, filter and concrete, aggregate, rock material and road material (in 1985 and 1989) show the following results:

i) Earth Material

(1) Physical properties

. Classification: SC, CH, MH, ML
. Specific Gravity (Gs): 2.52 to 2.76
. Natural Moisture Content (WN): 19.0 to 33.2 %
. Consistency: plastic index (IP) is 10 - 45.7
. Gradation: CH and MH constitutes 49 to 92 % of the silt and clay. Sc constitutes 38%.

LIST OF CONSTRUCTION MATERIALS FOR CAPAYAS DAM

Class of Materials	Location Sources	Volume	Geology	Hauling Distance	Laboratory Test
Embankment Materials (Impervious)	Damsite & Reservoir Area	Enough	Clay/Silty Clay Gravelly Clay	In Site	Laboratory Soil Test(1985) (1989)
Embankment M.(Rock)	Nagasnas Hill	Enough	Basalt	10km	Not Tested
	Lumangog	"	Andsite	3.5km	"
	Capayas River Bed	"	"	1 - 2km	
	Ilaya(Malingin) River	"	"	8km	"
	Abihilan	"	Basalt	22km	"
Sand & Gravel	Guinsularan River	Enough	Aluvial Deposit	40km	Rock Test(1985)
	Capayas River	"	"	1.5km	Gradation Test (1989,NIA)
	Kinanoan River	Not Enough	"	29km	Rock Test(1985)
	Hinlayagan River	"	"	32km	"
	Ilaya(Maringin) River	"	"	8km	Not Tested
Embankment M.Rord Surfacing	Capayas Quarry	Enough	Diorite/ Soil	In Site	Rock Test(1985)

(2) Mechanical Properties of Soil

. Compaction: The maximum dry density(dmax) ranges from 1.50 to 1.99 g/cm^3. It is comparatively high.
The optimum moisture content (Wopt) ranges from 14.5 to 22.8 %

. Shearing Strength: UU C = 7.8 to 19.5 t/m^2, o = 7.5 to 18
CU C'= 3.9 to 8.0 t/m^2, o = 15 to 19

. Permeability: K = 7.1 x 10^{-6} to 9.4 x 10^{-7}cm/sec

. Consolidation: Cc = 0.23 to 0.084

According to the results of laboratory tests, this material is available for the impervious material. But the earth material in the borrow area shows a rather high moisture content. The material itself belongs to class CH and MH and consists of fine clay and silt, therefore, the dam embankment should be made by using the earth material mixed with weathered rock and gravel. This material should be well controlled during the dam embankment.

ii) Filter and Concrete Aggregate

The result of the laboratory test of filter and concrete aggregate in Guinsularan river is summarized as follow:

. Specific Gravity (Gs): more than 2.36

. Gradation: Silt and clay content are less than 1 %

. Soundness: The corrected loss is 38.65 %

These materials are presently used for concrete aggregate in Bohol island. Its gradation shows a good distribution curve suitable for filter and concrete aggregate material, although the percentage of loss is slightly high.

iii) Rock Material

A laboratory test of rock material had not been carried out for Nagasnas Hill. The results for andesitic Dagohoy quarry described in the table refer to basaltic Nagasnas Hill. Fresh basaltic rock outcropped in Nagasnas Hill is similar to andesitic rock in Dagohoy Quarry.

iv) Road Material

The result of the laboratory test at Capayas Quarry is summarized as follows:

. Specific Gravity (Gs): more than 2.67
. Gradation: Gravel is 67 % and sand silt and clay is 33 %
. Soundness: The corrected loss is 46.21 %.

Capayas quarry is located upstream of the damsite. The materials found in this quarry can be used as road material, although percentage of loss is high.

5-3-5. Dam design

The basic dimensions and conditions for the design of Capayas Dam are described in section 5-2. Accordingly the basic design of the dam and appurtenant structures is as follows:

a) Location of Dam

Capayas dam is located in Barangays Bayang and Lumangog, Ubay Municipalities, District II, Bohol Province, Region VII and at the point of the national road bridge over the river Bayang between these barangays.

Capayas dam, which is also located in BIDP Phase II area, is the most suitable location for the regulating reservoir because it is slightly lower than the Bayongan damsite (the main reservoir of Phase II), and slightly higher than the beneficial area of Ubay. Furthermore Capayas dam has its own catchment area of 14.6 sq.km.

b) Layout of Dam

As shown in the Basic Design Drawing, salients features on the layout of Capayas Dam are as follows:

i) The dam axis is set at a distance of 26 m from the center of Bayang bridge parallel to the national road. The existing national road functions as the downstream toe of the dam. The length of the dam is 1,160 m.

The embankment of the national road has been well compacted by the traffic over the years, and there are no dobuts regarding the structural aspect. And due to the interceptor (filter zone) between the dam body and the road embankment, the seepage aspect is also not affected.

ii) For the standard cross-section of the dam, the simplest homogeneous type of earthfill dam is adopted. This type is only suitable for dams which are somewhat low and long.

It consists of the impervious zone being shielded by the upstream stone layer (riprap) with a thickness of one meter and the inclined interceptor (filter) with a thickness of two meters. The height of the dam on the maximum cross-section is 18 m. According to the recent investigation, the height of the dam was 17 m during BIDP Phase II feasibility study but was increased due to the high depth of the cutoff-trench in the Bayang river bed.

The stability analysis of Capayas dam is summarized in para. c) below.

iii) As for the foundation treatment, the cutoff-trench with a base width of five meters extending to the firm rock formation will be prepared along on the dam axis. Cement grouting has not been prepared as mentioned above.

iv) The spillway will be located from the left bank of the damsite to the downstream area of the Bayang. The type of the inflow section is a normal overflow type- the chute section is a side channel type, the downstream section is a ski-jump type, and the bridge for the national road will be located between the inflow section and the chute section.

At the inflow section there will be no gate in order to establish a free over-flow so that flood water will be released.

The hydromechanical condition of the spillway is summarized in para. d) below.

v) The intake facility, which functions as diversion conduit, will be located just crossing the dam axis at the lower portion of the left side of the Bayang. However, the irrigible area extends to the right side of the downstream area so that water released on the left side will be conveyed to the right side. For this purpose the side bank on the national road at the downstream toe of the dam could be used because its elevation is almost the same as that of the canal.

The hydromechanical condition of the intake is summarized in para. e) below.

vi) Although the river diversion is a temporary work, it may become an important factor in the schedule of the dam construction because the construction must be completed in one year and work can be expected only during the dry season. The location of the diversion works (conduit) is described above and the main portion of conduit will be utilized as the intake conduit later.

The hydromechanical condition of the diversion is mentioned in section 5-4-1.

vii) The existing national road bridge will not be used when the Bayang bridge is demolished so as not to hinder the smooth embankment of the downstream toe of the dam.

On the other hand, a national road bridge must be constructed over the inflow section of the spillway, and its type will be of reinforced concrete girder with the effective width of 7.32 m, which is similar to the existing national bridge.

c) Stability analysis of the dam

For the maximum standard section of the dam, the slope stability analysis has been performed. The standard section is shown in Drawing 3. The soil mechanical data applied in the stability analysis of the dam is shown in Table A-5-13, and the result is shown in Table A-5-14 in the Appendix.

This analysis has been performed according to the computer program made under the technical transfer on the job of the F/S of BIDP Phase II in 1985. The program is based on the revised Japanese standard on design of dams for irrigation and drainage projects, and is registered and used in the Project Development Department of NIA.

d) Hydromechanical condition of the spillway.

The spillway is a free overflow type (gateless) on which flood water begins to flow on the full water level of the reservoir.

The synchronous amounts of the inflow and overflow have been analysed (Flood routing) and the result is shown in Figure A-5-10 in the Appendix.

The flood routing proves that, in case of a crest length of 60 m, the maximum amount of overflow will be 226 cu.m/sec with a flood of maximum inflow of 417 cu.m/sec and corresponding maximum overflow head reaches to 1.5 m. Although other alternatives of crest length such as 40 to 80 m are studied accordingly, the crest length of 60 m is the most appropriate from the viewpoint of the size of the dam and the spillway.

From the crest point to the stilling basin, the hydromechanical condition of the design flood is analysed and shown in Table A-5-16 in the Appendix.

e) Hydromechanical condition of the Intake (Diversion works)

Intake water from the dam will flow in through the Drop-inlet opening at the Low Water Level of El.30.00 m in the reservoir, through the Conduit (basement at about El.22.00) under the dam body and the national road, lift up to El.28.00 through the Vertical Chamber, then be conveyed from the left side of the river to the right side by a box-type canal, and then be delivered to the Capayas Main Irrigation Canal.

The release of water shall be controlled by the sluice gate (0.8 x 0.8 m) installed in the Vertical Chamber, and the Chamber can also function as an energy dissipator of the released water.

The hydromechanical condition of the Intake is shown in Figure A-5-12 in the Appendix. Compared with the small amount of the maximum design intake of 2.13 cu.m/sec, the necessary size of diversion work for the dam construction is so large (refer to sub-section 5-4-1) that in case of multi-purpose diversion for the intake conduit, the velocity of intake water shall be so slow that the loss of water head will also be small.

5-3-6. Irrigation Canal Design

a) Canal Alignment

The irrigation canals are provided to supply irrigation water from the Capayas Dam, and the irrigable area can be divided into 21 irrigation blocks according to the topographical conditions.

The main canal starts from the Capayas Dam and runs along the national road from south to north. The route of the main canal was aligned to avoid the high embankment as much as possible. Siphons will be constructed where the canal crosses creeks and the national road.

The proposed irrigable land is undulating plain with an elevation difference of more than 20m, therefore, the lateral and sub-lateral canals are aligned at the higher land to supply irrigation water by gravity. Accordingly, drop structure and siphon are required to cross the embankment as well as creeks and national road.

The irrigation canal network consists of one main canal, three lateral canals and two sub-lateral canals and the plan and profile is shown in the Appendix.

b) Design of Irrigation Canal

The total irrigable area of the Capayas Irrigation System is 1,160 ha. The irrigable land of the Project is 750 ha in the upstream portion as shown in Figure 5-1. The irrigation blocks are shown in Figure 5-5

and the design discharge of each irrigation canal will be adopted as the canal capacity as shown in Figure 5-5.

The alignment of irrigation canals was made based on the site survey using the 1/4,000 scale topo-maps prepared during the feasibility study of BIDP (Phase II).

The total number of diversion structures is 26, including 3 from the main to the lateral canals, 2 from the lateral to the sub-lateral canals, and 21 from the irrigation blocks.

One irrigation block supplied by the CB lateral canal is located outside the Project Area (750 ha), however, this block is included in the Project because the diversion structure is situated on the proposed irrigation canal. The total length, kind and number of major structures are shown in Table 5-8. The main canal is provided with a thin concrete lining while the lateral and sub-lateral canals are earth canals without lining.

Table 5-8. Canal Record

Name of Canal	Total Length	Syphon	Check	Drop	Diversion
Main Canal	3,110 m	210 m	2	1	4
Branch Canal CA	2,530	-	3	7	3
" CB	3,820	-	5	4	8
" CC	3,980	-	9	10	8
Sub-Branch Canal CC	2,950	600	0	6	2
"	1,300	-	0	0	2
TOTAL	17,690 m	810 m	19	28	27

To cross the canals, 40 siphons and 8 road crossing structures are necessary.

c) Maintenance Road

In order to operate and maintain the canal system, maintenance roads with gravel pavement will be constructed along the right bank of open canals. The widths of the maintenance roads were decided at 6m (pavement width of 4.5 m) along the main canal and 4m (pavement width of 3m) along the lateral and sub-lateral canals for easy transportation by operation and maintenance vehicles.

At portions where yhere is a siphon, the maintenance road will not be provided. If a maintenance road is cut by a siphon, a detour road connecting to the existing road will be considered. The width of the detour road will be 6m (pavement width of 4.5 m).

5-3-7. Drainage Canal Design

a) Drainage Canal Network

The drainage canal network was determined after considering the topography, location of creeks and irrigation canals. The existing creeks, such as the Bayang river and its tributaries, two creeks running in the center of the Project Area and the Sonok river will be used for main drainage channels. As a result of the site survey, the cross-sections of the Bayang river, which is the uppermost tributary, and the Sonok river have enough capacity to drain the excess water. While the cross-sections of two creeks running in the center of the Project Area, do not have enough capacity. Accordingly, drainage improvement of those tributaries is planned.

The lateral drainage canal was not planned because the rainwater and drainage water from the paddy fields reach the main drainage canal through paddy fields.

b) Design of Drainage Canal

The unit drainage discharge of the main canal was calculated as 5.61 l/sec/ha. The drainage canal was designed as an earth canal with a side slope of 1:1. The hydraulic computation for the drainage canal was made using the Manning Formula with a roughness coefficient of 0.04, and the maximum velocity was estimated as 0.8 m/sec.

At the crossing of drainage channels and the existing roads, concrete pipes are provided at present. However, because the capacity is insufficient and the elevation of the bottom of pipes are higher than those of the proposed drainage canal bed, the road crossing structure was designed.

5-3-8. On-farm Development Plan (Equipment Plan)

The on-farm development plan includes preparation of 420 ha of newly developed paddy fields on slightly undulating land and construction of terminal irrigation and drainage facilities for 750 ha of existing paddy fields and newly developed paddy fields.

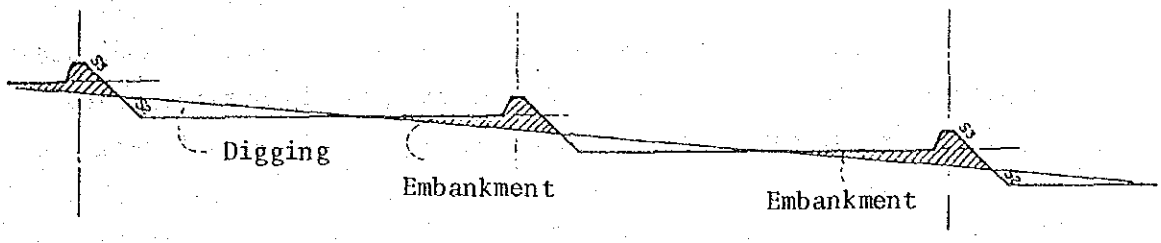
The necessary quantity of construction machinery for on-farm development in the standard irrigation block based that construction period of two years.

a) Implementation Plan

i) New Paddy Field Development Plan

The plan is to make new paddy fields on the slightly undulating land, therefore, earth works of digging and embankment will be required. The profiles are shown in the following figure, and it was decided that the thickness of surface soil treatment would be 30 cm.

Figure 5-6. Standard Profile of New Paddy Field Preparation



The construction quantities per ha for this Plan are as follows:

(Unit: cu,m/ha)

Surface soil treatment	3,000
Paddy field foundation (digging or embankment)....	750
Paddy field border embankment	140

ii) Terminal Irrigation and Drainage Plan

The terminal irrigation and drainage plan includes the main field irrigation ditch, the lateral field ditch, field drain, field road and field diversion.

The field irrigation ditch and drain are planned as earth canal and the field road is planned to have a width of 3m (gravel pavement width of 2.5 m and pavement thickness of 5cm).

The construction per ha is as follows:

Main field irrigation ditch	16.2 m/ha
Lateral field ditch	52.7 "
Field drain	55.3 "
Field road	50.2 "
Field diversion	5 places

iii) Land Preparation

The construction plan for the land preparation was formulated under the condition that all construction works would be executed uniformly, i.e., the annual construction quantities (230 working days) are 210 ha of new paddy field development and 375 ha of terminal irrigation and drainage canals. Total annual construction quantities are as follows:

	Construction Quantity	
	Per Hectare	Per Year
Surface soil treatment	3,000 cu.m/ha	630,000 cu.m
Paddy field foundation (digging and embankment)	750 "	157,500 "
Paddy field border embankment	140 "	29,400 "
Main field irrigation ditch	16.2 m/ha	6,075 m
Lateral field ditch	52.7 "	19,763 "
Field drain	55.3 "	20,738 "
Field road	50.2 "	18,825 "
Field diversion	5 places	1,875 places

b) Construction Plan

i) Detailed Design

Before the construction works begin, a detailed design including the layout on the topo-maps and topo-survey on the site should be executed on the basis of: (i) 1/4,000 scale topo-maps prepared during the feasibility study of BIDP in 1985; and (ii) the basic design and the detailed design of water source and irrigation and drainage canals. In the detailed design, the land preparation plan including the elevation modification will be studied in addition to the layout of irrigation and drainage canals.

The topo-survey will be started with the traverse survey using theodolite and distomat. Distomat, which is used for measuring the distance optically, will be useful for the traverse survey in the undulating land, i.e., the Project Area. The Distomat includes a reflect. Then, the route survey on the spot for major field irrigation ditch, lateral field ditch and field drain will be executed based upon the layout on the topo-maps as a result of the traverse survey and planimetric measurement.

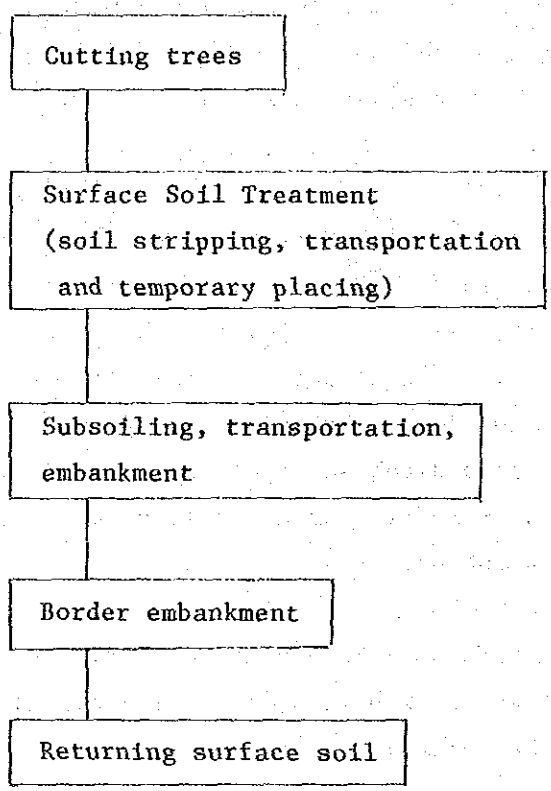
The topo-survey will be conducted by two groups. One group will conduct the survey for a period of 2-3 months, while the other will be equipped with the following instruments:

Theodolite	1
Automatic level	2
Rod	10
Pole	10
Measuring tape (50m)	3
Measuring tape (100m)	3

ii) Construction Method

Land levelling works

In accordance with the field preparation plan formulated in the detailed design, new paddy fields will be constructed on the gradually sloping land under the following procedures:



Field Irrigation Ditch and Drain

The construction works for field irrigation ditches and drains as well as field roads will be done through digging by backhoe, earthmoving by bulldozer and compaction by small compactor during the land levelling works.

c) Calculation of the Required Number of Construction Machinery

i) Topo-survey Instruments

The necessary topo-survey instruments are as follows:

1) Distomat including a reflector and tripods	1
2) Theodolite with tripod	2
3) Automatic level with tripod	4
4) Rod (stadia, aluminum, 5 meters)	10
5) Pole (aluminum, 3 meters)	10
6) Measuring Tape (Eslon, 50 meters)	6
7) -ditto- (Eslon, 100 meters)	6
8) Planimeter	2

ii) Construction Machinery

The working efficiency of construction machinery is calculated based upon the Cost Estimate Standard for Land Improvement Works of MAFF.

Cutting Trees

Earth movement distance is 20 m on an average. Soil texture is clay.

By bulldozer (14 tons):

$$Q_B = \frac{60 \times q \times f \times E}{0.034L + 0.25} = \frac{60 \times 1.83 \times 1.35 \times 0.75}{0.34 \times 20 + 0.25} = \frac{111.17}{0.93}$$

$$= 119.6 \text{ cum/hr.}$$

By wheeldozer (1 cum):

$$Q_W = \frac{3,600 \times 1.0 \times 1.35 \times 0.70}{3.14 \times 20 \times 20.8} = \frac{3.402}{99.3} = 40.7 \text{ cum/hr}$$

Required capacity per hour:

630,000 cum ÷ 100 days ÷ 8 hrs = 787.5 cum/hr

Accordingly, the number and capacity of construction machinery required are as follows:

Bulldozer (14 tons) ---	6 units -----	717.6 cum/hr
Wheeldozer (1 cum) ---	3 units -----	122.1 "
Total	9 units	839.7 cum/hr

Subsoiling and Embankment

Earth moving distance is 20 m on average. Soil texture is sandy.

By Bulldozer (14 tons):

$$Q = \frac{60 \times 1.83 \times 1.25 \times 0.75}{0.93} = 102.9 \text{ cum/hr}$$

By Wheeldozer (1 cum):

$$Q = \frac{3,600 \times 1.0 \times 1.25 \times 0.70}{83.6} = 37.7 \text{ cum/hr}$$

Required capacity per hour:

157,000 cum ÷ 30 days ÷ 8 hrs = 656.3 cum/hr

Accordingly, the number and capacity of construction machinery required are as follows:

Bulldozer (14 tons) ---	6 units ---	617.4 cum/hr
Wheeldozer (1 cum) ---	2 units ---	75.4 cum/hr
Total	8 units	692.8 cum/hr

Border Embankment

Border embankment will be built at the same time as subsoil digging and embankment. For this work, one motor grader (110 PS) is to be allocated.

Returning Surface Soil

The capacity and the required number of construction machinery is the same as for surface soil treatment. The motor grader will be engaged in the final surface soil treatment.

Digging Farm Ditch and Drain

Total annual construction quantity is 173,138 cum (1,742 cu.m + 171,396 cum), that is, 25.8 km of farm ditch and 20.7 km of farm drain.

By backhoe (0.35 cu.m):

$$Q = \frac{3,600 \times q \times f \times E}{Cm} = \frac{3,600 \times 0.35 \times 1.35 \times 0.70}{30}$$

$$= 40 \text{ cum/hr.}$$

Required capacity per hour:

174,000 cum ÷ 200 days ÷ 8 hrs = 108.75 cum/hr

Accordingly, the number and capacity of construction machinery that will be required are as follows:

Backhoe (0.35 cum) --- 3 units --- 120 cum/hr.

Embankment of Field Ditch, Drain and Road

The embankment of the field ditch, drain and road will be made with the dug soil. Spreading is done using manpower and compaction is done by small compactor. Five small compactors will be provided.

Gravel Pavement

Gravel for road pavement will be transported by dump truck from the quarry and spread by motor grader. One dump truck and one motor grader will be provided for this work.

Concrete Works

One dump truck (6 tons) will be exclusively provided for quarry transportation. Cement, iron bars, etc. will be transported by truck from Tagbilaran. For making small diversion boxes, concrete pipes, etc., a concrete mixer (capacity, 0.18 cu.m) will be used. Completed diversion boxes will be transported and installed at the site by a crane truck.

Other Works

The construction period is relatively long and the construction works within the dry seasons will not be possible. A pump (ϕ100 mm) with engine to pump water for concrete will be required.

Finally, the following construction machinery is necessary as a result of the above-mentioned calculation:

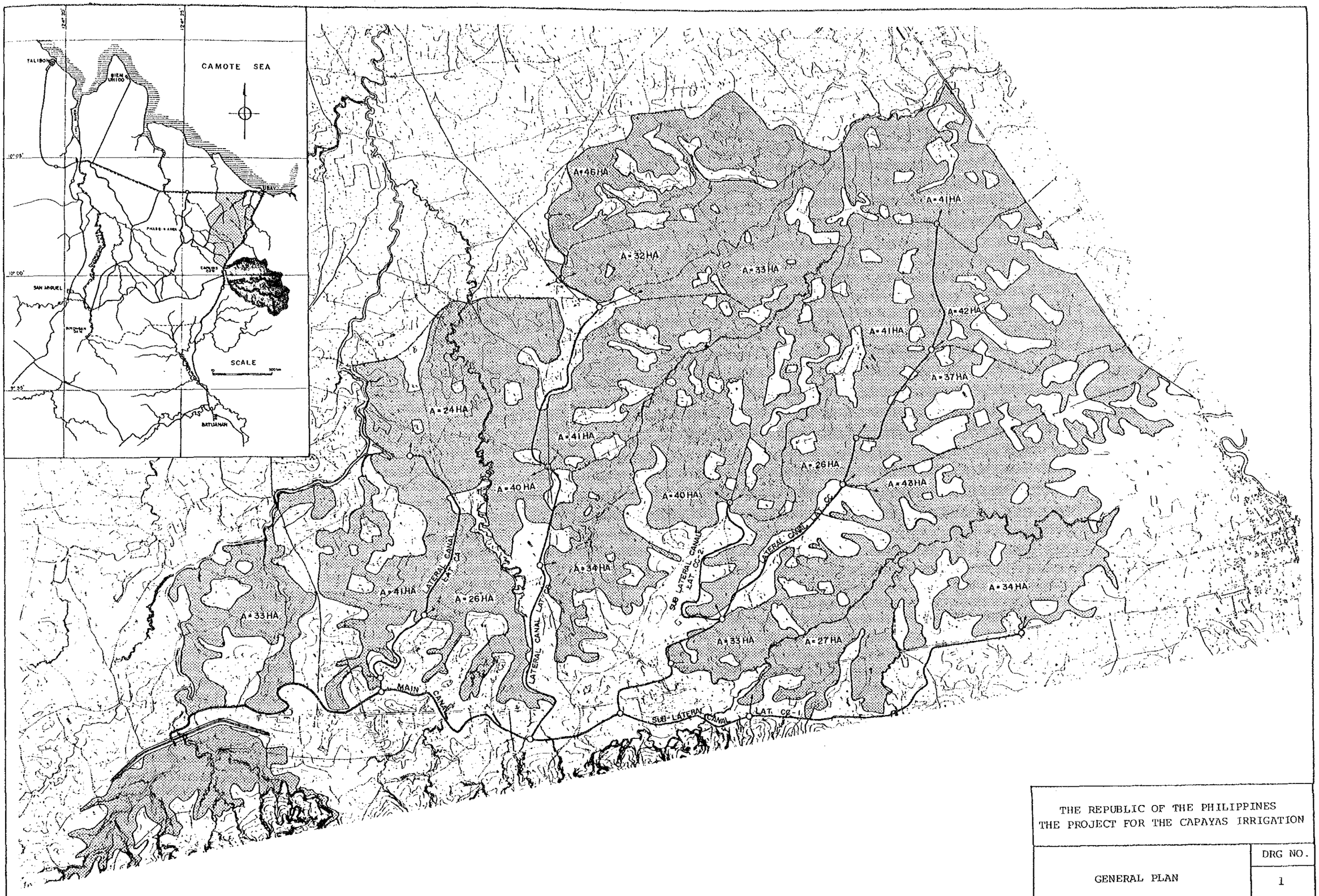
1) Bulldozer (14 tons, D60P)	6
2) Backhoe Wheel-Type (0.35 cu.m capacity)	3
3) Wheel Dozer (1.0 cu.m capacity)	3
4) Motor Grader (110 PS)	2
5) Dump Truck (6 tons)	2

6)	Truck (6 tons)	1
7)	Crane Truck (6 tons)	1
8)	Pick-Up Truck (0.5 ton)	2
9)	Station Wagon (5 seaters)	2
10)	Tractor Trailer & Trailer (20 tons)	1
11)	Fuel Tanker (4,000 liters)	1
12)	Compactor (3.5 PS)	6
13)	Centrifugal Pump with Diesel Engine (ϕ100 mm)	2
14)	Concrete Mixer (0.18 cu.m)	1
15)	Spare Parts	1

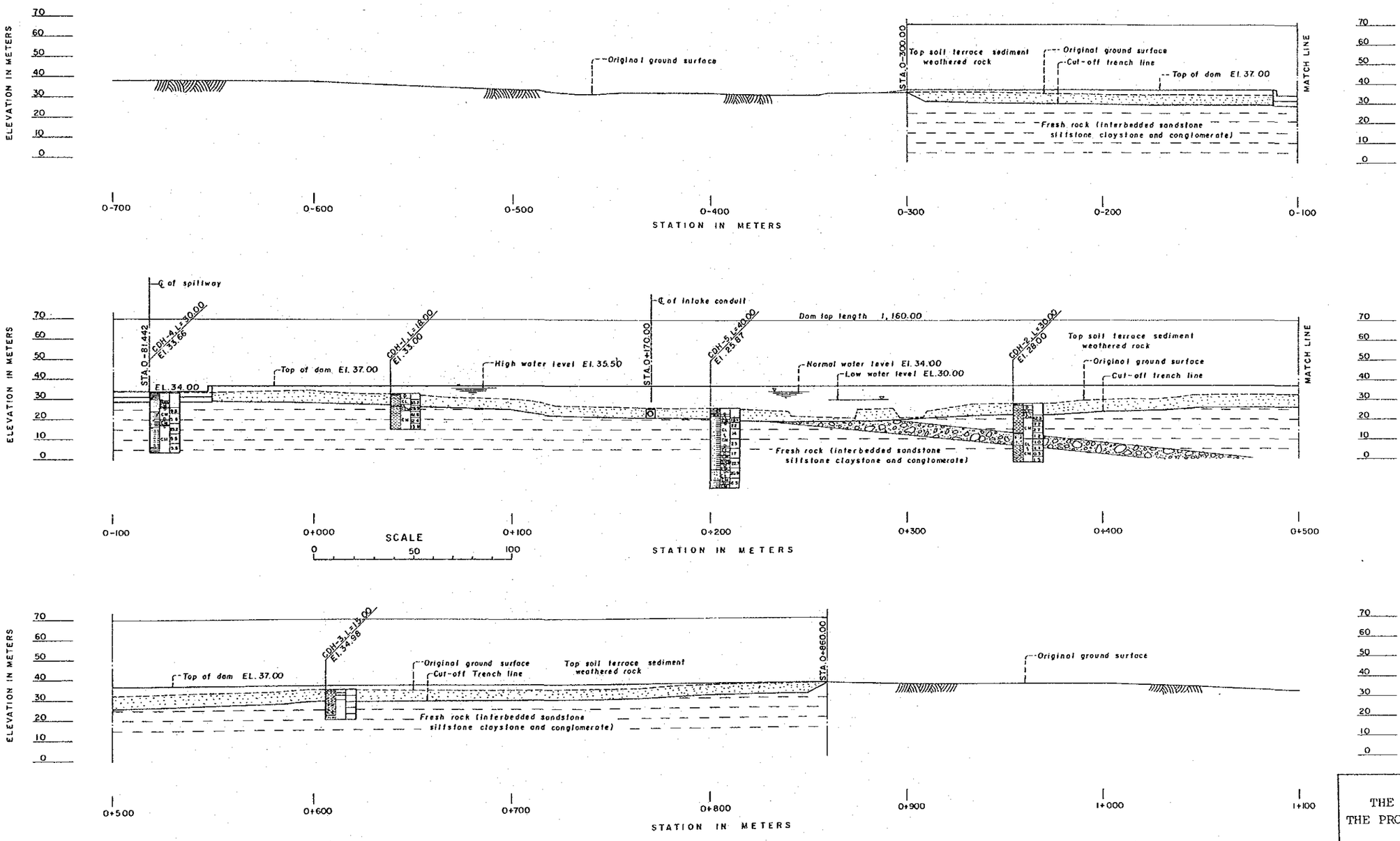
5-3-9. Basic Design Drawings

The necessary drawings of the basic design are listed below:

No. of Drawings	Title
DWG No. 1	General Plan
2	Profile of Capayas Dam
3	Plan of Capayas Dam
4	Typical Cross-Section of Capayas Dam
5	Intake of Capayas Dam
6	Spillway of Capayas Dam
7	Profile of Canal
8	Typical Cross-Section of Canal
9	Siphon
10	Check and Drop
11	Turn-out
12	Road Crossing
13	Cross Structure



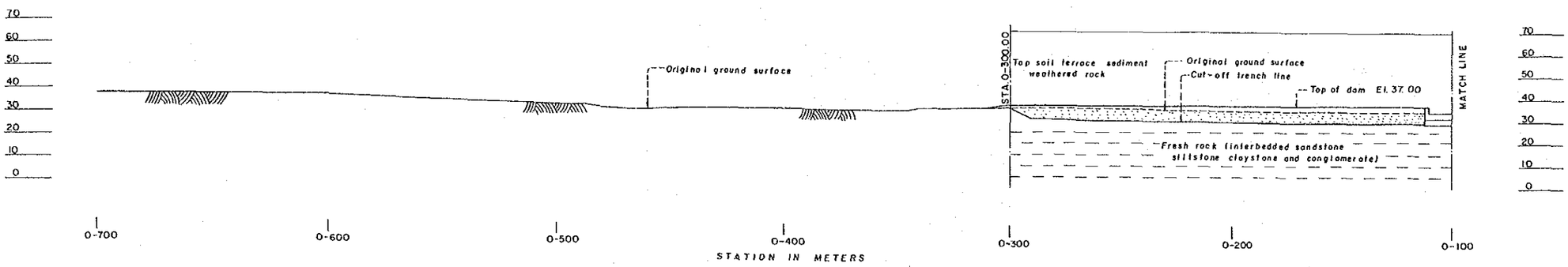
THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
GENERAL PLAN	DRG NO. 1
JAPAN INTERNATIONAL COOPERATION AGENCY	

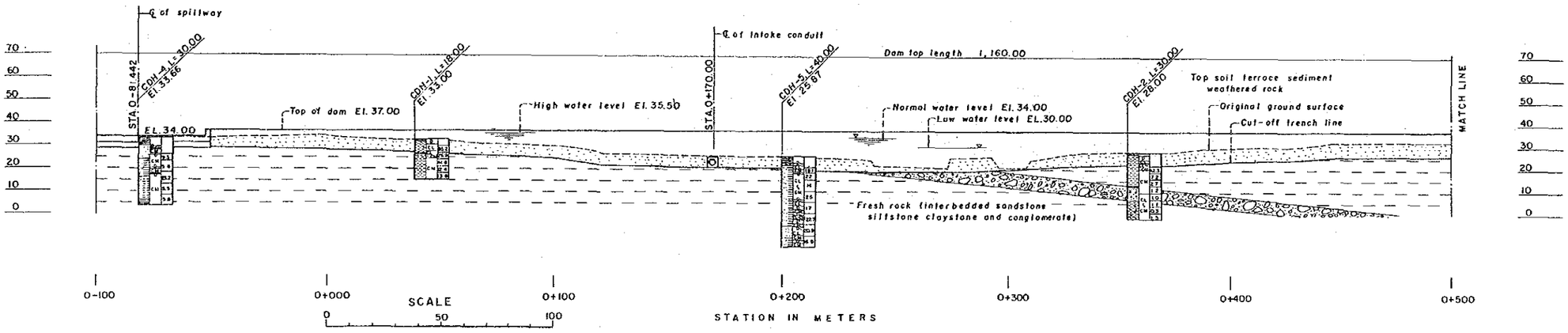


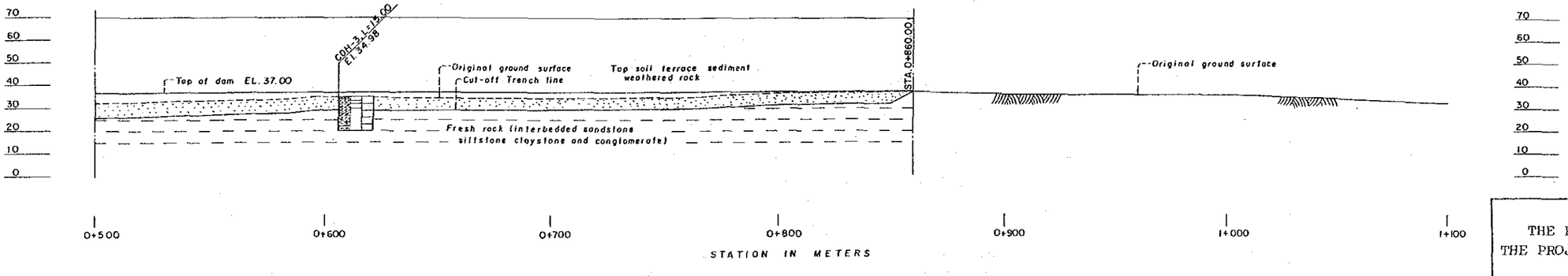
THE REPUBLIC OF THE PHILIPPIN
THE PROJECT FOR THE CAPAYAS IRRI

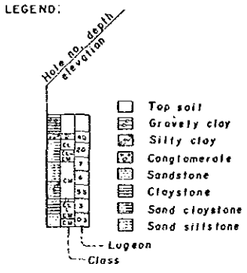
PROFILE OF CAPAYAS DAM

JAPAN INTERNATIONAL COOPERATION







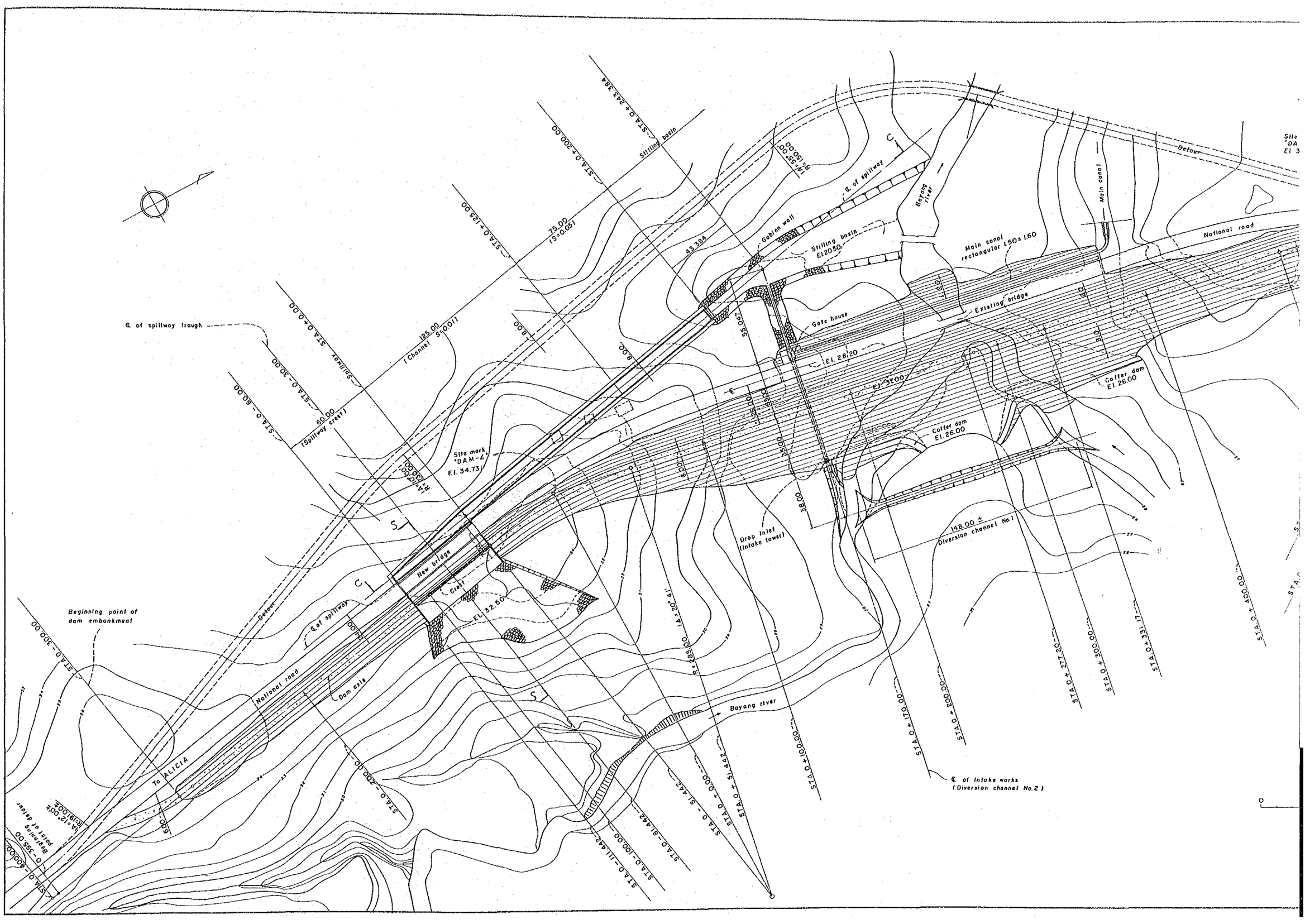


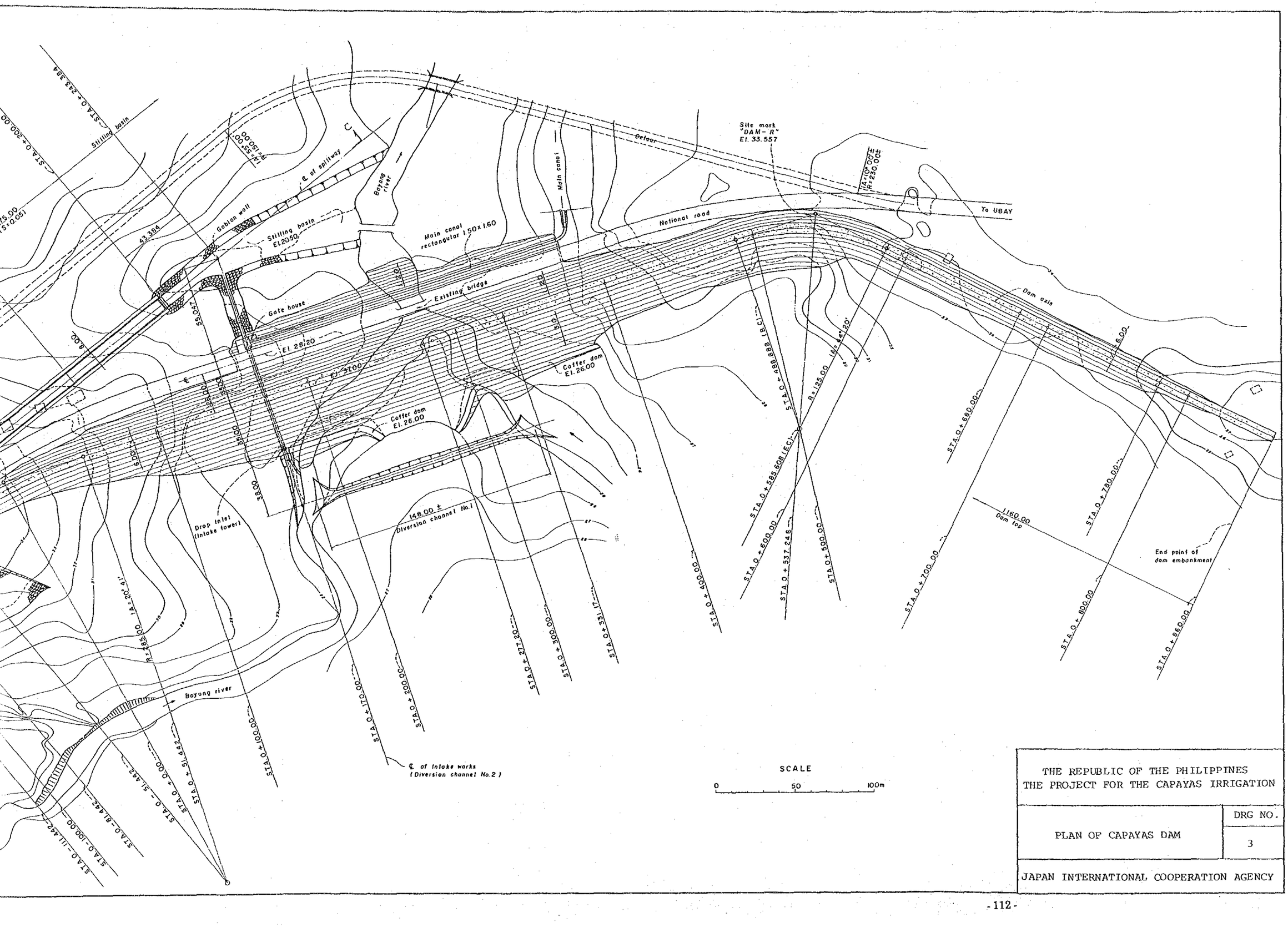
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

PROFILE OF CAPAYAS DAM

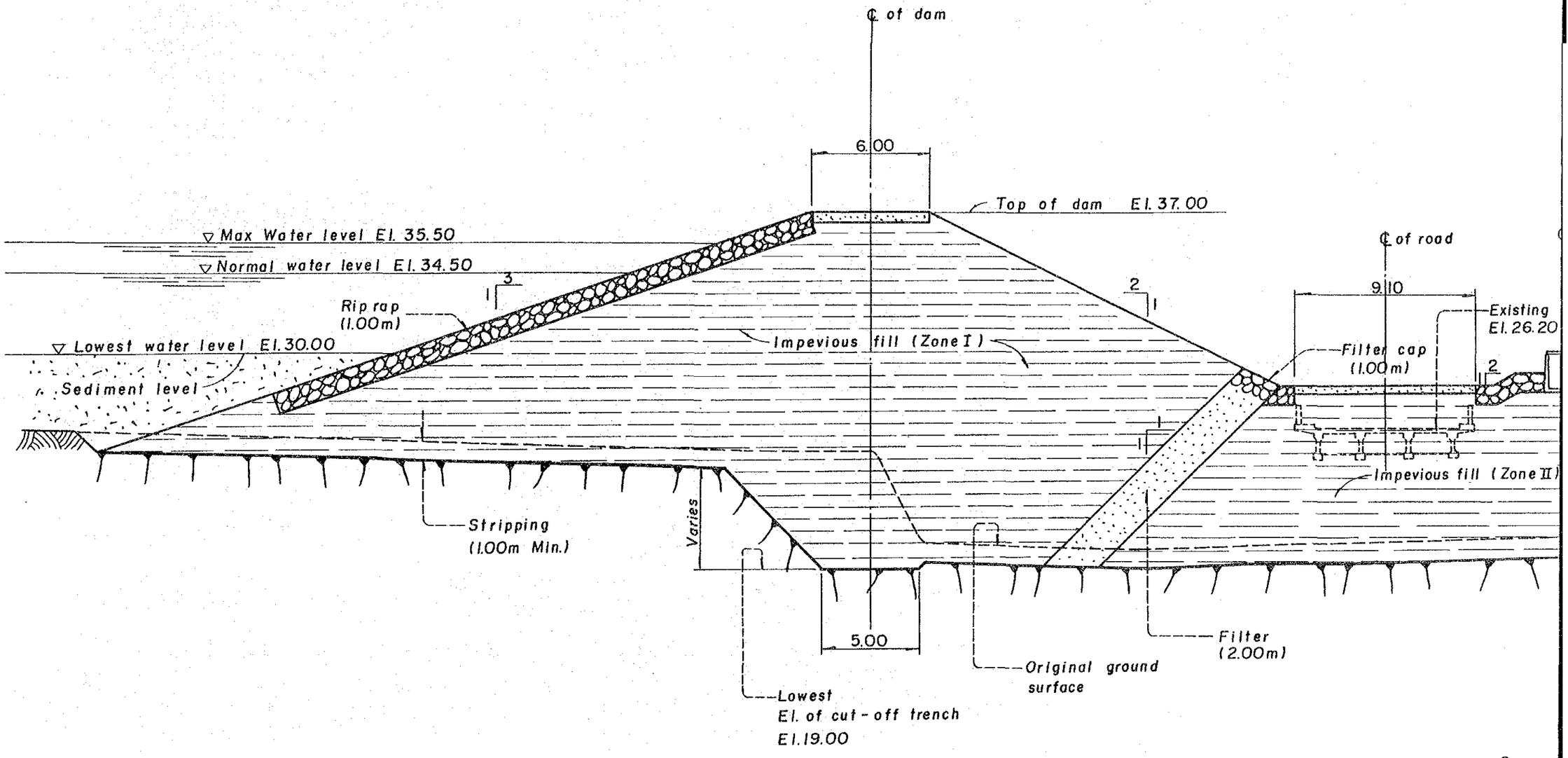
DRG NO. 2

JAPAN INTERNATIONAL COOPERATION AGENCY

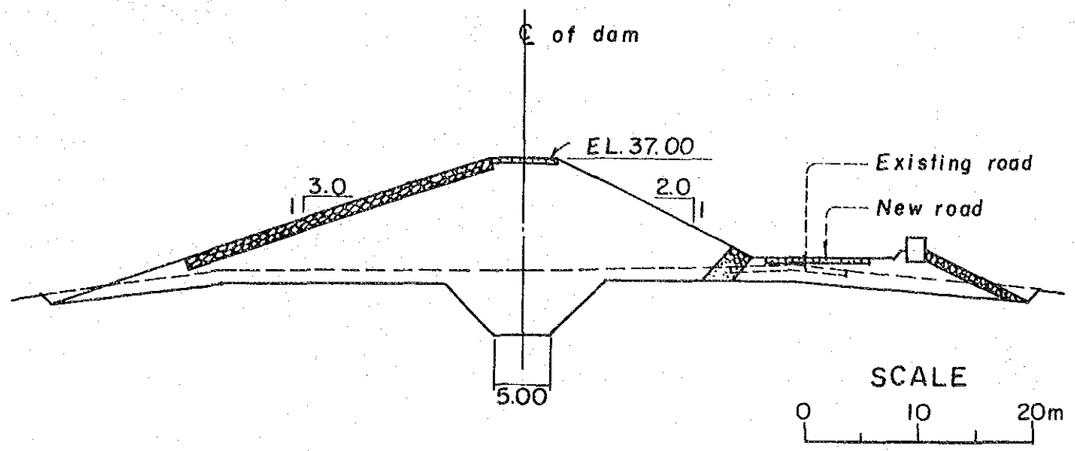

℄ of spillway trough
STA 0 + 0.00
STA 0 - 30.00
STA 0 - 60.00
60.00 (Spillway crest)
Spillway
125.00 (Channel S=0.01)
STA 0 + 123.00
75.00 (S=0.05)
STA 0 + 200.00
STA 0 + 243.384
Stilling basin
Site mark "DAM-4" El. 34.73
Detour
℄ of spillway
New bridge
Crest EL. 32.50
Beginning point of dam embankment
STA 0 - 300.00
STA 0 - 335.00
STA 0 - 600.00
To ALICIA
National road
Dam axis
STA 0 - 200.00
Gabion wall
Stilling basin El. 20.50
Bayang river
Gate house
El. 28.20
El. 31.00
Existing bridge
Main canal rectangular 1.50 x 1.60
Main canal
Coffer dam El. 26.00
Coffer dam El. 26.00
Drop inlet intake tower
198.00 ± Diversion channel No. 1
STA 0 + 100.00
STA 0 + 170.00
STA 0 + 200.00
STA 0 + 217.20
STA 0 + 300.00
STA 0 + 331.17
STA 0 + 400.00
STA 0 - 111.442
STA 0 - 100.00
STA 0 - 81.442
STA 0 - 51.442
STA 0 + 51.442
STA 0 + 81.442
STA 0 + 100.00
℄ of intake works (Diversion channel No. 2)
Bayang river



THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
PLAN OF CAPAYAS DAM	DRG NO. 3
JAPAN INTERNATIONAL COOPERATION AGENCY	

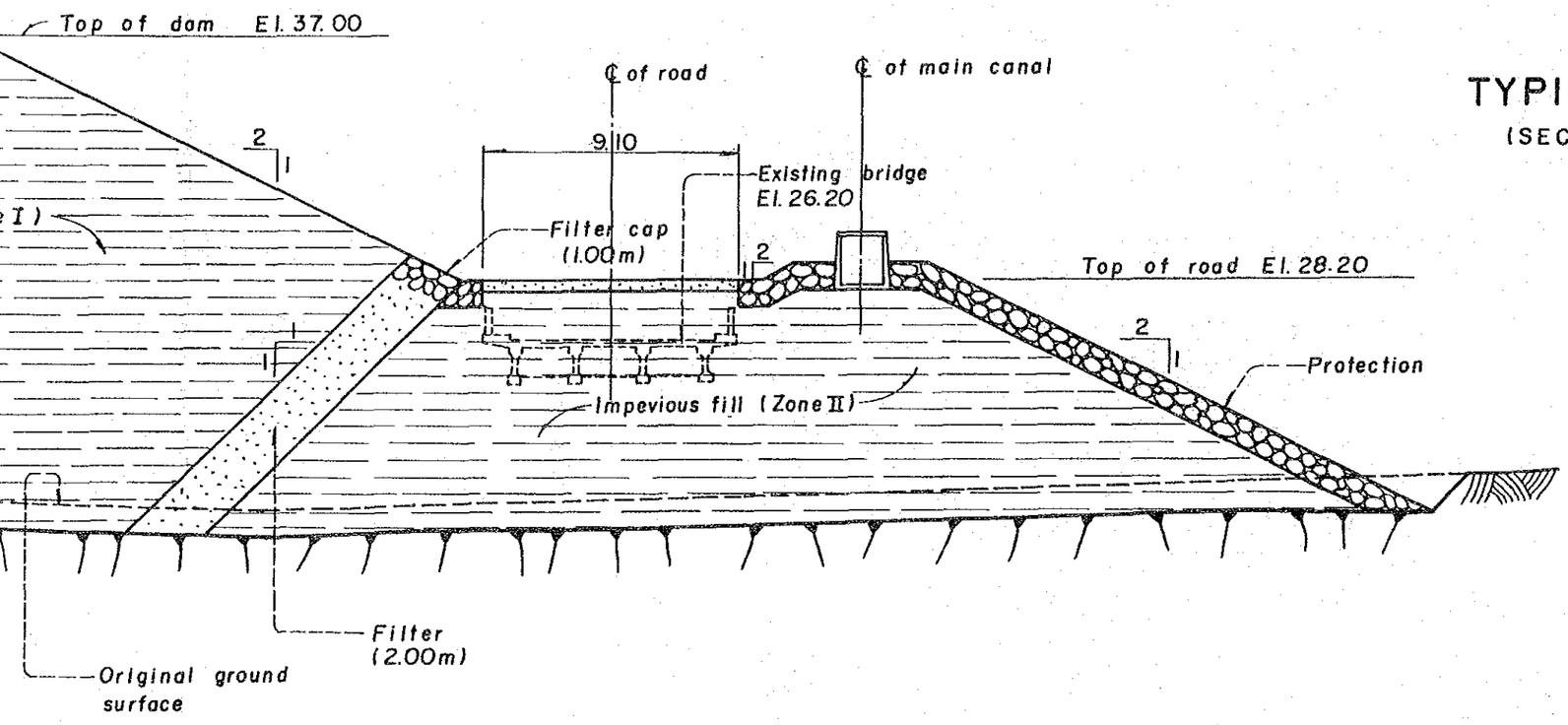


MAXIMAM SECTION OF DAM EMBANKMENT



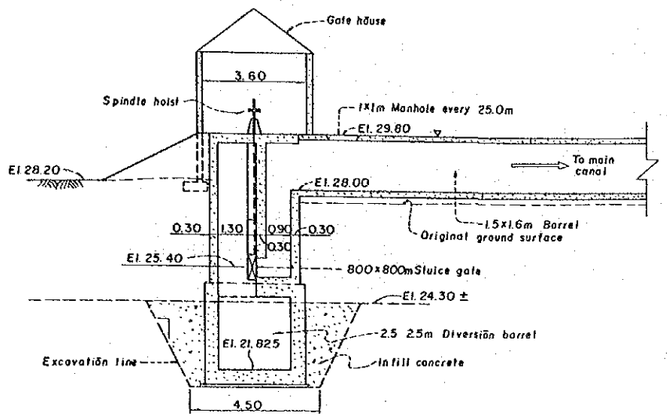
TYPICAL SECTION OF DAM

(SECTLON @ STA. 0+331.442)

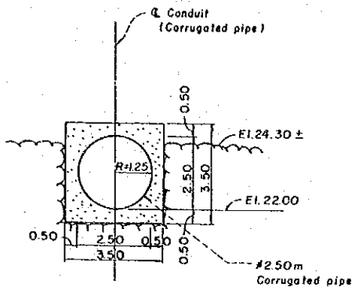


DAM EMBANKMENT

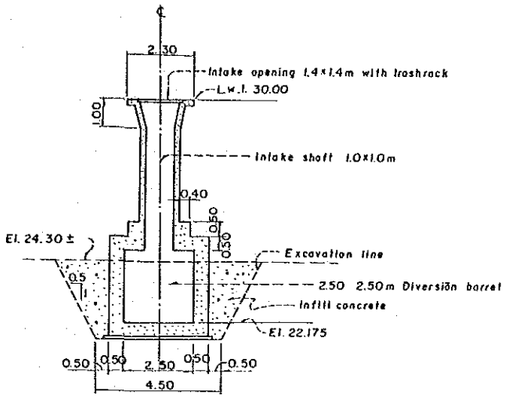
THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
TYPICAL CROSS SECTION OF CAPAYAS DAM	DRG NO. 4
JAPAN INTERNATIONAL COOPERATION AGENCY	



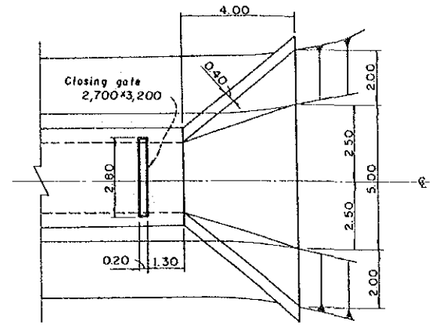
SECTION A-A



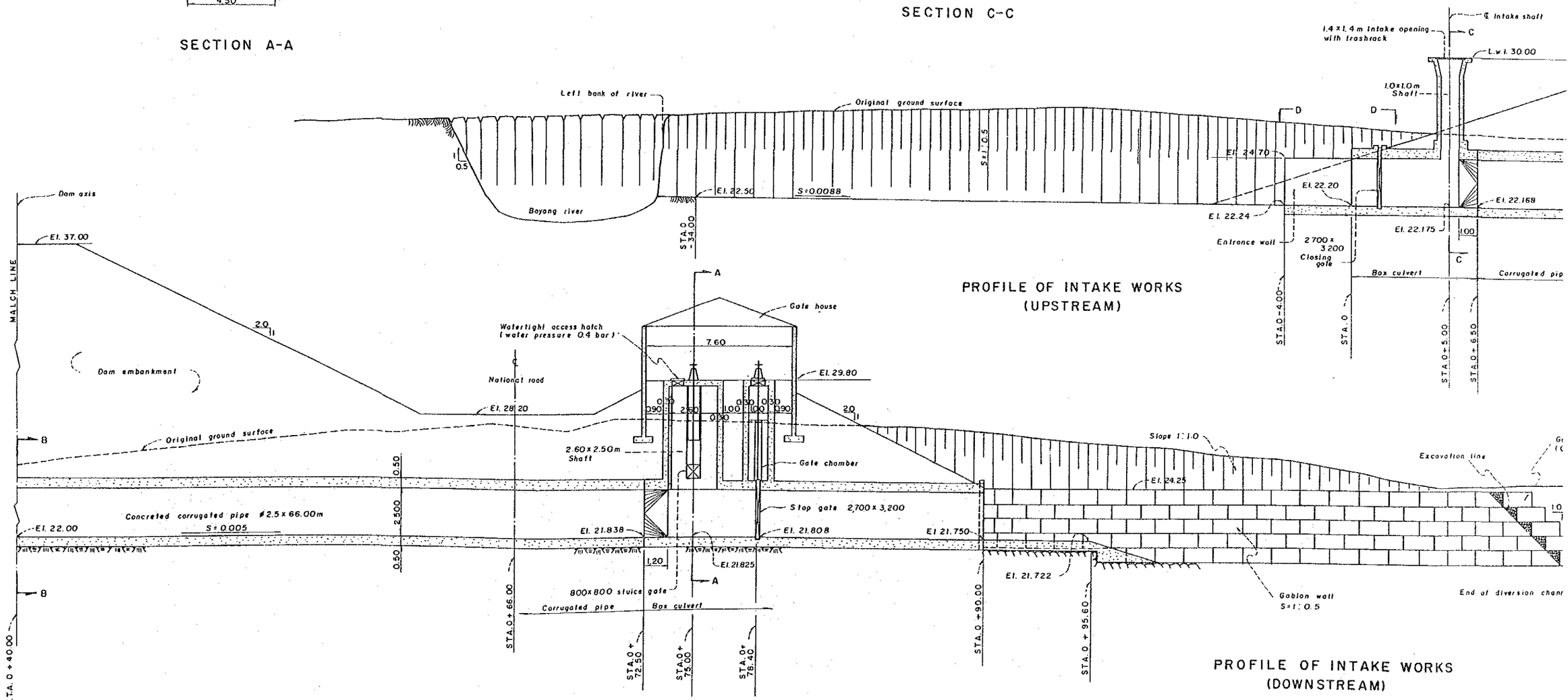
SECTION B-B



SECTION C-C

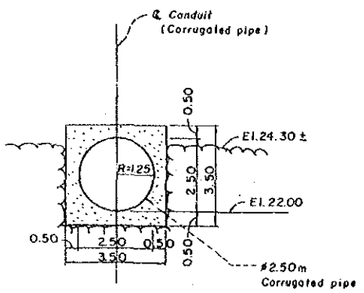


SECTION D-D

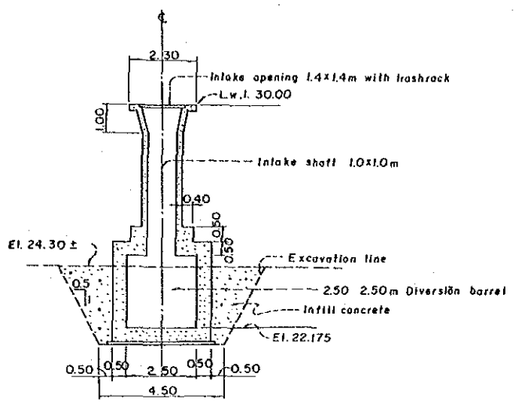


PROFILE OF INTAKE WORKS (UPSTREAM)

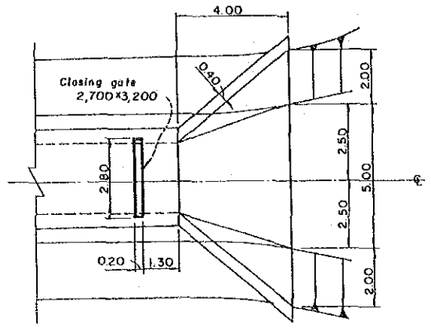
PROFILE OF INTAKE WORKS (DOWNSTREAM)



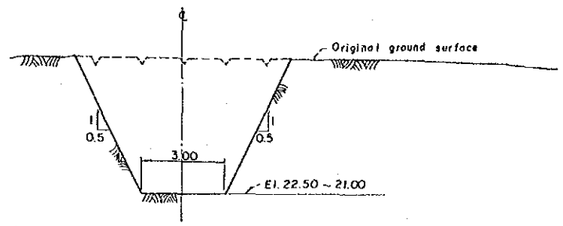
SECTION B-B



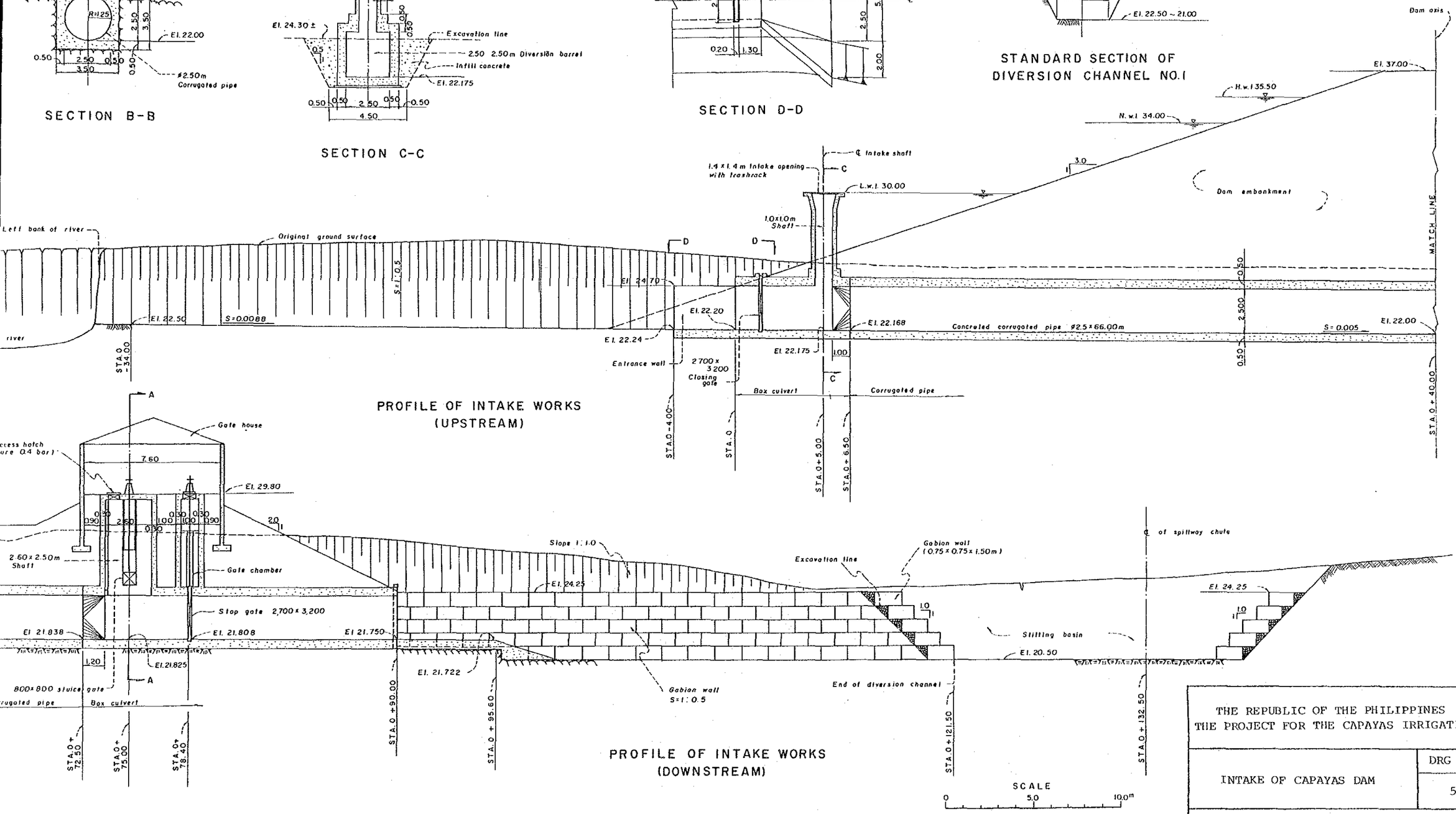
SECTION C-C



SECTION D-D



STANDARD SECTION OF
DIVERSION CHANNEL NO.1



PROFILE OF INTAKE WORKS
(UPSTREAM)

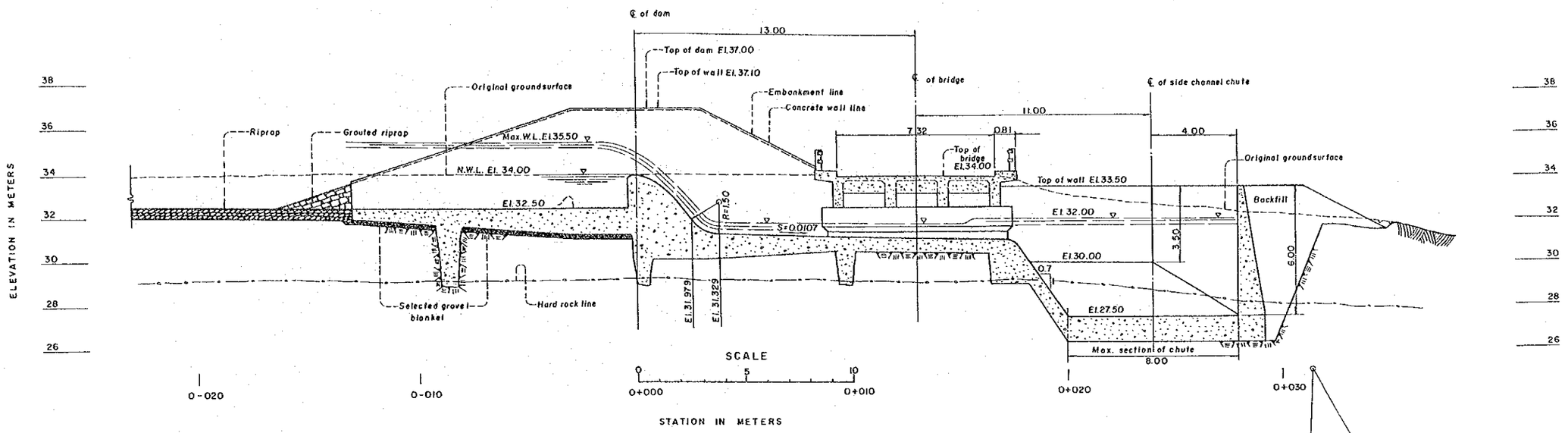
PROFILE OF INTAKE WORKS
(DOWNSTREAM)

SCALE
0 5.0 10.0m

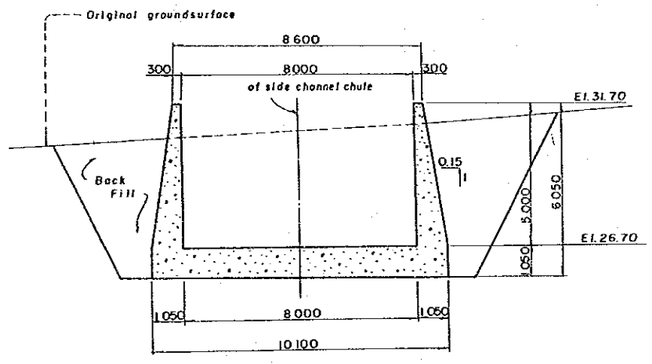
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

INTAKE OF CAPAYAS DAM	DRG NO. 5

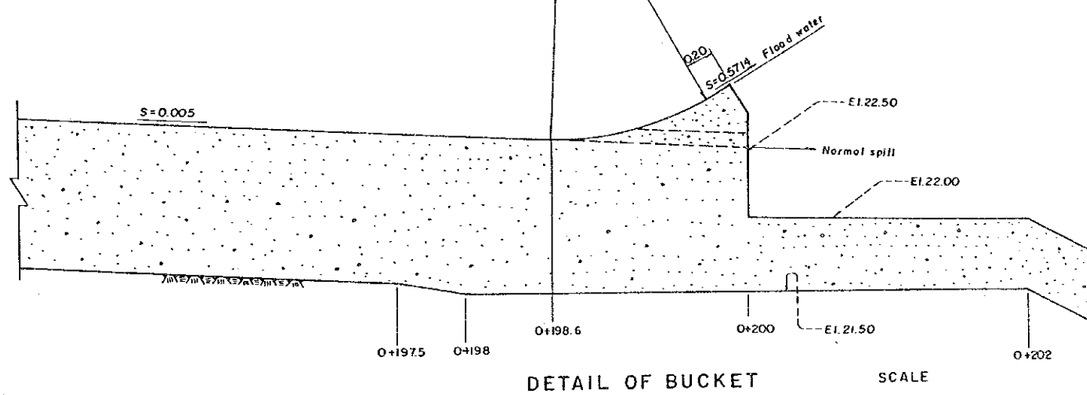
JAPAN INTERNATIONAL COOPERATION AGENCY



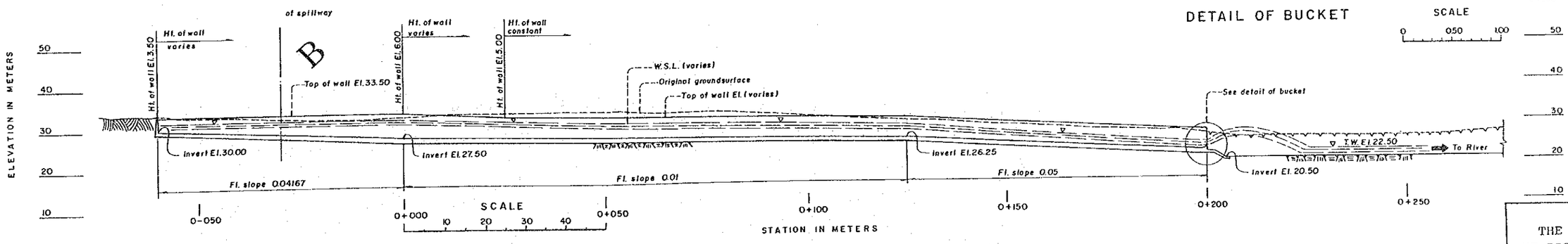
SECTION ALONG ℄ OF SPILLWAY (SECTION S-S)



CROSS SECTION OF CHANNEL CHUTE
(STA. 0 + 100)



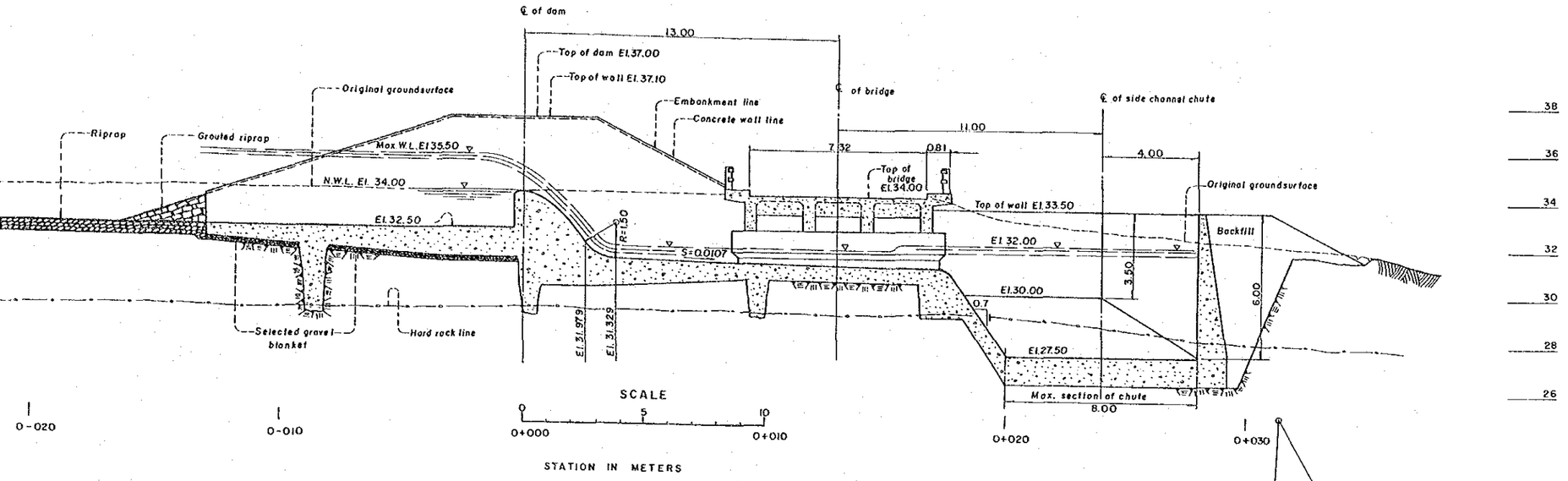
DETAIL OF BUCKET



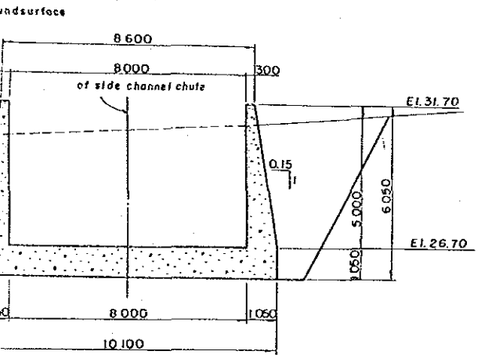
SECTION ALONG SIDE CHANNEL CHUTE (SECTION C-C)

SCALE
0 0.50 1.00

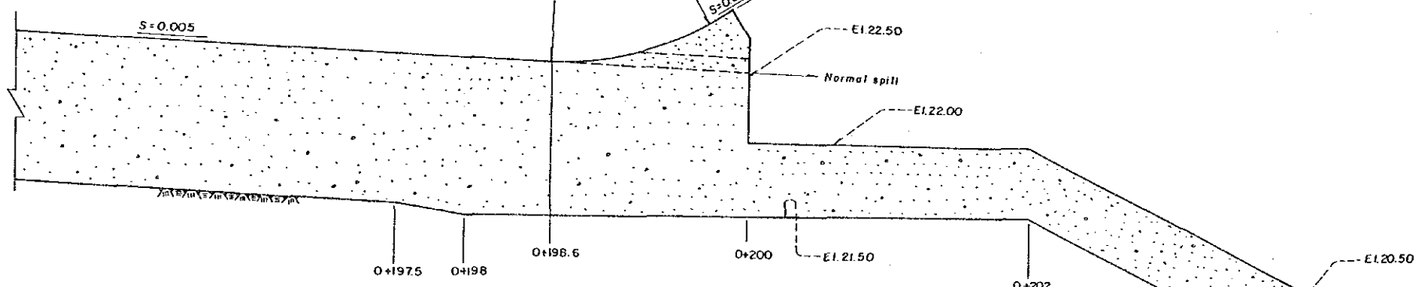
THE REPUBLIC
THE PROJECT FOR
SPILLWAY OF
JAPAN INTERNATIO



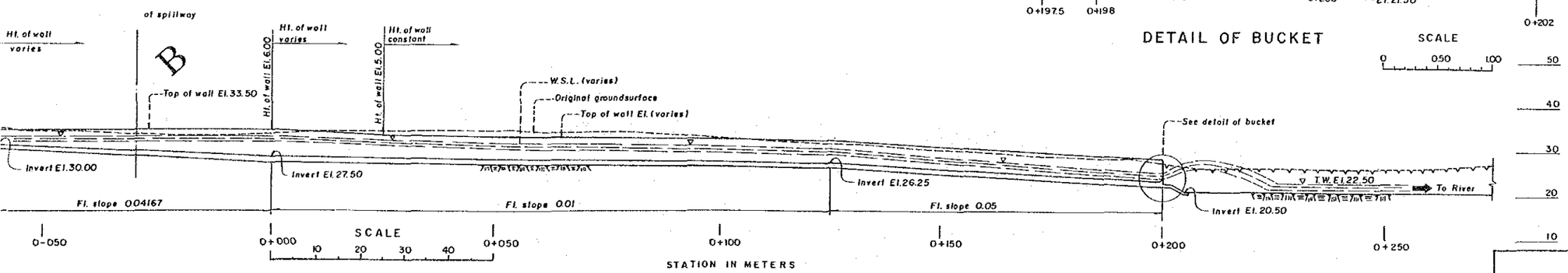
SECTION ALONG ℄ OF SPILLWAY (SECTION S-S)



SECTION OF CHANNEL CHUTE
(STA. 0 + 100)



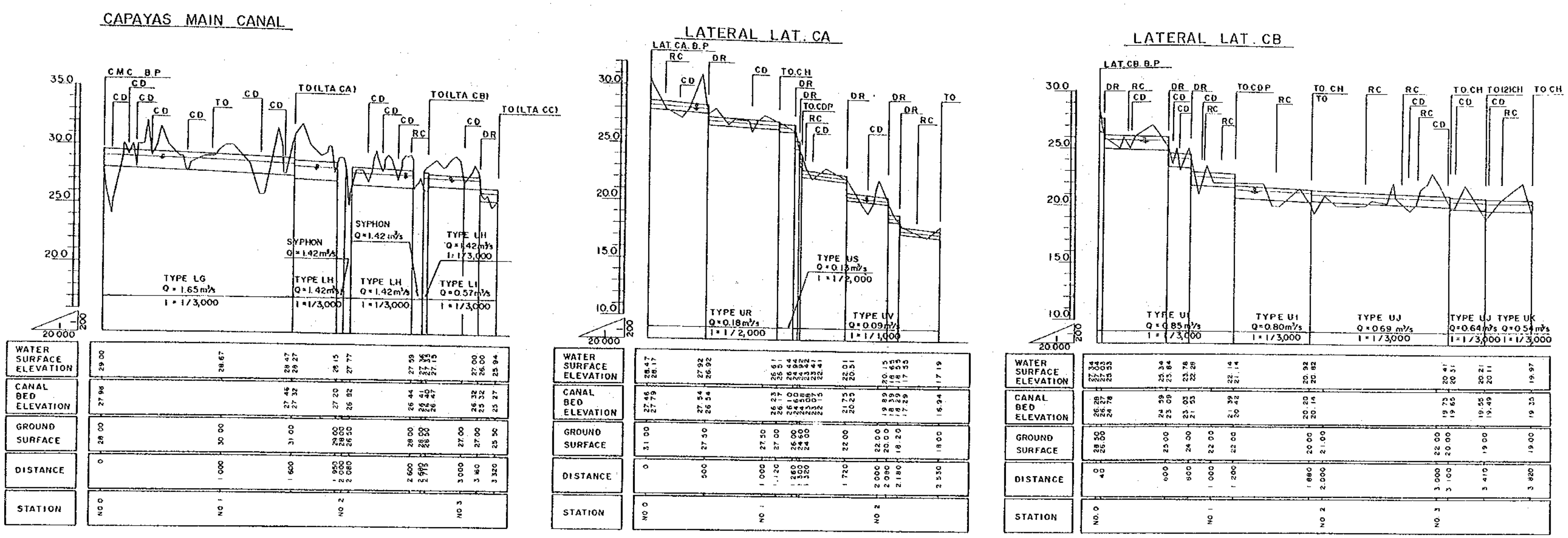
DETAIL OF BUCKET
SCALE
0 0.50 1.00

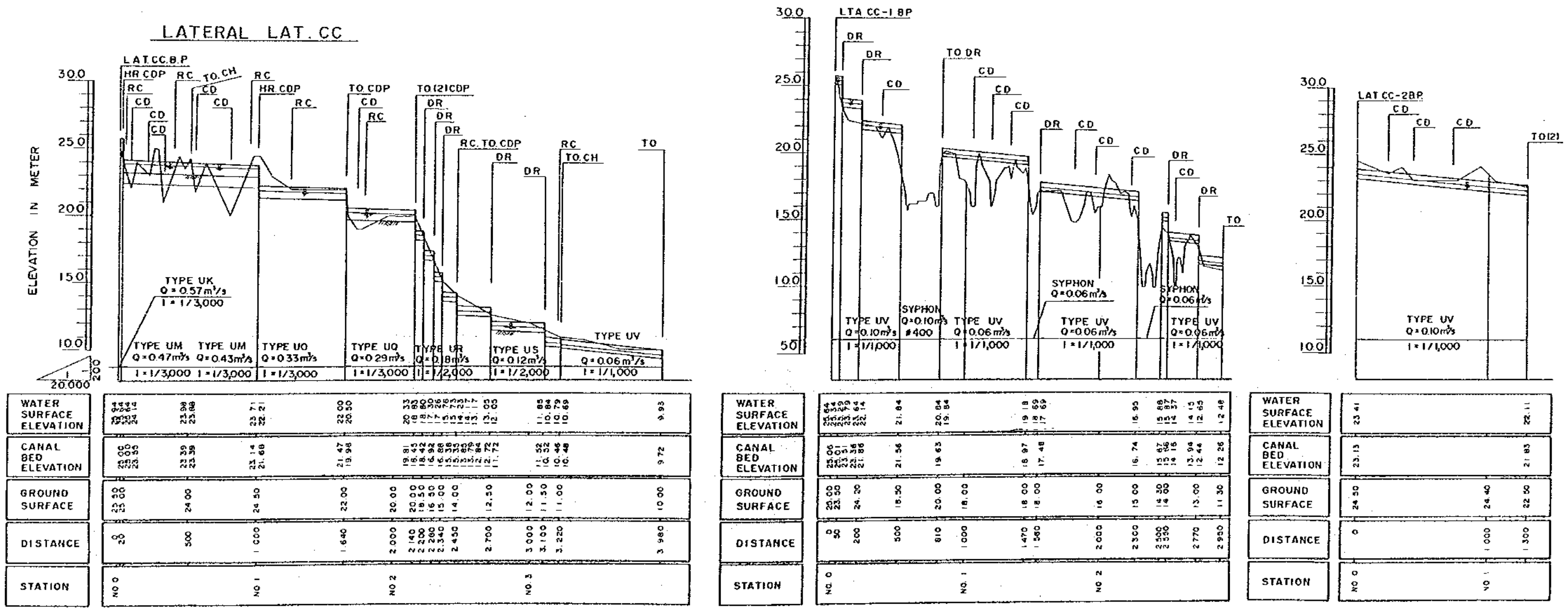


SECTION ALONG SIDE CHANNEL CHUTE (SECTION C-C)

50
40
30
20
10

THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
SPILLWAY OF CAPAYASDAM	DRG NO. 6
JAPAN INTERNATIONAL COOPERATION AGENCY	





LEGEND

HR	:	HEAD REGULATOR
CH	:	CHECK
TO	:	TURNOUT
DR	:	DROP
CDP	:	CHECK CUM DROP
BG	:	BRIDGE
SP	:	SPILLWAY
SY	:	SYPHON
RC	:	ROAD CROSSING

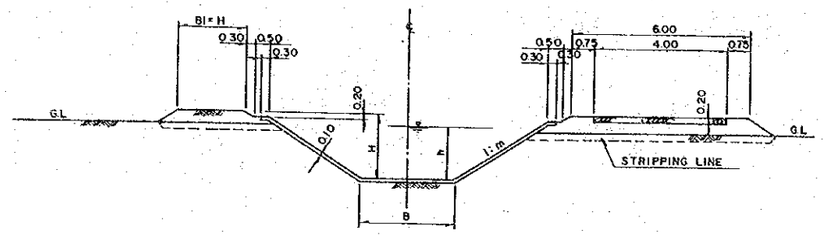
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

PROFILE OF CANEL

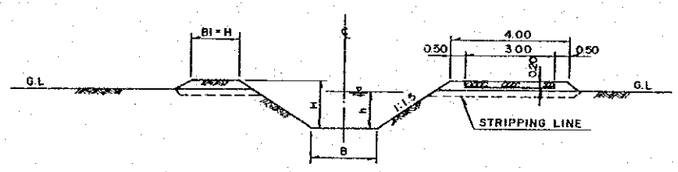
DRG NO. 7

JAPAN INTERNATIONAL COOPERATION AGENCY

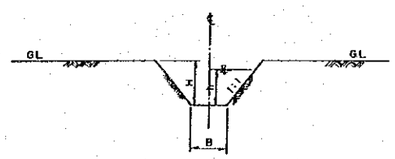
TYPICAL CANAL SECTIONS



MAIN CANAL (LINED)



LATERAL CANAL (UNLINED)



DRAINAGE CANAL (UNLINED)

DIMENSIONS TABLE

TYPE	DISCHARGE	B/H	n	I	m	B	r	V	H
MAIN CANAL (LINED)									
LG	1.65	2	0.015	1/3000	1.5	1.00	1.022	0.798	1.50
LH	1.42	2	0.015	1/3000	1.5	1.00	0.948	0.769	1.40
LI	0.57	2	0.015	1/3000	1.5	0.70	0.677	0.612	1.00
LATERAL AND SUB-LATERAL CANAL (UNLINED)									
UI	0.85	2	0.025	1/3000	1.5	1.50	0.75	0.449	1.10
	0.80	2	0.025	1/3000	1.5	1.50	0.72	0.433	1.10
UJ	0.69	2	0.025	1/3000	1.5	1.40	0.68	0.415	1.00
	0.64	2	0.025	1/3000	1.5	1.40	0.66	0.406	1.00
UK	0.57	2	0.025	1/3000	1.5	1.30	0.64	0.398	1.00
	0.54	2	0.025	1/3000	1.5	1.30	0.62	0.391	1.00
UM	0.47	2	0.025	1/3000	1.5	1.20	0.59	0.377	0.90
	0.43	2	0.025	1/3000	1.5	1.20	0.57	0.370	0.90
UD	0.33	2	0.025	1/3000	1.5	1.00	0.53	0.348	0.90
UQ	0.29	2	0.025	1/3000	1.5	0.90	0.52	0.339	0.80
UR	0.18	2	0.025	1/2000	1.5	0.80	0.38	0.345	0.70
US	0.13	2	0.025	1/2000	1.5	0.70	0.34	0.337	0.70
	0.12	2	0.025	1/2000	1.5	0.70	0.33	0.332	0.70
	0.11	2	0.025	1/2000	1.5	0.70	0.31	0.306	0.70
UV	0.10	2	0.025	1/1000	1.5	0.50	0.28	0.389	0.60
	0.09	2	0.025	1/1000	1.5	0.50	0.26	0.374	0.60
	0.06	2	0.025	1/1000	1.5	0.50	0.21	0.334	0.60

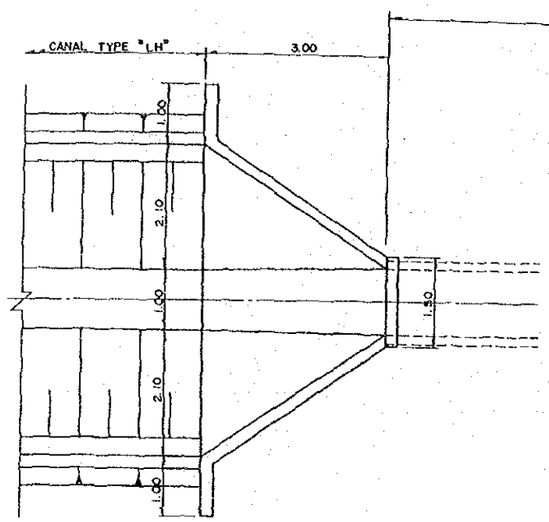
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

TYPICAL SECTION OF CANEL

DRG NO. 8

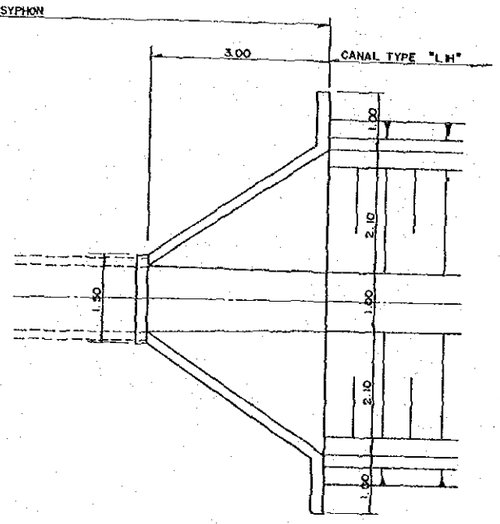
JAPAN INTERNATIONAL COOPERATION AGENCY

INLET OF SYPHON (A)



PLAN

OUTLET OF SYPHON (A)



PLAN

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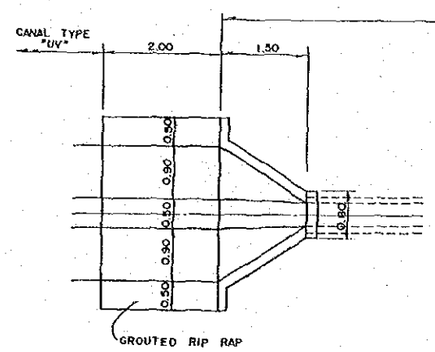

PLAN

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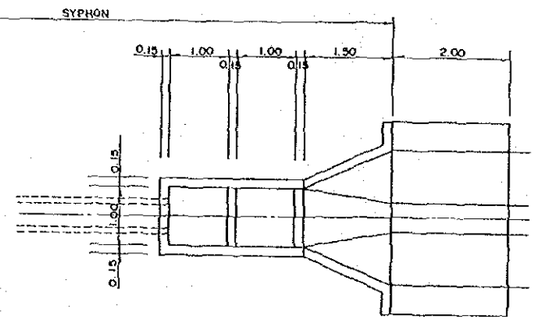
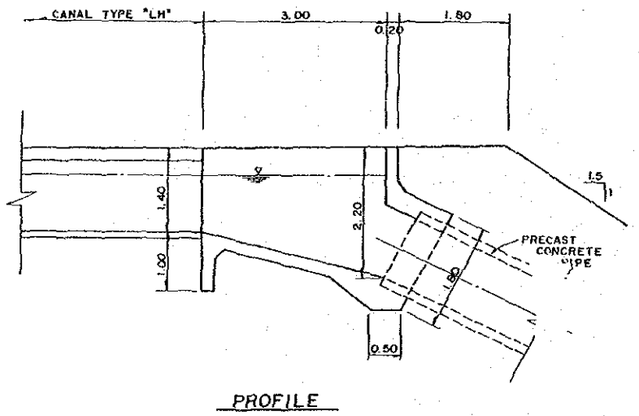
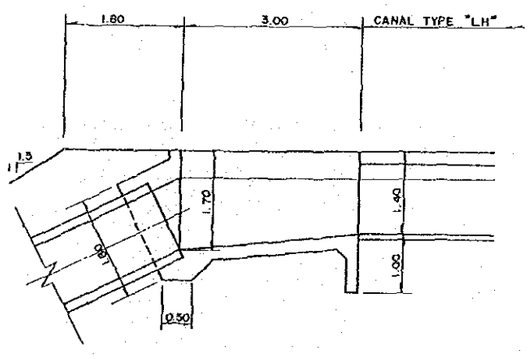


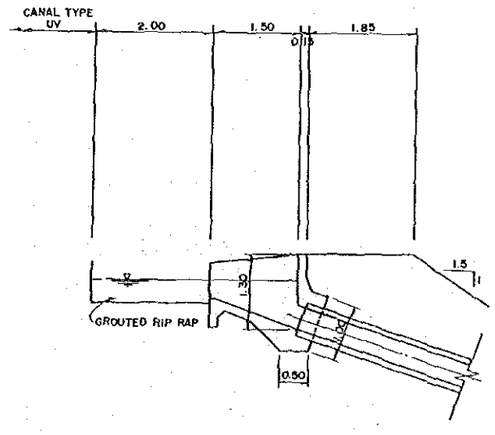
PLAN



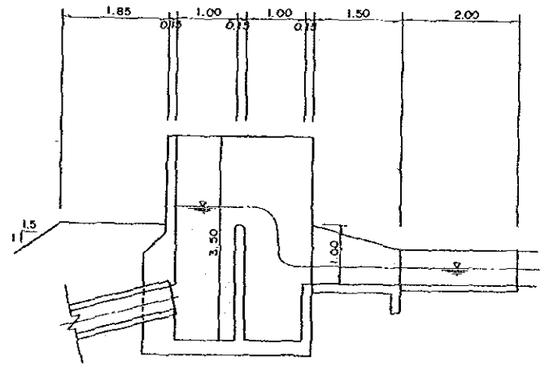
PROFILE



PROFILE



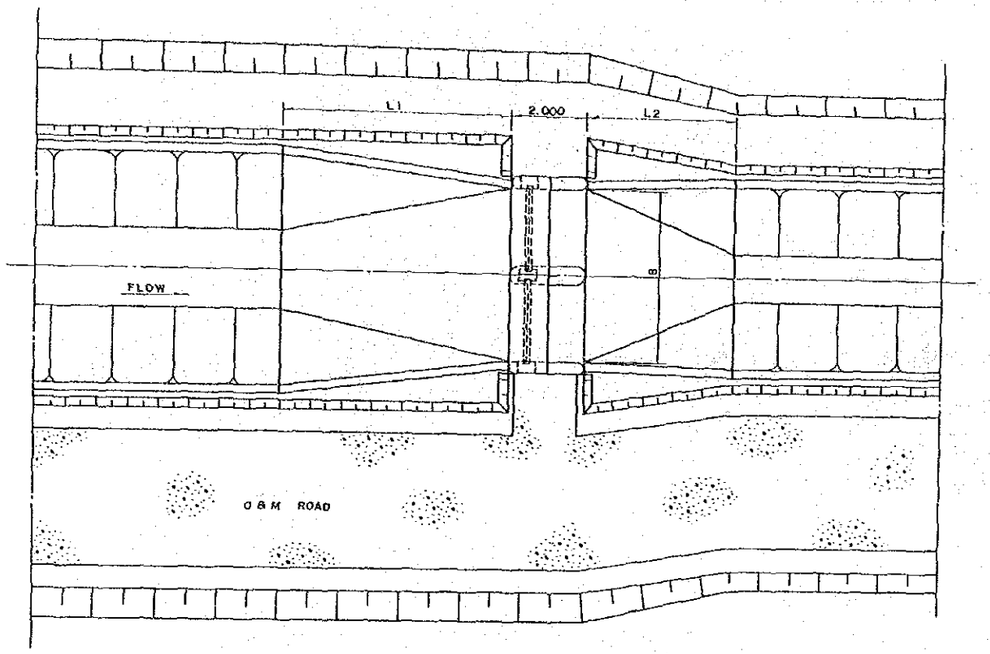
PROFILE



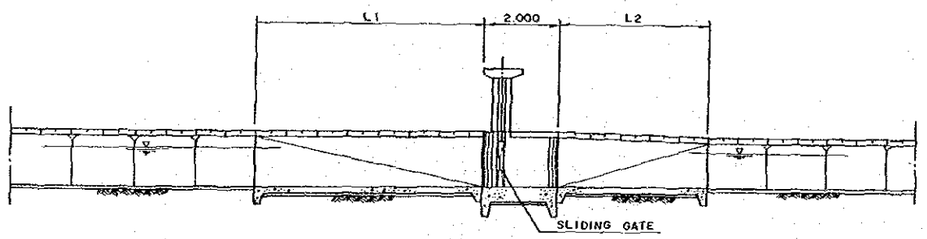
PROFILE

THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
SYPHONE	DRG NO. 9
JAPAN INTERNATIONAL COOPERATION AGENCY	

CHECK



PLAN

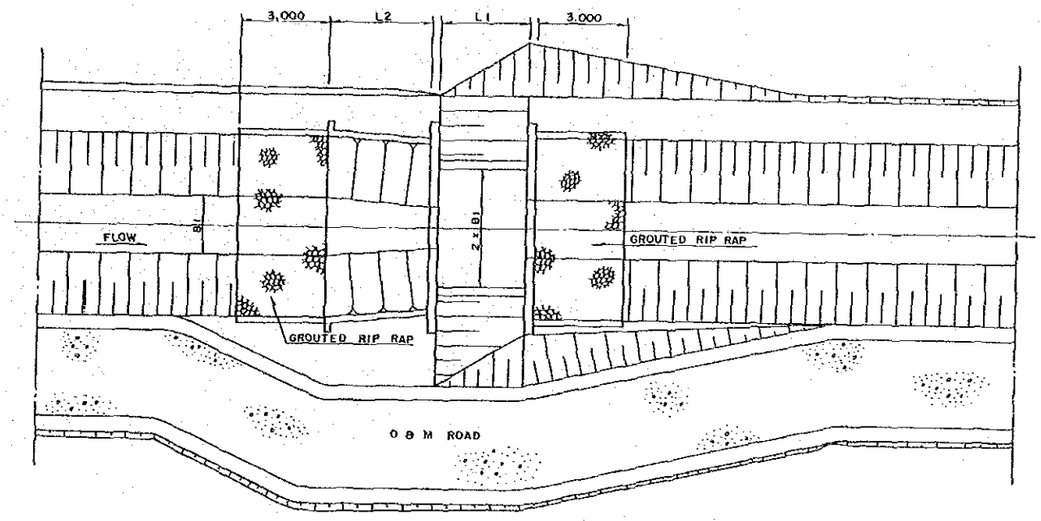


PROFILE

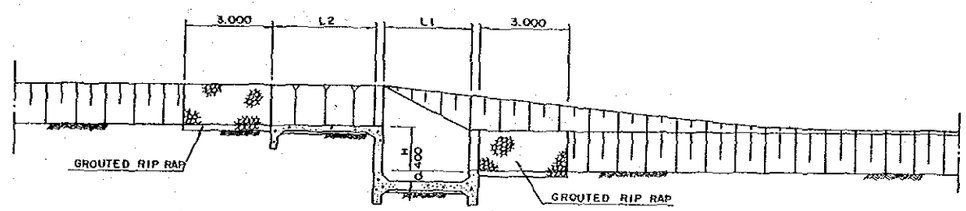
TABLE OF DIMENSIONS FOR CHECK

TYPE	Q (CMS)	B m	L1 m	NOS OF GATE	L2 m
CH-1	LESS THAN 0.5	1.00	1.00	1	3.00
CH-2	0.50 ~ 1.00	2.60	1.50	2	3.00
CH-3	1.00 ~ 2.00	3.00	3.00	2	4.00

DROP



PLAN



PROFILE

TABLE OF DIMENSIONS FOR DROP

TYPE	Q (CMS)	H	L1	L2
DP-1	LESS THAN 0.5	1.00 m	2.00 m	2.50 m
DP-2	"	1.50	2.50	"
DP-3	LESS THAN 2.5	1.00	2.50	3.50
DP-4	"	1.50	3.00	"

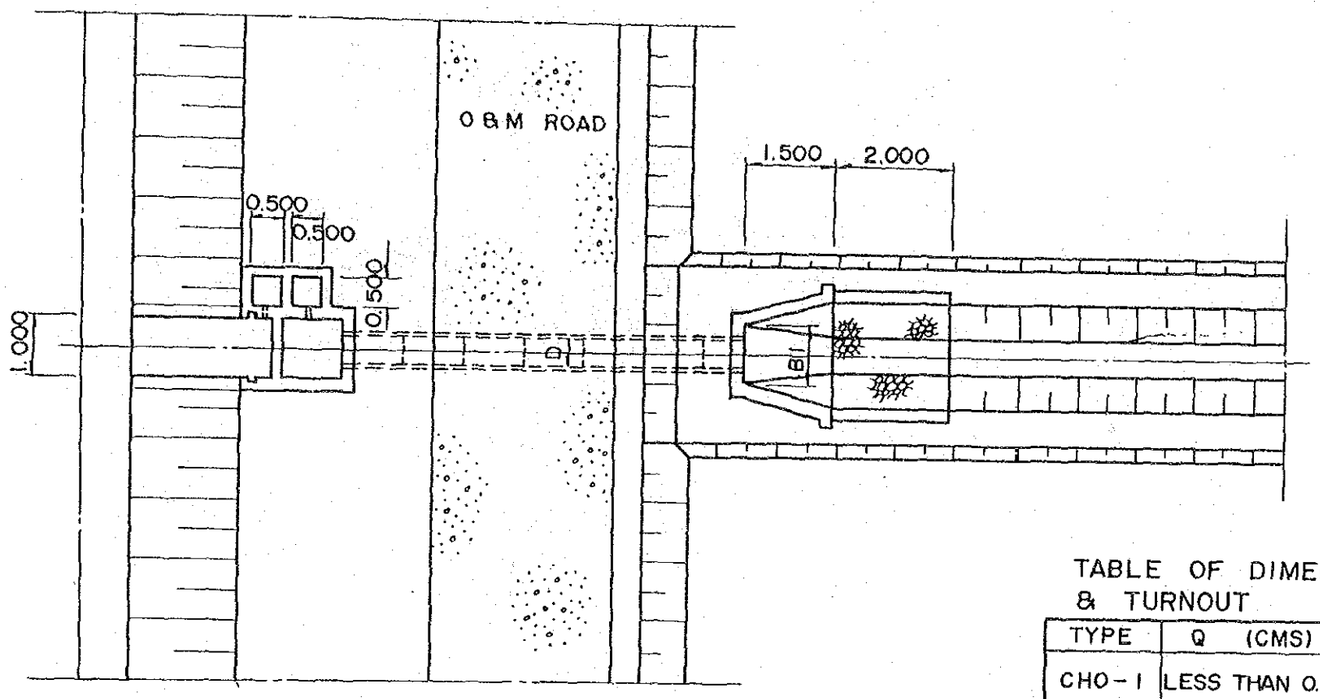
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

CHECK & DROP

DRG NO. 10

JAPAN INTERNATIONAL COOPERATION AGENCY

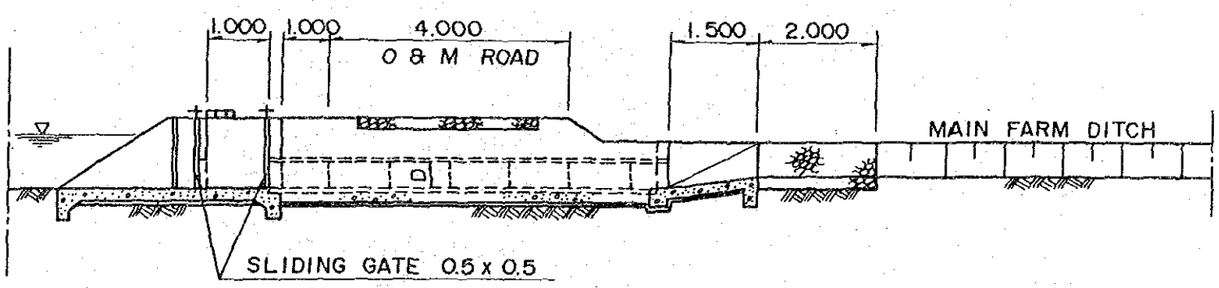
DIVERSION STRUC. & TURNOUT



PLAN

TABLE OF DIMENSIONS FOR DIVERSION STRUC & TURNOUT

TYPE	Q (CMS)	D m	B1 m
CHO-1	LESS THAN 0.1	0.45	1.00
CHO-2	0.10~0.50	0.60	1.00
CHO-3	MORE THAN 0.5	0.80	1.20

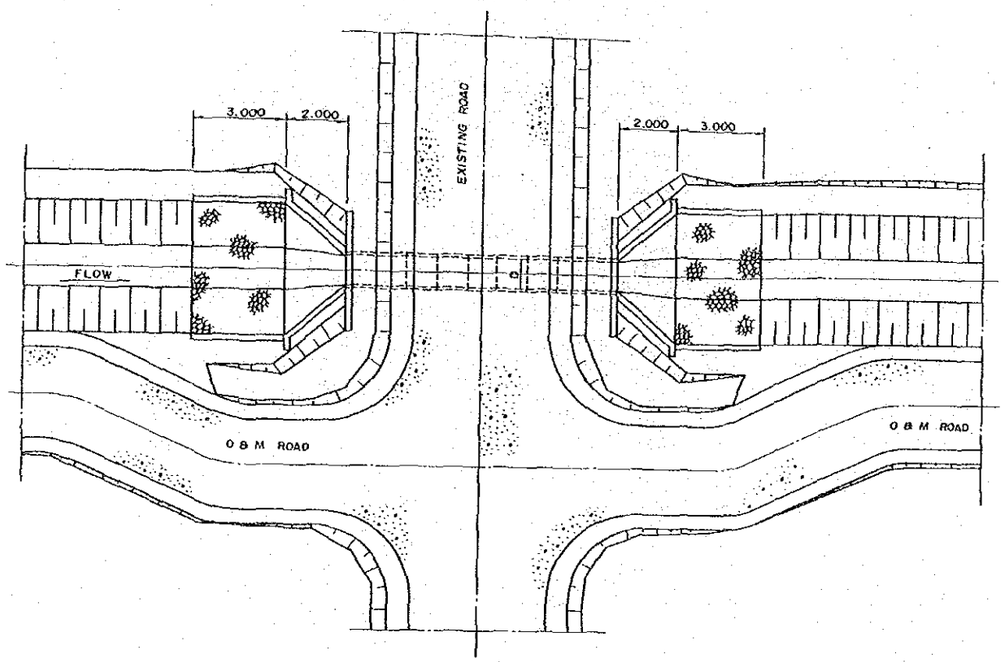


PROFILE

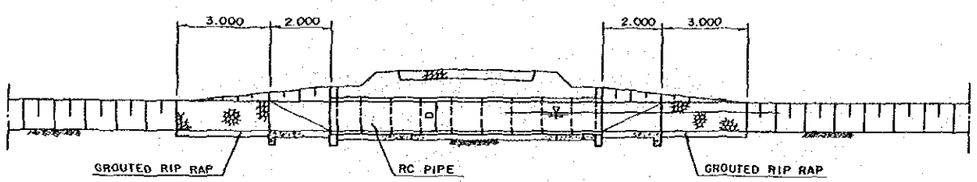
S = 1 : 100

THE REPUBLIC OF THE PHILIPPINES THE PROJECT FOR THE CAPAYAS IRRIGATION	
TURN OUT	DRG NO. 11
JAPAN INTERNATIONAL COOPERATION AGENCY	

ROAD CROSSING



PLAN

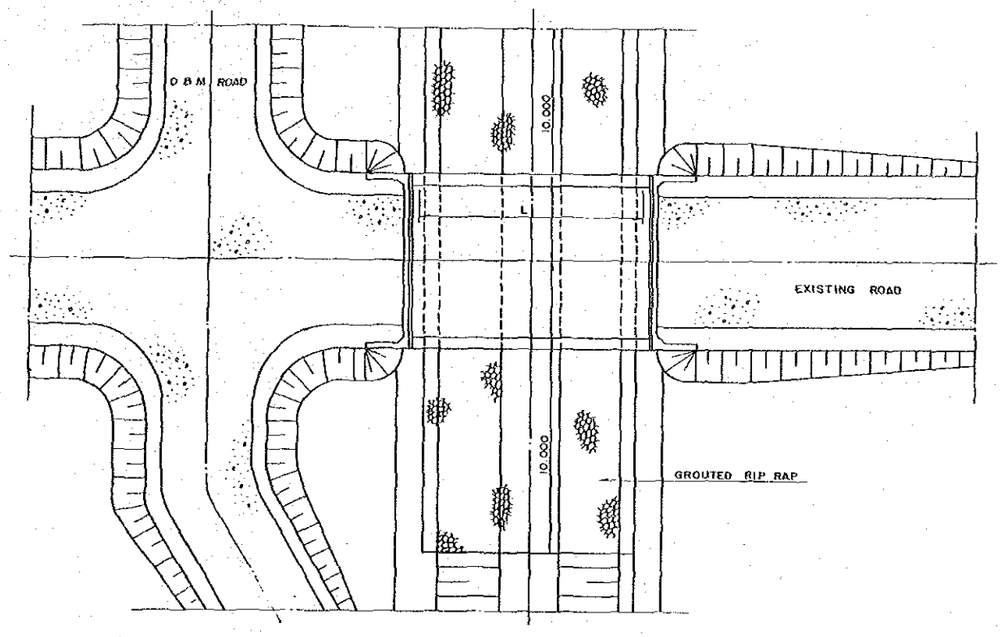


PROFILE

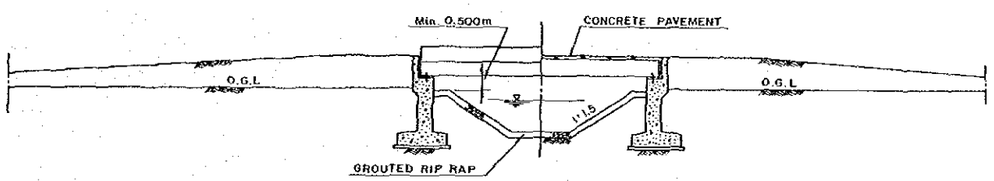
TABLE OF DIMENSIONS FOR ROAD CROSSING

TYPE	Q (CMS)	TYPE OF BARREL	D mm
CR-1	LESS THAN 0.3 m^3/s	PRE-CAST CONCRETE PIPE	450
CR-2	0.3 ~ 0.6	"	600
CR-3	0.6 ~ 1.0	"	1,000
-	MORE THAN 1.0	BRIDGE	

BRIDGE



PLAN



PROFILE

S = 1 : 100

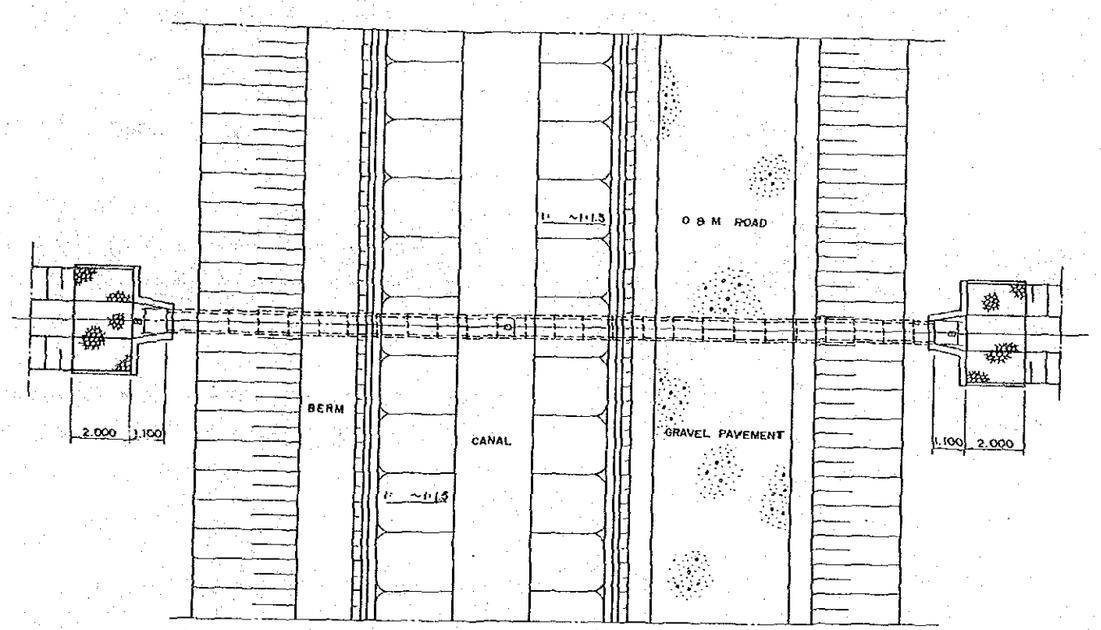
THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

ROAD CROSSING

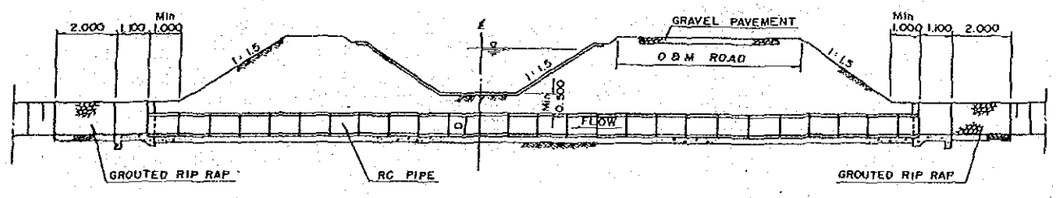
DRG NO. 12

JAPAN INTERNATIONAL COOPERATION AGENCY

CROSS DRAIN



PLAN



PROFILE

TABLE OF DIMENSIONS FOR CROSS DRAIN

TYPE	Q (CMS)	TYPE OF BARREL	D mm	B m
CD-1	LESS THAN 1.00	PRE-CAST CONCRETE PIPE	450	0.60
CD-2	1.00 ~1.50	〃	600	0.80
CD-3	MORE THAN 1.50	〃	1,000	1.20

THE REPUBLIC OF THE PHILIPPINES
THE PROJECT FOR THE CAPAYAS IRRIGATION

CROSS STRUCTURE

DRG NO. 13

JAPAN INTERNATIONAL COOPERATION AGENCY

5-4. Implementation Plan

5-4-1. Construction Condition

i) Flood diversion on the Dam Construction

The construction period of the dam is limited and then might have not enough days of the dry season even in which there happen sometimes sudden flooding by shower so that it requires an attention beforehand.

The nature of flooding in the Bayang river in dry season is studied based upon the rainfall data of Calanggaman Station nearby Capayas damsite and the result is as follows:

Station	Calanggaman Station (PAGASA-BOS)		
Records	January 1966 to October 1976		
Location	About one kilometer from the damsite (Bayang bidge)		
Nature of the rainfall	In division a year daringly, January to May shall be dry, June to December shall be wet and most dry is in April.		
Definition of dry season	Continuous one month (April)	Cont. two months (Lat.Mar.to Mid.May)	Cont. three months (March to May
Max. rainfall (in 11 years)	60.4 mm/day	60.4 mm/day	106.3 mm/day
Corresp. flood (estimated)	34 cu.m/sec	34 cu.m/sec	69 cu.m/sec
Returns of small flood (over 20 mm/day or 10 cu.m/sec approx. in 11 years)			
	4 times (0.36 times/ year)	6 times (0.55 times/ year)	16 times (1.45 times/ year)

As stated above, at least one flood of about 10 cu.m/sec on an average year occurs even in dry season and about 70 cu.m/sec on the maximum.

The scale of the diversion works, taking into consideration the dam scale and the construction schedule, would be very limited in order to save expenditures that the special arrangement for the dam construction will be proposed as follows:

River Diversion Scheme for Capayas Dam Construction

Classification	Normal Diversion	Emergency Diversion
Target flood	Normal flood in dry season (about 10 cu.m/sec)	Past Maximum flood in ditto (about 10 cu.m/sec)
Functional time	The middle and end of the dam construction period	Time of the embankment of river bed portion
Specification	Conduit cum Intake (Concreted corrugated pipe)	Broad open cut of left lower bank (Shallow overflow)
Size	2.5m x 2.5m x 90m (incl. C2.5m x 66m Corrugt.)	40m width, 65cm water depth, on the top of the conduit

The emergency diversion mentioned above of which the base could be, after completion of filling up of river portion of the dam body, elevated up according as embankment progress at the center of dam site and when it reaches upto the same elevation of the base of open cut for the spillway crest in the other side of the dam site, it becomes possible to transfer the diversion function to the spillway. For this purpose, the concrete work of the spillway crest shall be performed at the last step of the works.

ii) Treatment of the embankment materials

As for the impervious soil materials, the major embankment materials of Capayas dam could be taken from the proposed reservoir area. While its imperviousness and structural strength are present, it may be necessary to take care of the workability because the natural moisture content is rather high.

Therefore some countermeasures such as trenches at the borrow area for drainage would be recommendable. And to scrape and pile up soil materials together with gravelly materials or weathered rock sufficiently existing in the lower layers of the proposed borrow area might be effective for the improvement of workability of the materials.

On the other hand, the site is in rather high temperature and usually has a strong sunshine so that the moisture content of materials shall drop down immediately after borrowing. It may occur even in a few days of fine weather in the wet season, therefore, watering cart shall be necessary at the site of embankment.

5-4-2. Implementation Method

This project consists of construction works of dam and canals and procurement of equipment necessary for on-farm development. The construction of dam and canals will be carried out by the contractor, while the procurement of equipment such as topo-survey instrument and construction machinery will be carried out separately.

5-4-3. Construction Supervision Plan

Construction supervision includes execution of top-survey works, detailed design, tendering, tender evaluation and general and site supervision works. These activities will be carried out by the executing agency assisted by a Japanese consultant.

The consultant will appoint the chief representative for the Project.

5-4-4. Procurement Plan of Material and Construction Equipment

Following materials which will be used for the construction works are to be procured in the Philippines:

(1) Cement

(2) Reinforcing Bar

(3) Gate

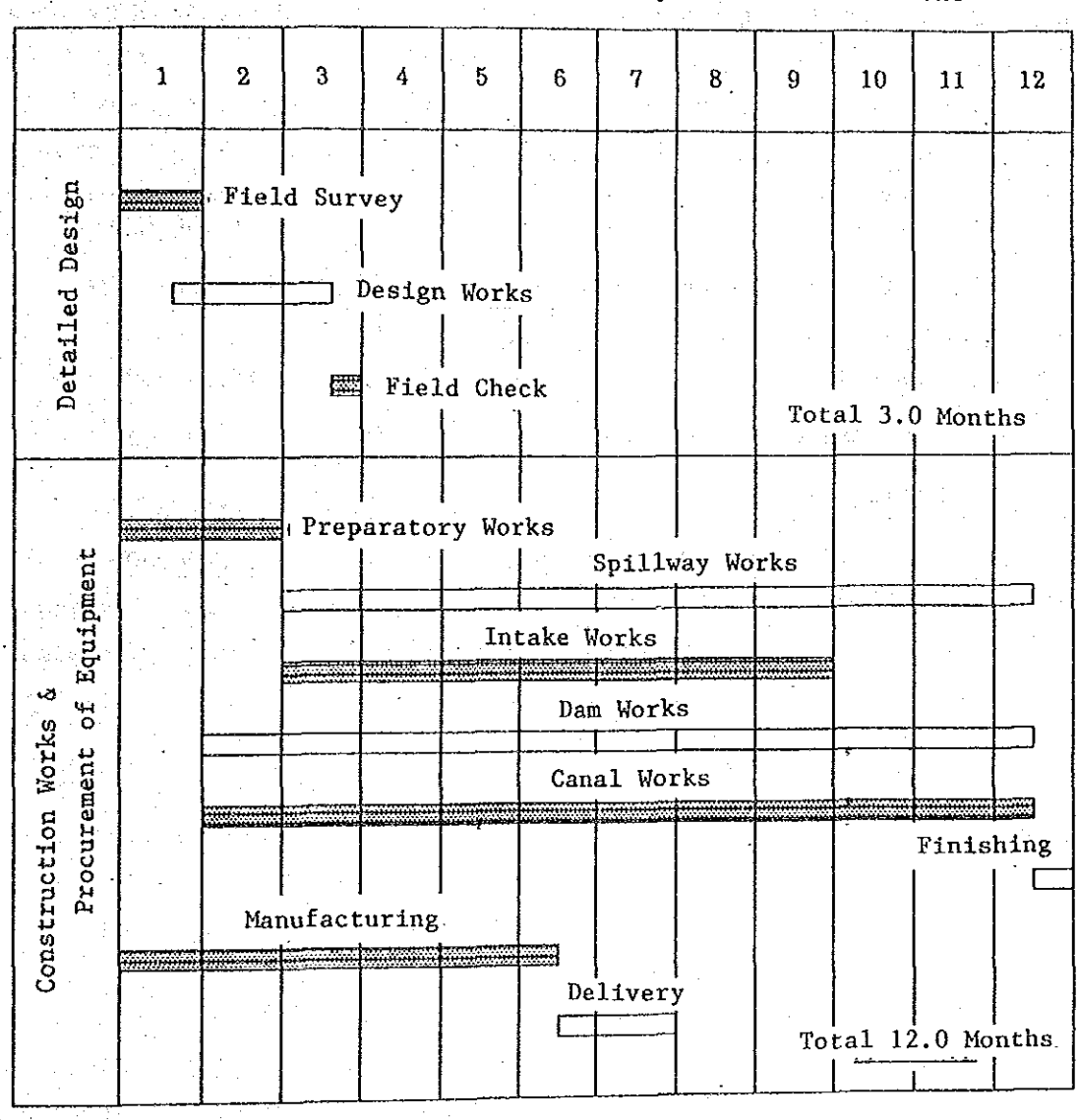
(4) Dynamite

(5) Construction Equipment

5-4-5. Implementation Schedule

The detailed design will take three months after verification of consultant's agreement, and the construction work will take twelve months after verification of construction contract. The detailed schedule is shown in Figure 5-7.

Figure 5-7. Tentative Project Implementation Schedule



5-4-6. Cost Estimation

The Philippine Government shall bear an amount of 42,000,000 pesos excluding taxes are as follows:

1) Land purchasing cost (1,024,000 x 2.5 ₱/sq.m)		₱ 2,560,000
2) Project facilities		
Site office	₱400,000	
Machinery lot	800,000	
Water supply	50,000	
Others	500,000	1,750,000
3) Construction work of on-farm development		
Fuels	₱ 541,800	
Labor	4,732,000	
Materials	500,000	14,950,000
4) Bank charge, customs fee, etc.		19,000,000
5) Contingency		3,740,000
TOTAL		₱42,000,000

CHAPTER 6. PROJECT EVALUATION AND CONCLUSION

6-1. Project Benefit

This project aims at (1) expanding the irrigated agricultural technology which has been established by the APC, and (2) establishing on-farm development engineering, as a pilot project of the entire Phase II development area of BIDP through construction of Capayas dam to supply water for 750 ha irrigable area and delivery of the equipment for on-farm development.

The direct beneficiaries of the Project cover 3,000 persons in Ubay Municipality, however, the people living in the entire BIDP Area (Phase I and Phase II) will be able to obtain benefit indirectly when irrigated agricultural technology is established.

The on-going construction of dam and main canal in BIDP (Phase I) financed under OECF Loan is expected to be completed by 1992. A construction office of BIDP (Phase I) and the NIA Provincial Office are, therefore, there is no problem for operation and maintenance of the Project.

6-2. Conclusions

The Project, upon its completion, is expected to give multiple benefits to the people in Bohol province, and on the national economy as a whole. It will also contribute to the modernization of the field irrigation system and thus modernize the rural society in the Island in general. Operation and maintenance works is also foreseeable upon completion of the Project. Toward this end, NIA, which is the executing agency of the Project, could well provide sufficient and capable engineers/experts.

In the light of the above, it is concluded that the Project will be implemented under the grant aid extended by the Japanese Government.

APPENDICES

APPENDIX 1. Member-List of Survey Team

1-1. Basic Design Study Stage

Specialty	Name	
Team Leader/Development Plan	Mr. Yoshimasa Kishi	MAFF
Grant Aid Program	Mr. Satoshi Kinugawa	MFA
Dam Design	Mr. Tadao Inaba	SCI
Irrigation and Drainage	Mr. Hiroshi Kondo	SCI
Farm Management	Mr. Kazuo Nakabayashi	SCI
Geology and Soil Exporation	Mr. Ryuzou Maruya	SCI

1-2. Draft Report Explanation Stage

Team Leader/Development Plan	Mr. Yoshimasa Kishi	MAFF
Dam Design	Mr. Tadao Inaba	SCI
Irrigation and Drainage	Mr. Hiroshi Kondo	SCI

MAFF: Ministry of Agriculture, Forestry and Fisheries

MFA: Ministry of Foreign Affairs

SCI: Sanyu Consultants Inc.

APPENDIX 2. Survey Schedule

2-1. Basic Design Study Stage

Date	Work Performed
Aug.24	All members of B/D Study Team arrived at Manila. Coutesy call to EOJ and JICA Manila Office.
25	Coutesy call to NIA and NEDA.
26	Leaving for Bohol. Coutesy call to Governor. Meeting with NIA (Bohol).
27	Site survey (Capayas damsite)
28	Site Survey (BIDP)
29	Return to Manila
30	Meeting with NIA
31	Study Team meeting
Sep. 1	Signing of Minutes of Meeting
2	Arrangement of collected data
3	Off
4	Reporting to EOJ and JICA Of-ice. Leaving for Tokyo (Governmental members).
5	Leaving for Bohol.
6	Site survey at Ubay.
7	Site survey(dam catchment and command area)
8	Site survey (dam sito and APC farm)
9	Site survey and data collection (quarry site, Provincial Irrigation Office)
10	Off
11	Site survey and data collection (Bayang bridge, meteorology, Ubay Municipality
12	Site survey and data collection. Leaving for Cebu (Nakabayashi).
13	Supervising of test pit. Data collection at Bohol and Cebu (NEDA, APC)
14	Supervising of boring. Data collection at Bohol and Manila.
15	Supervising of boring. Data collection at Bohol and Manila.
16	Supervising of boring. Data collection at Bohol and Manila.
17	Meeting with Provincial Irrigation Officer
18	Leaving for Tacloban via Cebu. Meeting with NIA Regional Office (Inaba, Kondo)

Date	Work Performed
Sep.19	Leaving for Manila.
20	Reporting to JICA Office. Receiving topo-survey results.
21	Data collection (DPWH etc.)
22	Supervising of soil test at Manila and boring at Bohol
23	Supervising boring at Bohol. Leaving for Tokyo (Nakabayashi).
24	Off
25	Supervising of soil test and boring at Bohol.
26	Data collection
27	Data collection. Leaving from Bohol (Maruya).
28	Supervision of soil test
29	Data collection (PAGASA, PIVS)
30	Arrangement of collected data
Oct.1	Preparation of leaving
2	Reporting to EOJ and JICA Office. Leaving for Tokyo.

2-2. Draft Report Explanation Stage

Date	Work Performed
Jan. 29	Arrival in Manila. Courtesy call to EOJ and JICA Manila Office.
30	Courtesy call to NIA and NEDA.
31	Discussion with Manager of PADD.
Feb. 1	-do-
2	Signing of Minutes of Meeting.
3	Collection of Supplemental Data.
4	Departure for Tokyo.

APPENDIX 3. Member List of Filipins Party

1. NEDA

Mr. Jesus M. SUNGA	Director, Infrastructure Staff
Ms. Sharon S. SARMIENTO	Program Financing Div.I, Public Investment Staff
Dr. M. ADRIANO	Director, Agriculture Staff
Mr. Librado F. QUITORIANO	Water Resources Div. Infrastructure Staff
Mr. Jowathan L. Loy	JICA Desk Officer, PIS

2. NIA

Mr. Jose B. del ROSARIO, Jr.	Administrator
Mr. Avelino S. RIVERA	Manager, PDD
Mr. Romeo F. POTENCIANO	Div. Manager, WRUD
Mr. Epifanio C. GACUSAN	Div. Manager, LRED
Mr. Rogelio P. de la ROSA	Div. Manager, Project Investigation Div.
Mr. Edilberto B. PUNZAL	OIC, Plan Formulation Div.
Mr. Wilfred D. SILVA	Head, Project Identification Section
Mr. Abelardo Y. ARMENTIA	Head, Feasibility Studies & Environmental Studies
Mr. Ebeenezer J. De PANO	Regional Irrigation Manager, Region 7 & 8
Mr. Calixto M. SEROJE	Bohol Provincial Iririgation Engr.

3. Government of Bohol Province

Mr. Constancio C. TORRALBA	Bohol Governor
Mr. Juanito G. CAMBANGAY	Provincial Planning & Development Coordinator
Mr. Severino S. CABEDE	Provincial Administrator

4. Bohol Agricultural Promotion Center (APC)

Mr. Ricardo Oblena	Manager, Bohol Agricultural Promotion Center

APPENDIX 4 Minutes of Meeting

4-1 Basic Design Study Stage

MINUTES OF DISCUSSIONS
ON
THE PROJECT FOR CAPAYAS IRRIGATION
IN
THE REPUBLIC OF THE PHILIPPINES

In response to the request made by the Government of the Philippines for a grant-aid on the Project for Capayas Irrigation (hereinafter called as "the Project"), The Government of Japan decided to conduct a Basic Design Study on the Project and entrusted the study to the Japan International Cooperation Agency (hereinafter called as "JICA"). JICA sent to the Philippines a Study Team led by Mr. Yoshimasa KISHI to carry out the study from August 24 to October 2, 1989.

The Team had a series of discussions on the Project with the officials concerned of the National Irrigation Administration (hereinafter called as "NIA") , the Government of the Philippines, headed by Mr. Jose B. del Rosario, Jr., Administrator of NIA.

As a result of the initial findings of the study, both parties agreed to recommend to their respective Governments that the major points of understanding reached between them, as attached herewith, should be examined towards the realization of the Project.

September 7 , 1989.

YOSHIMASA KISHI
Team Leader
Basic Design Study Team, JICA

JOSE B. DEL ROSARIO, JR.
Administrator
NATIONAL IRRIGATION ADMINISTRATION

MAJOR POINTS OF UNDERSTANDING

1. Objective of the Project

The objective of the Project is to implement Capayas Irrigation System as first step development and pilot project prior to whole implementation of the Bohol Irrigation Development Project, Phase I & II, and to introduce the development model of irrigated agriculture in the Project area.

2. Project Components

The Project components consist of the following development concept to achieve the project objectives mentioned in the above;

a) Development of irrigation water resources by Capayas Dam.
b) Development of irrigation and drainage canal system upto field and maintenance and operation road along the irrigation canal.

3. Executing Agency

The NIA will be responsible for the administration and execution of the Project and for the operation and maintenance of the Project after completion.

4. Project Site

The proposed project site is located in the Bohol province as shown in Figure 1.

5. Understanding of Japanese Grant-Aid System

The Basic Design Study Team explained the system of the Japanese Grant-Aid system including employment of Japanese consultant to be recommended by JICA, and Japanese contractor. The Philippine Government representatives indicated their understanding of the system.

6. Undertaking of Government of Japan

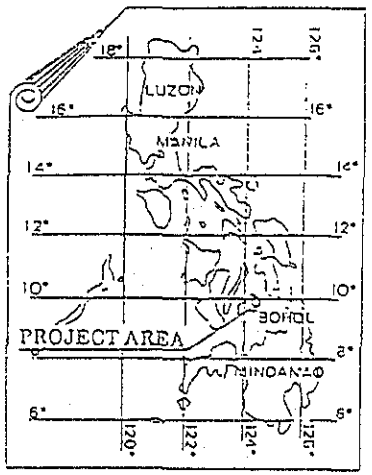
The Basic Design Study Team will convey to the Government of Japan the request of the Government of Philippines the former will take necessary measures to cooperate in implementing the Project within the scope of Japanese Grant-Aid System and its related items listed in Annex 1.

7. Undertaking of Government of Philippines

The Government of Philippines will take the necessary measures listed in Annex II on conditions that the Japanese Grant-Aid would be extended to the Project.

FIGURE 1

CAPAYAS IRRIGATION PROJECT LOCATION MAP



TALIBON
TRINIDAD
UBAY
IRRIGABLE AREA
S. MIGUEL
CAPAYAS DAM
TUBIGON
SAGBAYAN
DAGOHOY
ALICIA
CALAPE
MABINI
PILAR
CARMEN
TAGBILARAN
JAGNA

0 5 10 15 20 km
Scale

ANNEX I UNDERTAKING OF THE GOVERNMENT OF JAPAN

1. Construction of following facilities;

   a) Capayas Dam including spillway, intake and appurtenant facilities,
   b) Main and secondary irrigation canals for irrigable area of 750 ha,
   c) Maintenance and operation roads along the irrigation canal, and
   d) Drainage canals for irrigable area of 750 ha.

2. Supply and delivery of construction equipment for on farm development.

ANNEX II UNDERTAKING OF THE GOVERNMENT OF PHILIPPINES

1. To acquire the land and right of way required for dam and reservoir area, project road, canals and related structures.

2. To ensure prompt unloading and customs clearance at the port of disembarkation in the Philippines for the materials and facilities to be imported related to the Project.

3. To exempt Japanese nationals concerned from custom duties, internal taxes and other fiscal levies which may be imposed in Philippines with respect to the supply of materials and services for the construction.

4. To provide and accord necessary permission, licences and other authorization required for the execution of the Project.

5. To provide available data and information to Japanese consultant and contractor necessary for the detailed engineering services and construction.

6. To provide space necessary for construction, such as temporary office, working area, stock yard and others.

7. To ensure budgetary arrangements for operation and maintenance of the completed project facilities.

8. To execute the on-farm development utilizing construction equipment provided by the Government of Japan under the Project.

4-2 Draft Report Explanation Stage

MINUTES OF DISCUSSIONS

ON

EXPLANATION OF DRAFT FINAL REPORT FOR THE PROJECT FOR CAPAYAS IRRIGATION

IN

THE REPUBLIC OF THE PHILIPPINES

In response to the request made by the Government of the Philippines for a grant-aid on the Project for Capayas Irrigation (hereinafter called as "the Project"), The Government of Japan decided to conduct a Basic Design Study on the Project and entrusted the study to the Japan International Cooperation Agency (hereinafter called as "JICA"). JICA sent to the Philippines a Study Team led by Mr. Yoshimasa KISHI to present and explain the draft Final Report of the Project from January 29 to February 4, 1990.

The team had a series of discussions on the Project with the concerned officials of the National Irrigation Administration (hereinafter called as "NIA"), the Government of the Philippines, headed by Mr. Jose B. del Rosario, Jr., Administrator of NIA.

As a result of the discussions, both parties agreed to recommend to their respective Governments that the major points of understanding reached between them, as attached herewith, should be examined towards the realization of the Project.

February 2, 1990

YOSHIMASA KISHI
Team Leader
Basic Design Study Team, JICA

JOSE B. DEL ROSARIO, JR.
Administrator
NATIONAL IRRIGATION ADMINISTRATION

MAJOR POINTS OF UNDERSTANDING

1. Both parties agreed to reconfirm the Minutes of Discussions which was mutually signed on September 1, 1989. As for the undertakings of the Government of the Philippines, both parties reconfirmed the items described in Annex I.

2. The Government of the Philippines has agreed in principle the basic design proposed in the draft Final Report. Some minor improvements agreed by both parties during the course of the discussion will be incorporated in the Final Report.

3. The Government of the Philippines has accepted Japan's grant-aid system and the arrangements to be undertaken by the Government of the Philippines including provisions of the necessary staff and budgetary arrangement for the construction of on-farm development and maintenance of the Project on condition that Japan's Grant Aid would be extended.

4. 10 copies of the Final Report will be submitted to the Government of the Philippines by the end of March, 1990.

ANNEX I UNDERTAKINGS OF THE GOVERNMENT OF PHILIPPINES

1. To acquire the land and right of way required for dam and reservoir area, project road, canals and related structures.

2. To ensure prompt customs clearance at the port of disembarkation in the Philippines for the materials and facilities to be imported related to the Project.

3. To exempt Japanese nationals concerned from custom duties, internal taxes and other fiscal levies which may be imposed in Philippines with respect to the supply of materials and services for the construction.

4. To provide and accord necessary permission, licenses and other authorization required for the execution of the Project.

5. To provide available data and information to the Japanese consultant and contractor necessary for the detailed engineering services and construction.

6. To provide space necessary for construction, such as temporary office, working area, stock yard and others.

7. To ensure budgetary arrangements for operation and maintenance of the completed project facilities.

8. To execute the on-farm development utilizing construction equipment provided by the Government of Japan under the Project.

APPENDIX 5 Attached Tables and Figures

LIST OF ATTACHED TABLES AND FIGURES

Table A-2-1. Croppred Area

(unit: million Ha)

	1980	1983	1984	1985	1986	1987
Harvested Area	12.764	12.649	12.602	13.004	13.248	12.804
Grain, total	6.670	6.186	6.389	6.817	7.059	6.939
Rice	3.471	3.054	3.162	3.307	3.464	3.256
Maize	3.199	3.132	3.227	3.511	3.595	3.683
Other Food Crops	5.554	5.878	5.759	5.685	5.724	5.416
Coconuts	3.010	3.205	3.272	3.245	3.335	3.058
Sugarcane	0.460	0.480	0.486	0.407	0.298	0.256
Fruits	0.655	0.720	0.715	0.719	0.741	0.739
Vegetables	1.323	1.319	1.130	1.153	1.186	1.197
Non-Food Crops	0.539	0.585	0.453	0.502	0.466	0.449
Fiber Crops	0.285	0.229	0.207	0.213	0.206	0.198
Others	0.254	0.356	0.247	0.289	0.260	0.251

Table A-2-2. Crop Yield

(unit: ton/ha)

	1980	1983	1984	1985	1986	1987
Crop,total	3.69	3.28	3.17	3.31	3.31	3.35
Grain, total	1.60	1.69	1.73	1.86	1.89	1.85
Rice	2.20	2.39	2.48	2.66	2.67	2.62
Maize	0.95	1.00	1.01	1.10	1.14	1.16
Other Food Crops	6.42	5.20	4.92	4.14	5.23	5.46
Coconuts	5.18	3.40	3.35	3.44	3.58	3.86
Sugarcane	4.95	4.91	5.19	6.75	4.94	4.96
Fruits	11.36	10.53	10.23	10.74	10.67	10.72
Vegetables	7.74	7.29	6.54	6.98	7.15	7.05

Table A-2-3. Crop Production

(unit: million tons)

	1980	1983	1984	1985	1986	1987
Crop, total	47.90	41.55	39.96	43.10	43.86	42.93
Grain, total	10.70	10.43	11.08	12.67	13.34	12.82
Rice	7.65	7.29	7.83	8.81	9.25	8.54
Maize	3.05	3.13	3.25	3.86	4.09	4.28
Other Food Crops	35.68	30.57	28.32	23.55	29.93	29.57
Coconuts	15.59	10.89	10.97	11.15	11.93	11.80
Sugarcane	2.27	2.36	2.52	2.75	1.47	1.27
Fruits	7.44	7.58	7.31	7.72	7.91	7.92
Vegetables	10.24	9.61	7.39	8.05	8.48	8.44
Non-Food Crops	0.71	0.55	0.56	0.62	0.59	0.55
Fiber Crops	0.51	0.33	0.27	0.29	0.28	0.26
Others	0.20	0.22	0.28	0.33	0.31	0.29

Table A-5-1. SEISMIC ANALYSIS BY DR. OKAMOTO'S FORMULA

PROJECT NAME ; BOHOL IRRIGATION PROJECT II F/S

LOCATION ; BAYONGAN, SAN-MIGUEL, BOHOL

DAMSITE'S LATITUDE ; 9.96(DEGREES)

DITTO LONGITUDE ; 124.35(DEGREES)

NUMBER OF DATA ; 83 RECORDS ; 1907 TO 1982 = 76 YRS

NO.	DATE (M-D-Y)	LAT. (DEG)	LON. (DEG)	MG.	DIST. (KM)	ACC. (GAL)	NO./Y
1	03.07.50	10.00	124.00	6.8	38.52	191.1	0.0132
2	09.02.48	10.00	125.00	7.0	71.20	134.4	0.0263
3	10.30.26	9.50	124.50	6.3	53.63	101.9	0.0395
4	07.19.41	10.00	124.00	5.8	38.52	89.6	0.0526
5	02.04.41	9.00	124.00	6.9	113.24	67.4	0.0658
6	09.21.29	10.00	125.00	6.0	71.20	51.1	0.0789
7	07.12.11	9.00	126.00	7.8	209.73	46.3	0.0921
8	01.26.56	10.00	124.00	5.0	38.52	37.3	0.1053
9	03.10.75	9.60	124.10	5.2	48.42	34.2	0.1184
10	03.19.52	9.50	126.50	7.8	240.69	33.4	0.1316
11	01.24.48	10.50	122.00	8.2	263.61	31.7	0.1447
12	05.05.25	9.50	123.00	6.8	156.27	31.2	0.1579
13	01.24.48	11.00	122.00	8.2	281.28	26.6	0.1711
14	03.31.55	8.00	124.00	7.3	220.92	25.5	0.1842
15	05.24.31	10.00	125.50	6.3	125.80	24.7	0.1974
16	07.25.42	11.50	124.50	6.8	171.72	24.6	0.2105
17	06.07.47	11.50	125.00	6.9	185.06	23.5	0.2237
18	05.06.65	9.60	124.10	4.9	48.42	22.6	0.2368
19	02.10.57	10.25	126.00	6.8	183.16	20.6	0.2500
20	02.10.57	10.00	126.00	6.7	180.43	18.2	0.2632
21	12.14.77	10.00	125.30	5.8	103.95	17.4	0.2763
22	01.14.82	9.99	124.23	3.4	13.54	17.1	0.2895
23	10.20.42	8.50	122.50	7.3	259.51	15.8	0.3026
24	02.10.57	10.00	126.00	6.6	180.43	15.3	0.3158
25	03.12.15	12.00	124.00	7.0	229.63	14.5	0.3289
26	01.01.19	8.00	126.00	7.4	282.95	13.7	0.3421
27	02.11.57	10.00	126.00	6.5	180.43	12.7	0.3553
28	05.03.82	10.03	124.44	3.1	12.54	12.5	0.3684
29	02.10.57	10.25	126.00	6.5	183.16	12.1	0.3816
30	09.23.73	10.35	125.30	5.7	112.46	11.7	0.3947
31	09.22.40	8.00	124.00	6.8	220.92	11.5	0.4079
32	08.30.24	8.50	126.50	7.3	285.92	11.4	0.4211
33	05.03.43	12.50	125.50	7.4	308.49	10.1	0.4342
34	03.07.50	11.00	122.50	6.8	232.59	9.6	0.4474
35	04.27.19	11.00	123.00	6.4	187.19	9.2	0.4605
36	03.07.50	10.50	122.25	6.8	237.10	9.0	0.4737
37	01.24.31	10.00	126.00	6.3	180.43	8.5	0.4868
38	02.11.57	10.00	126.00	6.3	180.43	8.5	0.5000

CONTINUED

CONTINUED

NO.	DATE (M-D-Y)	LAT. (DEG)	LON. (DEG)	MG.	DIST. (KM)	ACC. (GAL)	NO./Y
39	02.10.57	10.50	126.50	6.8	242.38	8.3	0.5132
40	08.13.36	9.00	126.50	6.8	258.39	6.5	0.5263
41	03.15.80	9.79	124.45	3.1	21.81	6.2	0.5395
42	08.18.57	12.00	124.50	6.5	227.03	5.5	0.5526
43	04.10.55	8.00	125.00	6.5	228.93	5.4	0.5658
44	07.08.51	9.90	122.20	6.5	235.17	4.8	0.5789
45	09.16.82	10.09	124.79	4.0	50.21	4.7	0.5921
46	05.27.79	9.92	124.91	4.3	61.39	4.7	0.6053
47	11.14.81	10.07	125.29	5.1	103.47	4.4	0.6184
48	03.31.55	8.10	123.20	6.5	241.91	4.3	0.6316
49	03.31.55	8.10	123.20	6.5	241.91	4.3	0.6447
50	09.23.82	9.60	124.34	3.6	39.97	4.1	0.6579
51	11.15.57	8.00	124.50	6.3	218.18	4.0	0.6711
52	11.05.41	12.50	123.00	6.9	317.95	3.3	0.6842
53	02.17.70	9.80	125.90	5.8	170.42	3.3	0.6974
54	07.04.81	10.35	124.84	4.3	68.85	3.3	0.7105
55	02.05.81	9.84	124.09	3.1	31.40	3.0	0.7237
56	01.16.78	9.68	124.81	4.0	59.14	2.9	0.7368
57	05.01.79	9.36	125.46	5.4	138.52	2.9	0.7500
58	07.13.62	10.00	123.00	5.5	147.65	2.8	0.7632
59	09.10.52	10.50	123.50	5.0	110.52	2.8	0.7763
60	12.12.68	9.67	125.78	5.6	159.68	2.6	0.7895
61	07.13.62	10.00	122.50	6.0	202.29	2.6	0.8026
62	07.12.31	12.00	123.00	6.5	270.03	2.6	0.8158
63	07.12.70	10.84	125.41	5.5	151.44	2.5	0.8289
64	11.25.81	9.39	124.35	4.0	63.27	2.3	0.8421
65	11.25.62	11.20	124.80	5.4	146.14	2.3	0.8553
66	07.08.51	11.00	122.00	6.5	281.28	2.1	0.8684
67	03.20.81	9.67	124.56	3.2	39.54	2.0	0.8816
68	11.10.75	10.57	124.10	4.1	73.01	1.7	0.8947
69	09.16.82	10.14	124.72	3.3	45.11	1.7	0.9079
70	10.10.80	10.59	124.78	4.3	84.24	1.6	0.9211
71	06.15.28	11.50	121.50	6.8	354.72	1.5	0.9342
72	12.07.69	9.67	125.63	5.2	143.65	1.5	0.9474
73	12.28.79	9.85	125.18	4.4	91.57	1.4	0.9605
74	04.01.65	9.93	125.85	5.4	164.03	1.3	0.9737
75	01.21.64	10.50	125.50	5.1	139.19	1.3	0.9868
76	03.17.62	9.50	123.00	5.3	156.27	1.3	1.0000
77	09.13.73	9.20	126.10	5.8	209.30	1.2	1.0132
78	05.03.81	9.44	124.48	3.6	59.45	1.2	1.0263
79	06.12.64	11.25	124.75	5.2	149.69	1.2	1.0395
80	03.06.82	10.01	125.06	4.0	77.81	1.0	1.0526
81	09.22.77	10.39	124.17	3.3	51.62	1.0	1.0658
82	11.16.82	10.23	124.74	3.3	52.10	1.0	1.0789
83	04.08.77	9.04	121.82	4.4	295.20	0.0	1.0921

Table A-5-2. Comparative Estimation of Design Flood (Capayas)

Step	Method	Description	Max. Discharge	Equivalent Creager's C	Remarks
The Prime	B.P.W's Formula (Rare)	$Q_{max} = \frac{150 \cdot A}{\sqrt{A + 13}}$	417 cu.m/sec or 28.6 cu.m/sec/sq.km	77	A; Catchment Area 14.6 sq.km
Verif. 1	Creager's Formula (C = 75) 1/	$Q_{max} = 46CA^{(0.894A^{-0.048})}$	405 cu.m/ sec or 27.7 cu.m/sec/sq.km	75	Q; in cu.ft/sec A; in sq. mile
Verif. 2	Rational Method (R.P = 1,000 yrs)	$Q_{max} = \frac{1}{3.6} \cdot f \cdot r_t \cdot A$ With the Rainfall data at Dagohoy 1957 - 84	369 cu.m/sec or 25.3 cu.m/sec/sq.km	68	$f = 0.9$ $r_t = \frac{R24}{24}\left(\frac{24}{T}\right)^{0.6}$ $= \frac{403.5}{24}\left(\frac{24}{1.2}\right)^{0.6}$ $\fallingdotseq 101$ mm/hr $T \fallingdotseq 200A^{0.22}r_t^{-0.35}$ $= 1.2$ hr 2/
Verif. 3	From Traces of Historic Floods in Bohol	Typhoon "DELILAH: at Nov. 22, 1964	2,219 3/ cu.m/sec or 3.80 cum./sec/sq.km	40.7	
		Typhoon "NITANG" at Sept. 2, 1984	1,410 3/ cu.m/sec 2.41 cu.m/sec/sq.km	25.9	
Verif. 4	From the Probably Maximum Precipitation	-	-	-	Meteorological P M P may be only about 200 mm/day $403.5 \gg 200$

Note: 1. C = 75 is particularly applied because of small scale of Capayas dam.
2. Fukushima & Kadoya's Formula
3. These data were obtained by the survey of Flood Traces at Loboc Hydropower Station (Mar. 1985)

Table A-5-3. ESTIMATION OF POTENTIAL EVAPOTRANSPIRATION BY PENMAN METHOD

Station : Tagbilaran (Latitude : 10°00', Altitude : 30m MSL)

Month	Rediation Term						Aerodynamic Term					Adjust-ment Factor	Reference Crop Evapotranspiration ETo	
	Weighting Factor	Net Radiation (mm/day)					Weighting Factor	Wind Function	Vapour Pressure (mbar)					
	W.	Ra	Rs	Rns	Rnl	Rn	1-W	f(u)	ea	ed	ea-ed	C	mm/day	mm/month
Jan.	0.75	13.2	5.9	4.44	0.78	3.66	0.25	0.59	33.80	28.02	5.78	1.00	3.60	111.6
Feb.	0.75	14.2	6.4	4.78	0.80	3.99	0.25	0.60	34.00	27.64	6.36	1.00	3.94	110.3
Mar.	0.76	15.3	7.7	5.74	0.95	4.79	0.24	0.58	35.30	27.96	7.34	1.00	4.66	144.5
Apr.	0.77	15.7	7.9	5.91	0.94	4.97	0.23	0.56	37.00	28.64	8.36	1.01	4.96	148.8
May.	0.77	15.5	7.0	5.21	0.73	4.49	0.23	0.52	38.70	30.50	8.20	1.01	4.48	138.9
Jun.	0.77	15.3	5.9	4.40	0.53	3.88	0.23	0.50	38.30	31.21	7.09	1.01	3.84	115.2
Jul.	0.77	15.3	6.1	4.60	0.59	4.01	0.23	0.54	37.80	30.62	7.18	1.00	3.98	123.4
Aug.	0.77	15.5	6.2	4.64	0.59	4.05	0.23	0.57	38.50	30.42	8.09	1.00	4.18	129.6
Sep.	0.77	15.3	6.1	4.58	0.58	4.00	0.23	0.55	38.00	30.70	7.30	1.00	4.00	120.0
Oct.	0.77	14.7	5.9	4.39	0.57	3.82	0.23	0.51	37.00	30.71	6.29	1.01	3.72	115.3
Nov.	0.76	13.6	6.1	4.57	0.71	3.86	0.24	0.53	36.30	30.67	5.63	1.01	3.69	110.7
Dec.	0.76	12.9	5.2	3.89	0.61	3.28	0.24	0.55	35.10	29.45	5.65	1.00	3.24	100.4
Average	0.76	14.7	6.3	4.76	0.69	4.07	0.24	0.55	36.70	29.76	6.94	1.00	4.01	122.4

Table A-5-4. Calculation of Evapotranspiration by Penman Method

Latitude : 10°00'
Altitude : 30 m MSL

$$ETo = C\,[W.Rn + (1-w).f(u).(ea-ed)]$$

Month	Temperature (°C)			Relative Humidity (%)			Dewpoint Temperature	Vapour Pressure	Wind Speed Height		Weighting Factor		Sunshine hour (hr)		Radiation (mm/day)	Adjustment Factor: Wind Speed (m/sec)			Adjustment Factor: Solar Radiation (mm/day)	
	Tmax	Tmin	Tmean	RHmax	RHmin	RHmean	Tdmean	ea	Uz	He	(1-W)	W	n	N	Ra	Uday	Unight	Ud/Un	Rs	c
Jan.	30.4	21.7	26.1	93.3	72.1	82.9	22.6	33.8	132.0	3.7	0.25	0.75	4.6	11.6	13.2	1.53	1.02	1.5	5.9	1.00
Feb.	30.8	21.6	26.2	90.8	70.3	81.3	22.4	34.0	136.8	3.7	0.25	0.75	4.7	11.8	14.2	1.58	1.05	1.5	6.4	1.00
Mar.	31.7	21.8	26.8	90.5	69.8	79.2	22.5	35.3	129.6	3.7	0.24	0.76	6.0	12.0	15.3	1.50	1.00	1.5	7.7	1.00
Apr.	32.8	22.5	27.6	86.8	68.0	77.4	23.3	37.0	120.0	3.7	0.23	0.77	6.2	12.3	15.7	1.39	0.93	1.5	7.9	1.01
May.	33.1	23.6	28.4	89.1	71.3	78.8	24.3	38.7	105.6	3.7	0.23	0.77	5.0	12.6	15.5	1.22	0.81	1.5	7.0	1.01
Jun.	32.6	23.8	28.2	90.7	72.6	81.5	24.4	38.3	96.0	3.7	0.23	0.77	3.4	12.7	15.3	1.11	0.74	1.5	5.9	1.01
Jul.	32.3	23.7	28.0	91.5	71.4	81.0	24.2	37.8	112.8	3.7	0.23	0.77	3.8	12.6	15.3	1.31	0.87	1.5	6.1	1.00
Aug.	32.6	23.9	28.3	90.5	70.4	79.0	24.1	38.5	127.2	3.7	0.23	0.77	3.7	12.4	15.5	1.47	0.98	1.5	6.2	1.00
Sep.	32.5	23.7	28.1	90.8	72.7	80.8	24.1	38.0	115.2	3.7	0.23	0.77	3.6	12.1	15.3	1.33	0.89	1.5	6.1	1.00
Oct.	32.1	23.3	27.6	92.4	73.5	83.0	24.1	37.0	100.8	3.7	0.23	0.77	3.5	11.8	14.7	1.17	0.78	1.5	5.9	1.01
Nov.	31.8	22.8	27.3	93.5	75.0	84.5	24.0	36.3	108.0	3.7	0.24	0.76	4.6	11.6	13.6	1.25	0.83	1.5	6.1	1.01
Dec.	31.2	22.5	26.7	93.5	74.4	83.9	23.6	35.1	117.6	3.7	0.24	0.76	3.5	11.5	12.9	1.36	0.91	1.5	5.2	1.00
Average	32.0	22.9	27.4	91.1	71.8	81.1	23.6	36.7	116.8	3.7	0.24	0.76	4.4	12.1	14.7	1.35	0.90	1.5	6.3	1.00

Table A-5-5. Consumptive Use of Rice

Month	Evapotranspiration			Crop Consumptive Use	
	mm/day	mm/month	ET/ETc.	mm/day	mm/month
Jan.	3.60	111.6	1.45	5.3	161.9
Feb.	3.94	110.3	1.37	5.4	151.2
Mar.	4.66	144.5	1.38	6.4	199.4
Apr.	4.94	148.2	1.46	7.2	216.4
May.	4.48	138.9	1.50	6.7	208.4
Jun.	3.84	115.2	1.50	5.8	172.8
Jul.	3.98	123.4	1.49	5.9	183.9
Aug.	4.18	129.6	1.42	5.9	184.1
Sep.	4.00	120.0	1.27	5.1	152.4
Oct.	3.72	115.3	1.28	4.8	147.6
Nov.	3.69	110.7	1.41	5.2	156.1
Dec.	3.24	100.4	1.34	4.3	134.6

Table A-5-6. Crop Coefficient of Upland Crops

Month		Mungbeans	Peanut	Corn	Vegetable
Dec.	I				
	II				
	III		0.54	0.54	
Jan.	I		0.57	0.57	
	II		0.63	0.65	
	III	0.52	0.75	0.80	0.50
Feb.	I	0.56	0.87	0.95	0.57
	II	0.70	0.95	1.05	0.70
	III	0.87	0.97	1.08	0.88
Mar.	I	0.96	0.95	1.07	0.97
	II	0.97	0.88	1.04	0.96
	III	0.91	0.55	0.95	0.50
Apr.	I	0.85			
	II				
	III				

Table A-5-7. Consumptive Use of Upland Crops

Month	ETo	Mungbeans	Peanut	Corn	Vegetable
Dec. III	3.24		1.75 (–)	1.75 (–)	
Jan. I	3.60		2.05 (1.94)	2.05 (1.94)	
II	3.60		2.27 (2.05)	2.34 (2.05)	
III	3.60	1.87 (–)	2.70 (2.27)	2.88 (2.34)	1.80 (–)
Feb. I	3.94	2.21 (2.05) 1/	3.43 (2.96)	3.74 (3.15)	2.25 (1.97)
II	3.94	2.76 (2.21)	3.74 (3.43)	4.14 (3.74)	2.76 (2.25)
III	3.94	3.43 (2.76)	3.82 (3.74)	4.26 (4.14)	3.47 (2.76)
Mar. I	4.66	4.47 (4.05)	4.43 (4.52)	4.96 (5.03)	4.52 (4.10)
II	4.66	4.52 (4.47)	4.10 (4.43)	4.85 (4.99)	4.47 (4.52)
III	4.66	4.24 (4.52)	2.56 (4.10)	4.43 (4.85)	4.47 (4.47)
Apr. I	4.94	3.96 (4.50)	– (2.72)	– (4.69)	2.47 (4.74)
II	4.94	– (4.20)			(2.47)
III					

Note: 1/ : Figures in parenthesis show the consumptive use in case of planting lag of crops.

Table A-5-8. Unit Consumptive Use of Upland Crops by 10 Days

(Unit: mm)

		Paddy				Upland Crops			
		Dry Season		Wet Season					
		Paddy (1) 1/	Paddy (2) 2/	Paddy (1)	Paddy (2)	Mungbean	Peanuts	Corn	Vegetable
Oct.	I			21.8	36.3				
	II			7.3	21.8				
	III	30.0	30.0		7.8				
Nov.	I	42.5	42.5						
	II	49.9	49.9						
	III	64.6	64.6						
Dec.	I	46.3	46.3						
	II	47.3	47.3				9.5	9.5	
	III	58.4	58.4						
Jan.	I	63.0	63.0				20.0	20.0	
	II	63.0	63.0				21.6	22.0	
	III	68.3	68.3			10.3	27.3	28.7	10.1
Feb.	I	60.0	60.0			21.1	31.6	34.1	21.1
	II	52.5	60.0			24.6	35.5	39.0	24.8
	III	31.3	43.8			24.5	30.0	33.2	24.6
Mar.	I	25.9	43.1			43.0	45.1	50.0	43.5
	II	8.6	25.9			45.4	43.0	49.6	45.4
	III		9.4			48.6	37.0	57.4	41.6
Apr.	I					32.8	13.5	23.3	28.2
	II					10.5			12.3
	III								
May.	I								
	II								
	III			37.5	37.5				
Jun.	I			52.5	52.5				
	II			60.9	60.9				
	III			77.6	77.6				
Jul.	I			55.6	55.6				
	II			56.9	56.9				
	III			70.5	70.5				
Aug.	I			66.0	66.0				
	II			66.0	66.0				
	III			71.6	71.6				
Sep.	I			58.0	58.0				
	II			50.8	58.0				
	III			36.3	50.8				
Total		711.6	775.5	789.3	847.8	260.8	314.1	361.3	251.6

1/ : Paddy (1) ..... Transplanting Paddy
Paddy (2) ..... Direct Sowing Paddy

Table A-5-9. Average Irrigation Water Requirement of Wet Season Rice

No.	Month		Equation for Calculation of WCWR	Weighted 10-day CWR		Irrigation Water Requirement Per Hectare
1	May.	III	$WR = 19P_2/40$	$(19\times66)/40 =$	31.4	0.679
2	Jun.	I	$WR = (20P_2+9P_1+3P)/40$	$(20\times66+9\times29+3\times45)/40 =$	42.9	0.927
3		II	$WR = (20P_2+10P_1+10P+5W_2)/40$	$(20\times66+10\times29+10\times45+5\times67)/40 =$	59.9	1.295
4		III	$WR = (20P_2+10P_1+10P\times20W_2)/40$	$(20\times66+10\times29+10\times45+20\times67)/40 =$	85.0 (max.)	1.837 1/
5	Jul.	I	$WR = (P_2+10P_1+10P+20W_2+10W_3)/40$	$(66+10\times29+10\times45+20\times67+10\times65)/40 =$	69.9	1.511
6		II	$WR = (P_1+7P+20W_2+20W_3)/40$	$(29+7\times45+20\times67+20\times65)/40 =$	74.6	1.612
7		III	$WR = (15W_2+30W_3)/40$	$(15\times67+30\times65)/40 =$	73.9	1.597
8	Aug.	I	$WR = (30W_3+10W_4)/40$	$(30\times65+10\times66)/40 =$	65.3	1.412
9		II	$WR = (20W_3+20W_4)/40$	$(20\times65+20\times66)/40 =$	65.5	1.416
10		III	$WR = (10W_3+30W_4)/40$	$(10\times65+30\times66)/40 =$	65.8	1.422 2/
11	Sep.	I	$WR = (30W_4+10W_5)/40$	$(30\times66+10\times58)/40 =$	64.0	1.383
12		II	$WR = (20W_4+20W_5)/40$	$(20\times66+20\times58)/40 =$	62.0	1.340
13		III	$WR = (10W_4+20W_5)/40$	$(10\times66+20\times58)/40 =$	45.5	0.983
14	Oct.	I	$WR = 20W_5/40$	$(20\times58)/40 =$	29.0	0.627
15		II	$WR = 10W_5/40$	$(10\times58)/40 =$	14.5	0.313

Land soaking and land perparation water;

$P_2 = 132/2 = 66$ mm

$P_1 = 29$ mm

$P = 45$ mm

10-day crop water requirement;

$W_1 = 76.0$ mm $W_4 = 66.0$ mm

$W_2 = 67.0$ mm $W_5 = 58.0$ mm

$W_3 = 65.0$ mm $W_6 = 58.0$ mm

1/: Maximum irrigation water requirement; (land preparation stage)

$$q = \frac{8.5\times10^{-3}\times 1.0\text{ha}\times10^4\times10^3}{86{,}400(1-0.3)\times(1-0.15)\times(1-0.10)} = 1.837\ \ell/\text{sec/ha}$$

2/: Maximum irrigation water requirement; (Crop growing stage)

$$q = \frac{6.58\times10^{-3}\times 1.0\text{ha}\times10^4\times10^3}{86{,}400\times(1-0.3)\times(1-0.15)\times(1-0.10)} = 1.422\ \ell/\text{sec/ha}$$

Table A-5-10. Average Irrigation Water Requirement of Dry Season Rice

No.	Month		Equation for Calculation of WCWR	Weighted 10-day CWR		Irrigation Water Requirement Per Hectare
1	Oct.	III	$WR = 19P_2/40$	$(19\times57)/40 =$	27.1	0.511
2	Nov.	I	$WR = (20P_2+9P_1+3P)/40$	$(20\times57+9\times27+3\times33)/40 =$	37.1	0.769
3		II	$WR = (20P_2+10P_1+10P+5W_2)/40$	$(20\times57+10\times27+10\times33+5\times59)/40 =$	50.9	1.055
4		III	$WR = (20P_2+10P_1+10P+20W_2)/40$	$(20\times57+10\times27+10\times33+20\times59)/40 =$	73.0	1.513 1/
5	Dec.	I	$WR = (P_2+10P_1+10P+20W_2+10W_3)/40$	$(57+10\times27+10\times33+20\times59+10\times54)/40 =$	59.4	1.231
6		II	$WR = (P_1+7P+20W_2+20W_3)/40$	$(27+7\times33+20\times59+20\times54)/40 =$	63.0	1.306
7		III	$WR = (15W_2+30W_3)/40$	$(15\times59+30\times54)/40 =$	62.6	1.297
8	Jan.	I	$WR = (30W_3+10W_4)/40$	$(30\times54+10\times63)/40 =$	56.3	1.167
9		II	$WR = (20W_3+20W_4)/40$	$(20\times54+20\times63)/40 =$	58.5	1.212
10		III	$WR = (10W_3+30W_4)/40$	$(10\times54+30\times63)/40 =$	60.8	1.260
11	Feb.	I	$WR = (30W_4+10W_5)/40$	$(30\times63+10\times60)/40 =$	62.3	1.291 2/
12		II	$WR = (20W_4+20W_5)/40$	$(20\times63+20\times60)/40 =$	61.5	1.275
13		III	$WR = (10W_4+20W_5)/40$	$(10\times63+20\times60)/40 =$	45.8	0.949
14	Mar.	I	$WR = 20W_5/40$	$(20\times60)/40 =$	30.0	0.622
15		II	$WR = 10W_5/40$	$(10\times60)/40 =$	15.0	0.311

Land soaking and land perparation water;

$P_2 = 114/2 = 57$ mm

$P_1 = 27$ mm

$P = 33$ mm

10-day crop water requirement;

$W_1 = 58.0$ mm $W_4 = 63.0$ mm

$W_2 = 59.0$ mm $W_5 = 60.0$ mm

$W_3 = 54.0$ mm $W_6 = 69.0$ mm

1/: Maximum irrigation water requirement; (land preparation stage)

$$q = \frac{73.0\times10^{-3}\times 1.0\text{ha}\times10^4\times10^3}{86{,}400(1-0.27)\times(1-0.15)\times(1-0.10)} = 1.513\ \ell/\text{sec/ha}$$

2/: Maximum irrigation water requirement; (Crop growing stage)

$$q = \frac{62.3\times10^{-3}\times 1.0\text{ha}\times10^4\times10^3}{86{,}400\times(1-0.27)\times(1-0.15)\times(1-0.10)} = 1.291\ \ell/\text{sec/ha}$$

Table A-5-11 LIST OF CONSTRUCTION MATERIALS FOR CAPAYAS DAM

Class of Materials	Location Sources	Volume	Geology	Hauling Distance	Laboratory Test
Embankment Materials (Impervious)	Damsite & Reservoir Area	Enough	Clay/Silty Clay Gravely Clay	In Site	Laboratory Soil Test(1985) (1989)
Embankment M.(Rock)	Nagasnas Hill	Enough	Basalt	10km	No Test
	Lumangog	"	Andsite	3.5km	"
	Capayas River Bed	"	"	1 - 2km	
	Ilaya(Malingin) River	"	"	8km	"
	Abihilan	"	Basalt	22km	"
Sand & Gravel	Guinsularan River	Enough	Alluvial Depposit	40km	Rock Test(1985)
	Capayas River	"	"	1.5km	Gradation Test (1989,NIA)
	Kinanoan Rivir	Not Enough	"	29km	Rock Test(1985)
	Hinlayagan River	"	"	32km	"
	Ilaya(Maringin) River	"	"	8km	No Test
Embankment M.Rord Surfacing	Capayas Quarry	Enough	Diorite/ Soil	In Site	Rock Test(1985)

Table A-5-12 RESULT OF LABORATORY TESTS AT CAPAYAS DAM

Sample No.	CTP-1	CTP-2	CTP-3	CTP-4	CTP-5	CTP-6	CTP-7♦	CTP-8♦	CTP-9♦	CTP-10♦	CTP-11A♦	Dagohoy Q		Ilaya R	Guinsu-ipan R	Xina noan R	Hinia yaan R	Capayas R ♦		Capayas Q
Description of Soil	Earth Material											Rock Material		Sand & Gravel Material						Rord M
Color																				
Depth of Sampling	0.6~1.25	0.6~1.65	0.0~1.2	0.3~1.2	0.3~1.2	0.3~1.2	0.3~1.8	0.6~1.7	0.4~2.0	0.5~2.4	1.1~2.0	19.0	28.2							
Specific Gravity — 4.76 mm over G_s (%)																				
Specific Gravity — 4.76 mm under G_s (%)	2.64	2.54	2.59	2.59	2.76	2.64	2.52	2.61	2.51	2.70	2.72	2.70	2.69	2.60 2.64	2.32 2.46	2.79 2.70	2.61 2.69			2.67 2.75
Field Water Content — 4.76 mm over (%)																				
Field Water Content — 4.76 mm under (%)																				
Field Water Content — TOTAL (%)	23.3	33.2	33.2	29.0	31.7	27.1	33.0	20.0	37.0	21.0	19.0									
Grain Size and Unified Soil Classification — Maximum Grain Size D_{max} (cm)																		10	78	
Grain Size and Unified Soil Classification — Gravel (%)	34	1	2	0	8	1	2	7	2	15	22			87	71	74	77	90	90	67
Grain Size and Unified Soil Classification — Sand (%)	28	19	18	8	29	3	14	30	16	36	12			12	28	25	22	10	10	26
Grain Size and Unified Soil Classification — Silt (%)	38	55	65	60	50	96	62	32	54	37	38			1	1	1	1			7
Grain Size and Unified Soil Classification — Clay (%)		25	15	32	13		22	31	28	12	28									
Grain Size and Unified Soil Classification — Uniformity Coefficient U_c	SC	CH	MH	CH	CH		MH	ML	MH	SC	ML									
Grain Size and Unified Soil Classification — Unified Soil Classification																				
Plasticity — Liquid Limit w_L		76.1	75.5	69.1	72.4		58	40	53	40	48									
Plasticity — Plastic Limit w_P		30.4	43.1	31.5	31.6		28	29	29	30	32									
Plasticity — Plastic Index I_P		45.7	32.4	37.6	40.8		30	11	24	10	16									
Compaction — Internal Diameter of Mold (cm)							15.1	15.1	15.1	15.1	15.1									
Compaction — Maximum Dry Density γ_{dmax} (g/cm³)		1.50	1.50		1.61		1.74	1.96	1.76	1.99	1.94									
Compaction — Optimum Water Content w_{opt} (%)		21.7	22.8		20.0		18.5	15.8	17.7	14.5	16.0									
Initial Condition of Specimen — Test No.																				
Initial Condition of Specimen — Diameter of Specimen (mm)							3.55	3.55	3.55	3.55	3.55									
Initial Condition of Specimen — Dry Density γ_d (t/m³)			1.50				1.74	1.96	1.76	1.99	1.94									
Initial Condition of Specimen — Water Content w (%)			22.8				18.5	15.8	17.7	14.5	16.0									
Initial Condition of Specimen — Void ratio e			0.72				0.45	0.33	0.42	0.36	0.40									
Initial Condition of Specimen — Degree of Saturation S_r (%)			82.0				104	125	106	109	109									
Permeability Coefficient k (cm/sec)			7.1×10^{-6}				1.3×10^{-6}	1.5×10^{-6}	9.4×10^{-7}	1.1×10^{-6}	1.1×10^{-6}	Soundness (%)		27.54	38.65	9.91	8.21			48.21
Consolidation — Compression Index C_c																				
Consolidation — Coefficient of Consolidation c_v (cm²/sec)			8.4×10^{-3} 3.4×10^{-3}				4.2×10^{-3} 2.3×10^{-3}	1.99×10^{-3} 1.4×10^{-3}	1.69×10^{-3} 1.49×10^{-3}	5.31×10^{-4} 8.3×10^{-4}	2.49×10^{-3} 9.4×10^{-4}									
Consolidation — Degree of Consolidation U (%)																				
Triaxial Compression — UU-Test Total Stress c (kg/cm²)			0.78				1.5	1.7	1.3	1.6	1.85									
Triaxial Compression — UU-Test Total Stress ϕ (°)			7.5				16	17	13	18	12									
Triaxial Compression — CU-Test Effective Stress c' (kg/cm²)			0.39				0.5	0.8	0.4	0.8	0.5									
Triaxial Compression — CU-Test Effective Stress ϕ' (°)			15				16	17	19	17	17									
Unconfined Strength (kg/cm²)												776	14600							
Elastic Strength (kg/cm²)												649	12740							

Note: ♦ enforcement in 1989, and other in 1985

Table A-5-13. Soil Mechanical Data of Dam Body (Capayas)

Material (Zone)	Specific Gravity G_s	Void Ratio e	Dry Density γ_d (t/cu.m)	Moisture Content w (%)	Wet Density γ_t (t/cu.m)	Saturated Density γ_{sat} (t/cu.m)	Total Stress Base: Cohesion c (t/sq.m)	Total Stress Base: I.F.A ϕ (Degree)	Effective Stress Base: Cohesion c' (t/sq.m)	Effective Stress Base: I.F.A ϕ' (Degree)	Ratio of Pore Pressure u (%)
Homogeneous fill	2.55	0.70	1.50	25	1.88	1.91	-	-	5	10	10
Toe drain	2.60	0.40	1.86	10	2.05	2.14	0	43	-	-	-

Note: G_s; Based on the soil tests and or on the general informations (see Annex C)
e, w, c, ϕ, c', ϕ', and u; ditto
$\gamma_d = G_s (1 + e)$, $\gamma_t = \gamma_d (1 + w/100)$, $\gamma_{sat} = (G_s + e)/(1 + e)$

Table A-5-14. Slope Stability Analysis

SLOPE STABILITY ANALYSIS

(STANDARD METHOD OF SLICES)

カバヤスダム安定計算書

CAPAYAS DAM

UPSTREAM SLOPE : 3:1

DOWNSTREAM SLOPE: 2:1

** MINIMUM FACTOR OF SAFETY **

CASE NO.	CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY
		** UPSTREAM FACE **			
1	45	35	50	24.75	1.65
2	34	30	55	29.75	2.06
3	45	35	50	24.75	1.56
4	45	35	50	24.75	1.92
		** DOWNSTREAM FACE **			
1	29	65	55	29.75	1.50
2	25	65	50	24.75	1.71

Note: With Earthquake (Seismic Force Coefficient: K = .20)

Number of Slip Circles Analyzed for Each Case:
Upstream Face - 65 Downstream Face - 49

** EXPLANATION **

Case 1 - Reservoir is at Normal Water Level and Seepage is Steady.

Case 2 - End of Construction (there is residual construction pore pressure).

Case 3 - Reservoir is at Intermediate Water Level and Seepage is Steady.

Case 4 - Rapid Drawdown (from normal water level to low water level - there is residual pore pressure).

INPUT DATA

COORDINATES OF CENTER OF SLIP CIRCLE (X,Y):

	Upstream	Downstream
Minimum X - Meters	15	60
Maximum X - Meters	40	80
Increment of X - Meters	5	5
Minimum Y - Meters	40	40
Maximum Y - Meters	55	55
Increment of Y - Meters	5	5

INCREMENT OF RADIUS - Meters	2.50
SLICE THICKNESS - Meter/s	1.00
SEISMIC FORCE COEFFICIENT, K	.20

** SOIL MECHANICAL DATA OF EACH ZONE **

ZONE NO.	MOIST DENSITY (T/cu.m.)	SATURATED DENSITY (T/cu.m.)	COHESION (T/sq.m.)	ANGLE OF INT. FRIC. (Degrees)	CONST. PORE PRESSURE (Per cent)
0	1.00	1.00	0.00	0.0	0
1	1.88	1.91	5.00	10.0	10
2	2.05	2.14	0.00	43.0	0
3	0.00	0.00	0.00	0.0	0

** SLOPE STABILITY ANALYSIS **

Name of Dam: CAPAYAS
Location : BOHOL PROVINCE

Type of Dam: EARTHFILL
Face of Dam: UPSTREAM
Slope : 3:1

*** WITH EARTHQUAKE ***

CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY CASE 1	CASE 2	CASE 3	CASE 4
1	15	40	14.75	6.97	6.15	6.97	9.77
				6.97*	6.15*	6.97*	9.77*
2	15	45	19.75	6.34	5.60	6.34	8.43
				6.34*	5.60*	6.34*	8.43*
3	15	50	24.75	5.56	4.93	5.56	6.79
				5.56*	4.93*	5.56*	6.79*
4	15	55	29.75	4.97	4.42	4.86	5.67
				4.97*	4.42*	4.86*	5.67*
5	20	40	12.25	14.66	12.61	14.66	18.80
6	20	40	14.75	4.18	3.83	4.18	4.95
				4.18*	3.83*	4.18*	4.95*
7	20	45	17.25	11.19	9.67	11.19	12.37
8	20	45	19.75	3.82	3.49	3.67	4.20
				3.82*	3.49*	3.67*	4.20*
9	20	50	22.25	9.07	7.88	8.87	9.20
10	20	50	24.75	3.43	3.15	3.16	3.59
				3.43*	3.15*	3.16*	3.59*
11	20	55	27.25	7.64	6.66	7.01	7.35
12	20	55	29.75	3.17	2.99	2.89	3.29
				3.17*	2.99*	2.99*	3.29*
13	25	40	12.25	5.53	4.99	5.23	5.32
14	25	40	14.75	3.09	2.94	2.80	3.14
				3.09*	2.94*	2.80*	3.14*
15	25	45	17.25	4.99	4.48	4.40	4.63
16	25	45	19.75	2.69	2.63	2.41	2.73
				2.69*	2.63*	2.41*	2.73*
17	25	50	19.75	25.30	21.53	21.88	21.03
18	25	50	22.25	4.26	3.97	3.71	4.02
19	25	50	24.75	2.41	2.45	2.18	2.50
				2.41*	2.45*	2.18*	2.50*
20	25	55	24.75	16.22	13.88	12.82	13.49
21	25	55	27.25	3.68	3.61	3.25	3.60
22	25	55	29.75	2.21	2.32	2.03	2.35
				2.21*	2.32*	2.03*	2.35*
23	30	40	9.75	8.49	7.49	6.72	7.21

UPSTREAM.....

*** WITH EARTHQUAKE ***

CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY CASE 1	CASE 2	CASE 3	CASE 4
24	30	40	12.25	3.50	3.45	2.98	3.27
25	30	40	14.75	2.34	2.49	2.08	2.39
				2.34*	2.49*	2.08*	2.39*
26	30	45	14.75	6.62	6.15	5.29	5.90
27	30	45	17.25	3.06	3.16	2.68	3.02
28	30	45	19.75	2.03	2.24	1.85	2.15
				2.03*	2.24*	1.85*	2.15*
29	30	50	19.75	5.58	5.60	4.72	5.40
30	30	50	22.25	2.61	2.81	2.35	2.69
31	30	50	24.75	1.87	2.12	1.73	2.04
				1.87*	2.12*	1.73*	2.04*
32	30	55	24.75	4.66	4.93	4.10	4.77
33	30	55	27.25	2.41	2.68	2.21	2.56
34	30	55	29.75	1.78	2.06	1.66	1.98
				1.78*	2.06*	1.66*	1.98*
35	35	40	9.75	4.10	4.47	3.51	4.28
36	35	40	12.25	2.54	2.94	2.38	2.76
37	35	40	14.75	1.90	2.30	1.74	2.12
				1.90*	2.30*	1.74*	2.12*
38	35	45	12.25	11.42	12.61	10.24	12.45
39	35	45	14.75	3.36	3.82	3.04	3.67
40	35	45	17.25	2.17	2.58	2.00	2.41
41	35	45	19.75	1.74	2.15	1.63	1.98
				1.74*	2.15*	1.63*	1.98*
42	35	50	17.25	8.33	9.67	7.86	9.59
43	35	50	19.75	3.01	3.53	2.80	3.40
44	35	50	22.25	2.03	2.46	1.90	2.30
45	35	50	24.75	1.65	2.08	1.56	1.92
				1.65*	2.08*	1.56*	1.92*
46	35	55	22.25	6.39	7.61	6.17	7.57
47	35	55	24.75	2.83	3.40	2.66	3.27
48	35	55	27.25	2.01	2.49	1.90	2.33
49	35	55	29.75	1.66	2.14	1.58	1.98
				1.66*	2.14*	1.58*	1.98*
50	40	40	9.75	2.74	3.56	2.73	3.43
51	40	40	12.25	2.09	2.80	2.02	2.63
52	40	40	14.75	1.75	2.43	1.68	2.22
				1.75*	2.43*	1.68*	2.22*
53	40	45	12.25	3.97	5.05	4.02	5.02
54	40	45	14.75	2.54	3.31	2.51	3.19
55	40	45	17.25	1.93	2.61	1.87	2.44
56	40	45	19.75	1.66	2.35	1.60	2.14

UPSTREAM.....

*** WITH EARTHQUAKE ***

CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY CASE 1	CASE 2	CASE 3	CASE 4
				1.66*	2.35*	1.60*	2.14*
57	40	50	17.25	4.00	5.16	4.04	5.14
58	40	50	19.75	2.40	3.19	2.38	3.07
59	40	50	22.25	1.94	2.68	1.88	2.50
60	40	50	24.75	1.68	2.42	1.62	2.18
				1.68*	2.42*	1.62*	2.18*
61	40	55	19.75	18.27	22.96	18.27	23.01
62	40	55	22.25	3.80	4.97	3.83	4.95
63	40	55	24.75	2.45	3.31	2.42	3.18
64	40	55	27.25	1.97	2.79	1.92	2.59
65	40	55	29.75	1.74	2.56	1.68	2.30
				1.74*	2.56*	1.68*	2.30*

Note: * - Minimum factor of safety in every center of slip circle.

** SLOPE STABILITY ANALYSIS **

Name of Dam: CAPAYAS
Location : BOHOL PROVINCE

Type of Dam: EARTHFILL
Face of Dam: DOWNSTREAM
Slope : 2:1

*** WITH EARTHQUAKE ***

CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY CASE 1	CASE 2
1	60	40	9.75	2.57	2.97
2	60	40	12.25	1.99	2.25
3	60	40	14.75	1.50	1.82
				1.50*	1.92*
4	60	45	12.25	4.10	4.89
5	60	45	14.75	2.34	2.75
6	60	45	17.25	1.88	2.18
7	60	45	19.75	1.53	1.80
				1.53*	1.80*
8	60	50	17.25	3.82	4.67
9	60	50	19.75	2.36	2.82
10	60	50	22.25	1.85	2.19
11	60	50	24.75	1.55	1.86
				1.55*	1.86*
12	60	55	22.25	3.60	4.49
13	60	55	24.75	2.33	2.84
14	60	55	27.25	1.89	2.28
15	60	55	29.75	1.59	1.95
				1.59*	1.95*
16	65	40	9.75	4.63	5.29
17	65	40	12.25	2.33	2.44
18	65	40	14.75	1.70	1.85
				1.70*	1.85*
19	65	45	14.75	3.50	3.98
20	65	45	17.25	1.95	2.10
21	65	45	19.75	1.57	1.76
				1.57*	1.76*
22	65	50	17.25	23.80	27.75
23	65	50	19.75	2.85	3.27
24	65	50	22.25	1.86	2.05
25	65	50	24.75	1.51	1.71
				1.51*	1.71*
26	65	55	22.25	8.51	10.02
27	65	55	24.75	2.65	3.09
28	65	55	27.25	1.81	2.03
29	65	55	29.75	1.50	1.74
				1.50*	1.74*
30	70	40	12.25	3.30	3.67
31	70	40	14.75	2.15	2.26

DOWNSTREAM.....

*** WITH EARTHQUAKE ***

CIRCLE NO.	COORDINATES OF CENTER - X - (M)	- Y - (M)	RADIUS (M)	FACTOR OF SAFETY CASE 1	CASE 2
				2.15*	2.26*
32	70	45	17.25	2.89	3.09
33	70	45	19.75	1.84	1.96
				1.84*	1.96*
34	70	50	19.75	12.54	14.63
35	70	50	22.25	2.43	2.62
36	70	50	24.75	1.67	1.81
				1.67*	1.81*
37	70	55	24.75	6.59	7.68
38	70	55	27.25	2.14	2.33
39	70	55	29.75	1.59	1.76
				1.59*	1.76*
40	75	40	14.75	2.41	2.80
				2.41*	2.80*
41	75	45	17.25	19.33	22.56
42	75	45	19.75	2.41	2.62
				2.41*	2.62*
43	75	50	22.25	7.52	8.77
44	75	50	24.75	2.20	2.35
				2.20*	2.35*
45	75	55	27.25	4.70	5.48
46	75	55	29.75	1.93	2.08
				1.93*	2.08*
47	80	45	19.75	2.78	3.32
				2.78*	3.32*
48	80	50	24.75	3.49	4.12
				3.49*	4.12*
49	80	55	29.75	3.05	3.57
				3.05*	3.57*

Note: * - Minimum factor of safety in every center of slip circle.

Figure A-2-1. Gross Regional Domestic Product, Central Visayas
Percentage Share, 1987 and 1992

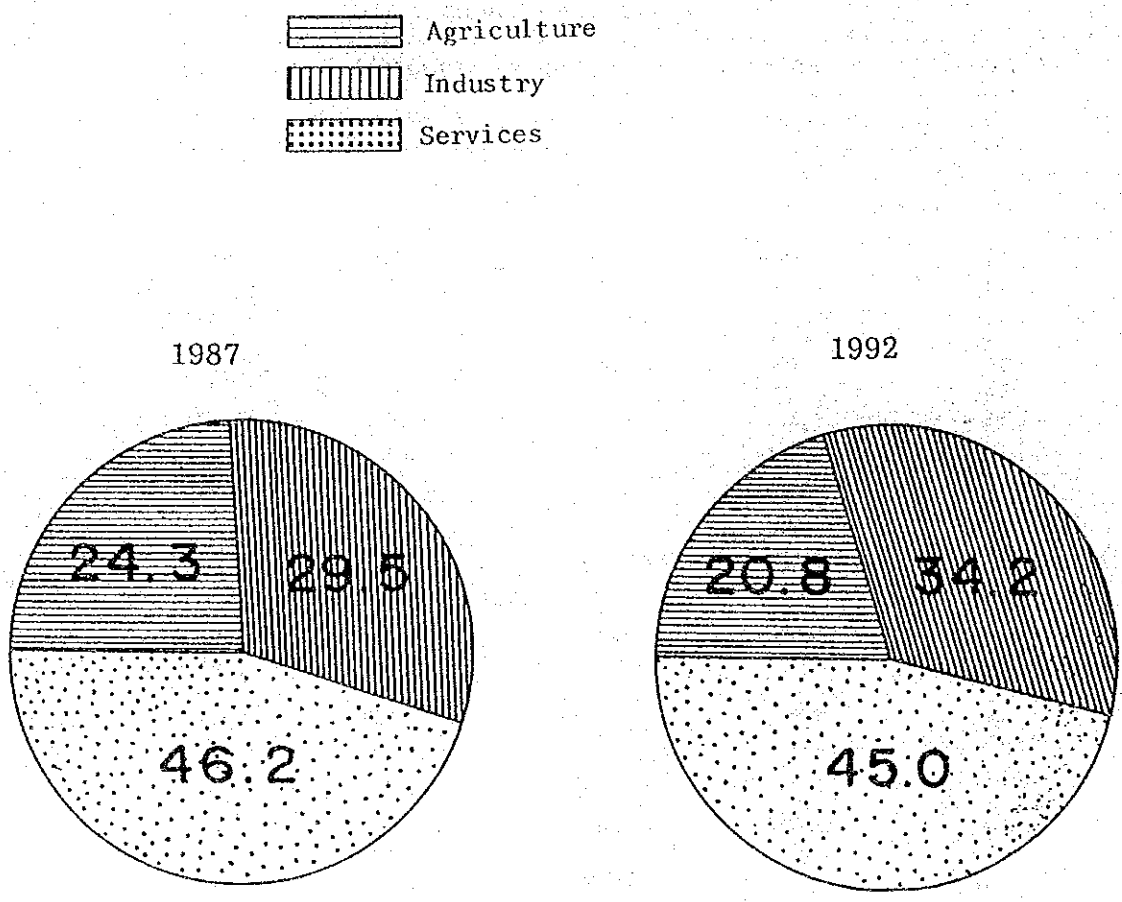


Figure A-4-1. Organization Chart of NIA

1988

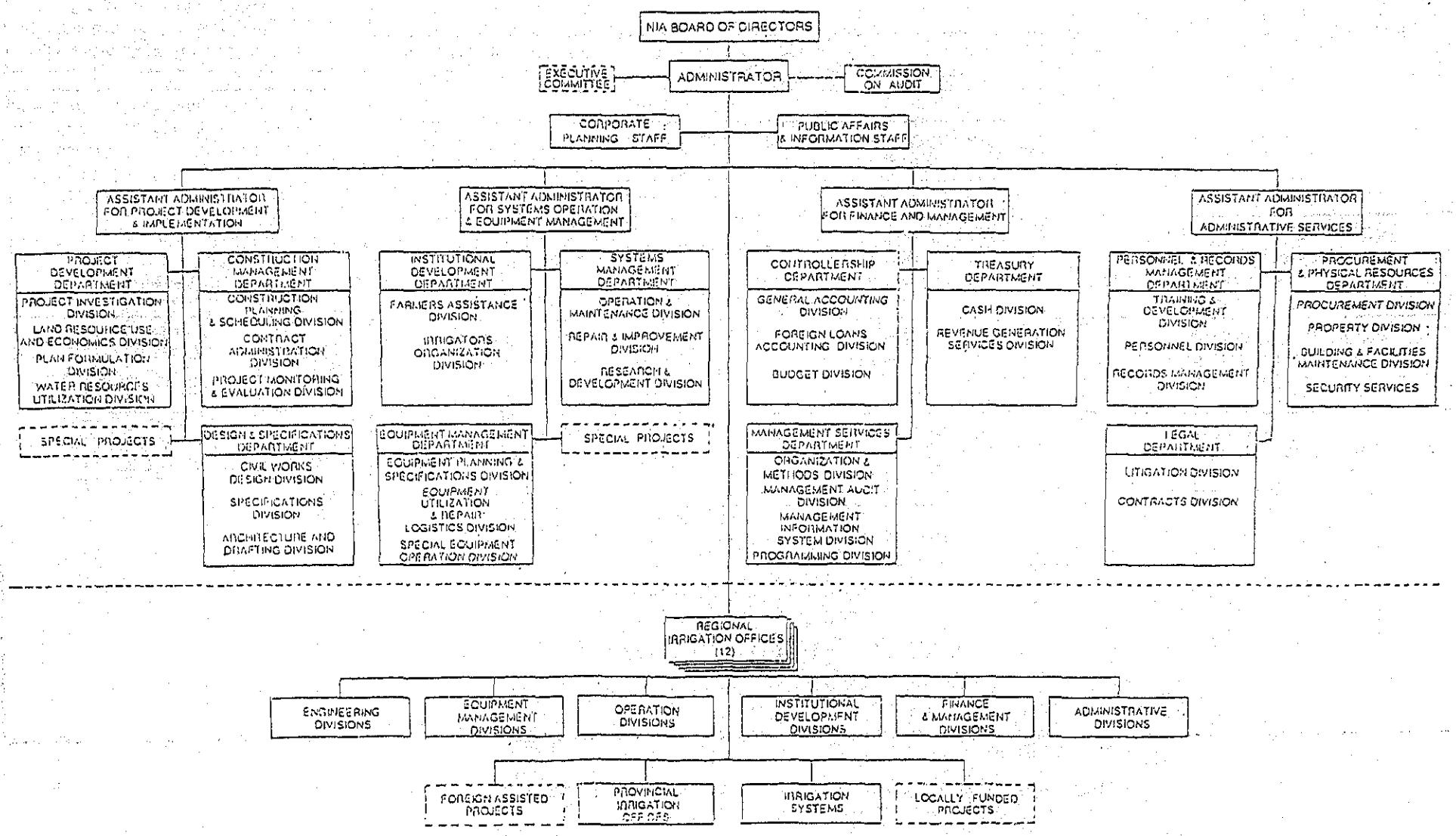


Figure A-4-2. Organization Chart of Bohol Provincial Irrigation Office