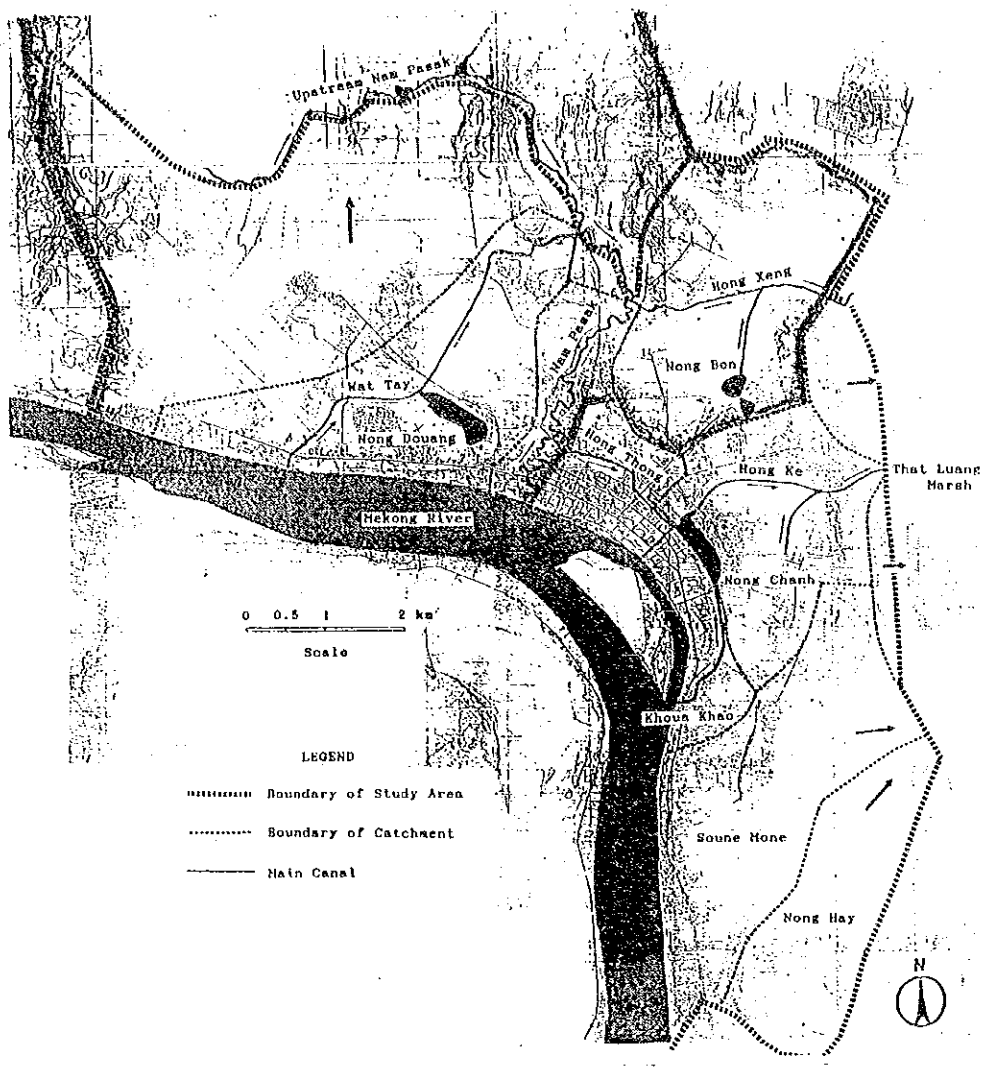

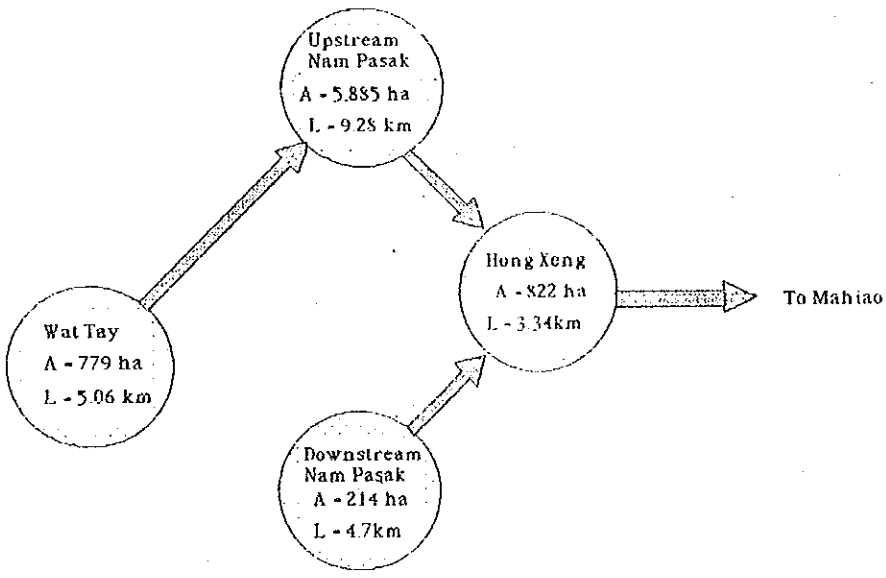

Fig. D.14 Present Drainage Condition in Hong Xeng System.

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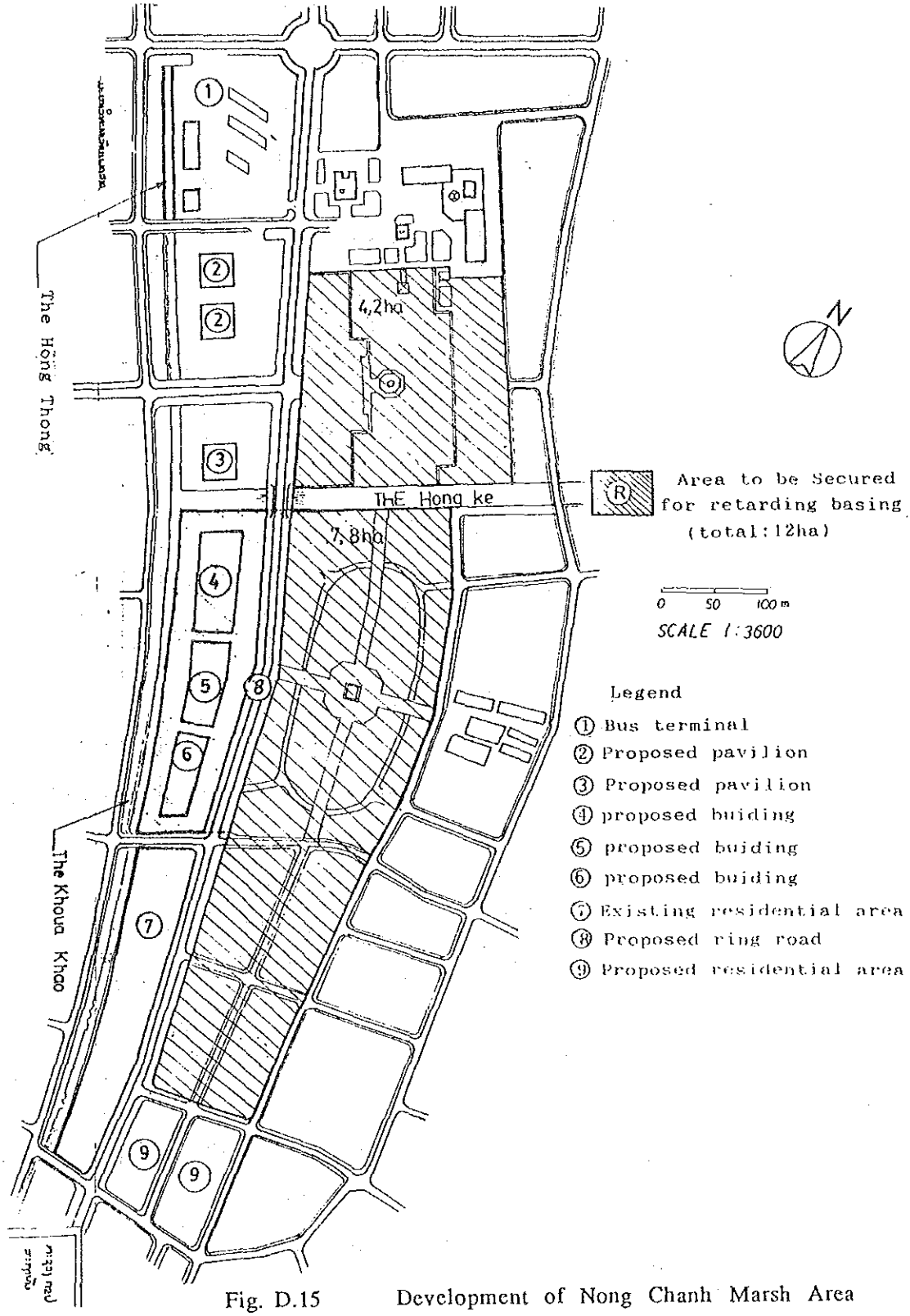

Fig. D.15 Development of Nong Chanh Marsh Area

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

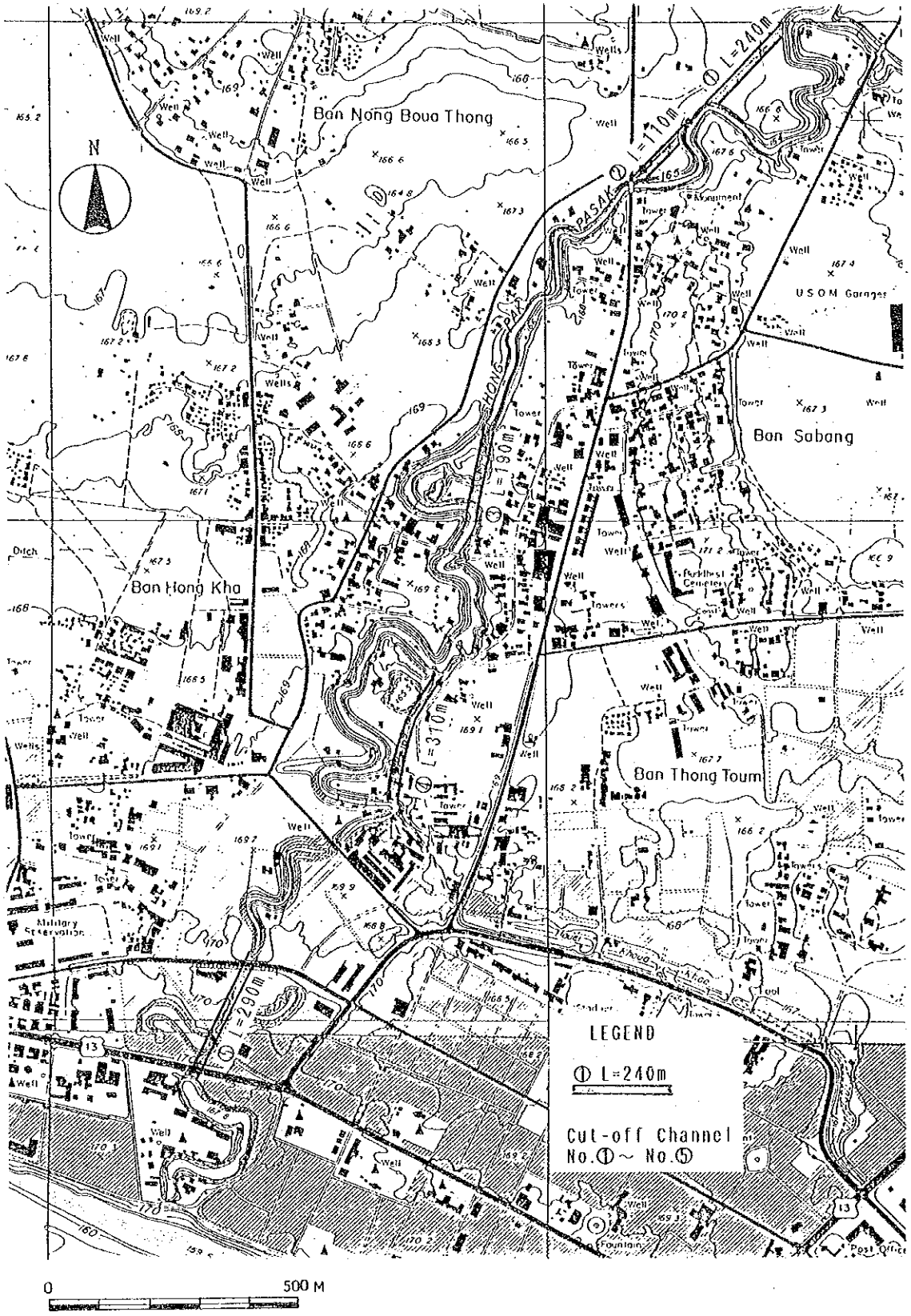

Fig. D.16 Proposed Realignment of Nam Pasak River

LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

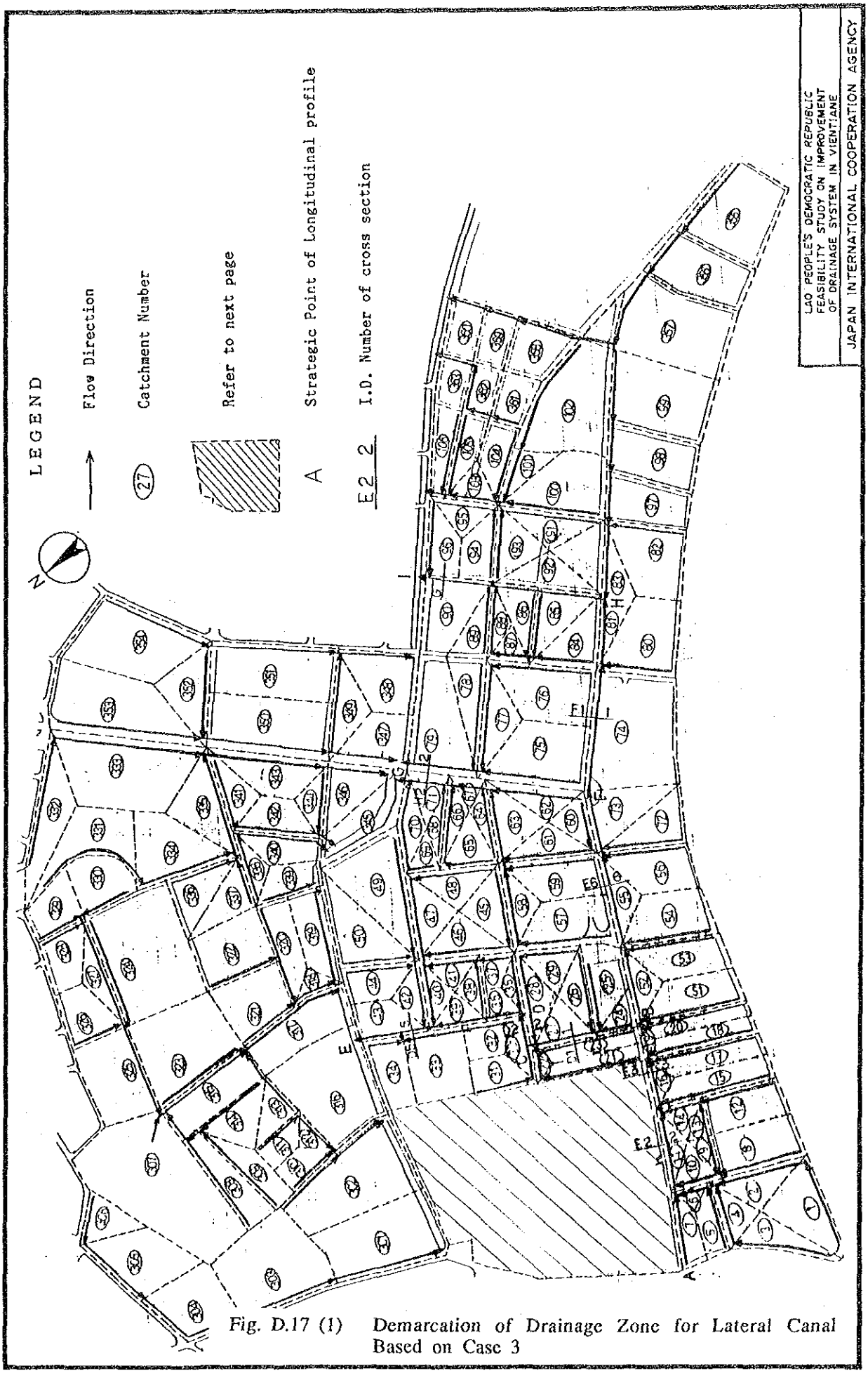

Fig. D.17 (1) Demarcation of Drainage Zone for Lateral Canal Based on Case 3

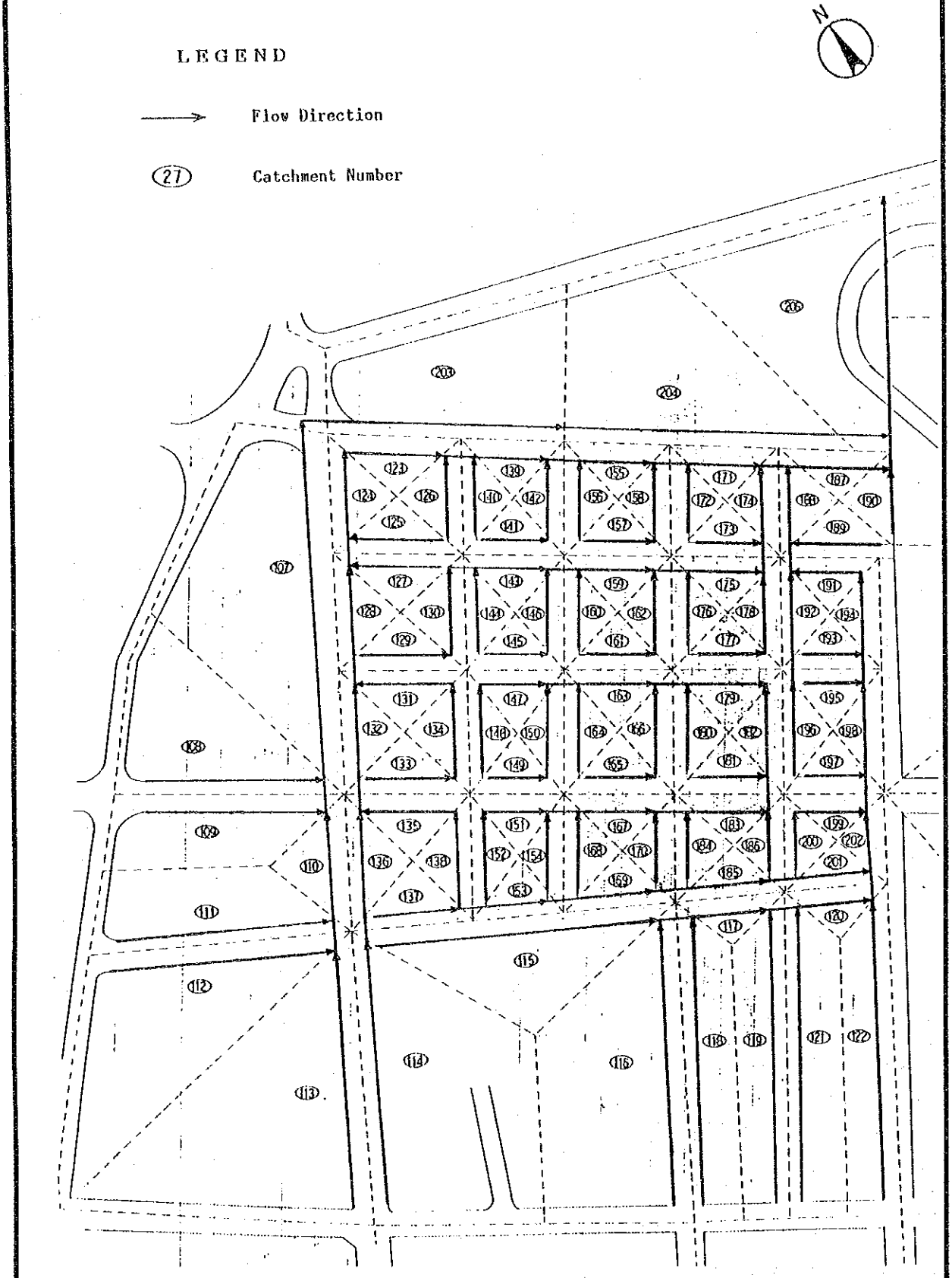

Fig. D.17 (2) Demarcation of Drainage Zone for Lateral Canal Based on Case 3

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
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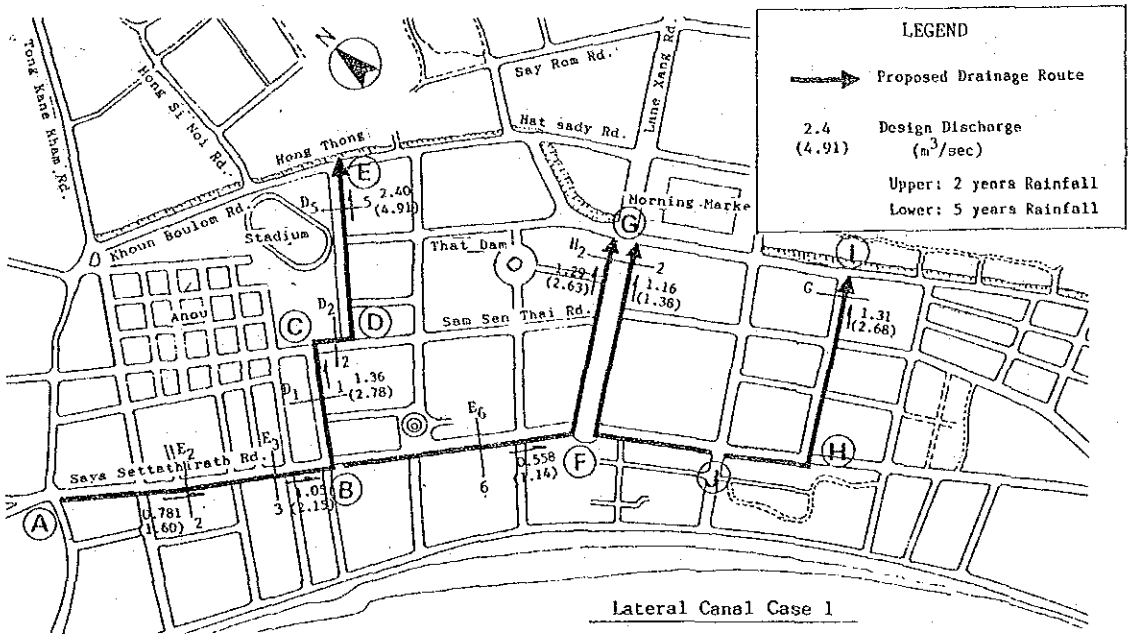

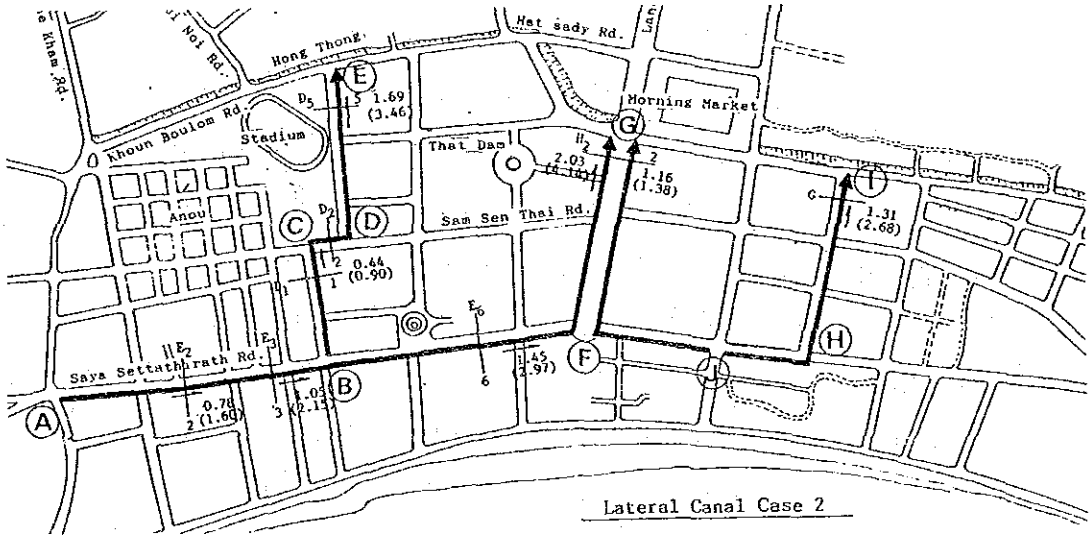

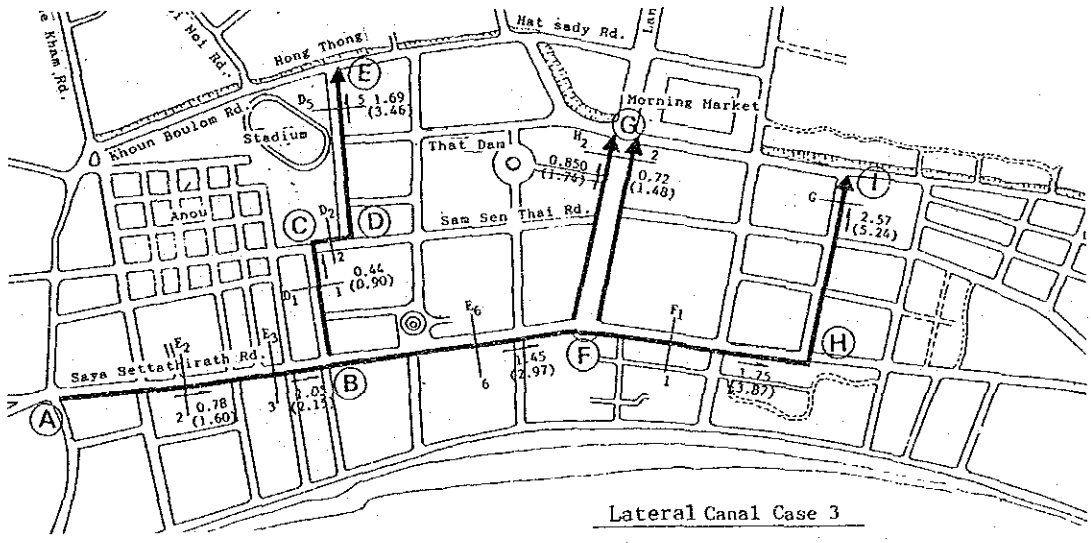

Fig. D.18 Alternative Cases and Peak Discharges

LAO PEOPLE'S DEMOCRATIC REPUBLIC
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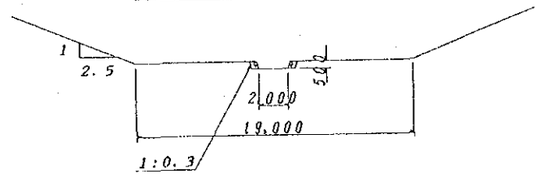
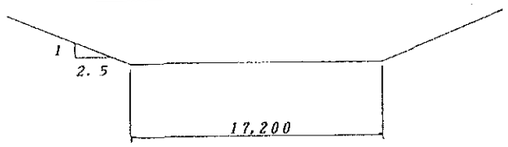
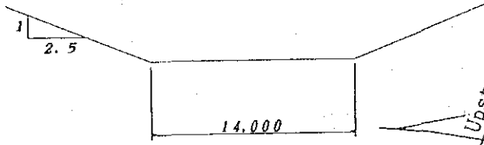
⑤Type7' (b=19m)



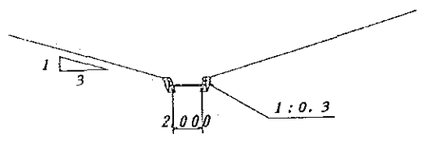
⑥Type1 (b=17.2m)



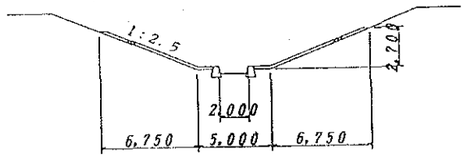
⑦Type1 (b=14m)



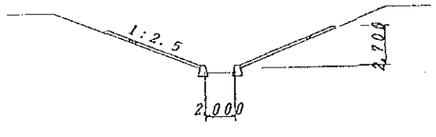
⑩Type7 : 1920~upstream end
(improved existing route)

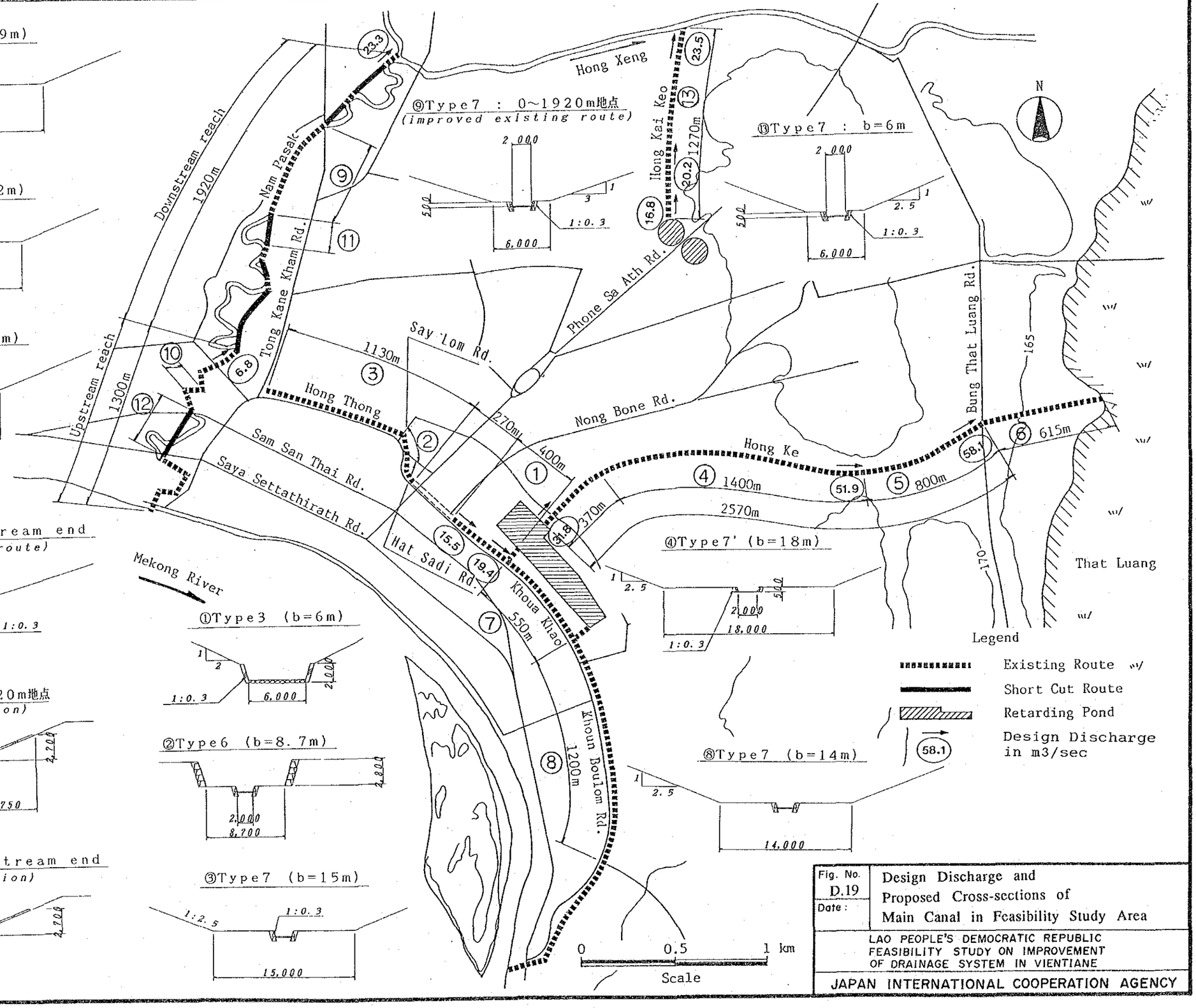


⑪Type4 : 0~1920m地点
(short cut porsion)



⑫Type4 : 1920~upstream end
(short cut porsion)





⑨Type7 : 0~1920m地点
(improved existing route)

⑬Type7 : b=6m

④Type7' (b=18m)

⑧Type7 (b=14m)

①Type3 (b=6m)

②Type6 (b=8.7m)

③Type7 (b=15m)

Legend

- Existing Route
- Short Cut Route
- Retarding Pond
- Design Discharge in m3/sec (58.1)

Fig. No. D.19	Design Discharge and Proposed Cross-sections of Main Canal in Feasibility Study Area
Date :	

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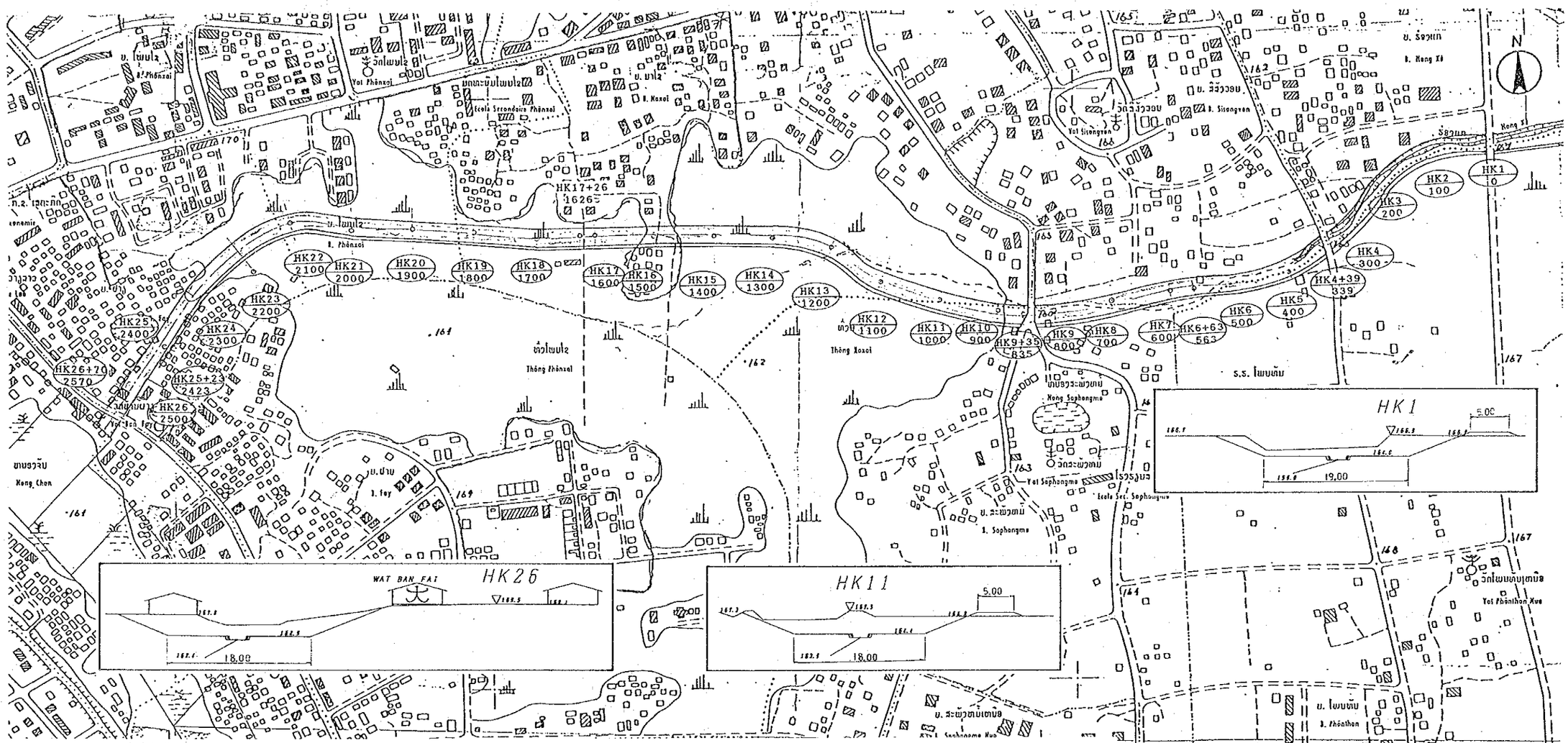

Fig. No.	Fig. D.20 (1)
Date :	Proposed Improvement Plan for Hong Ke
LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE	
JAPAN INTERNATIONAL COOPERATION AGENCY	

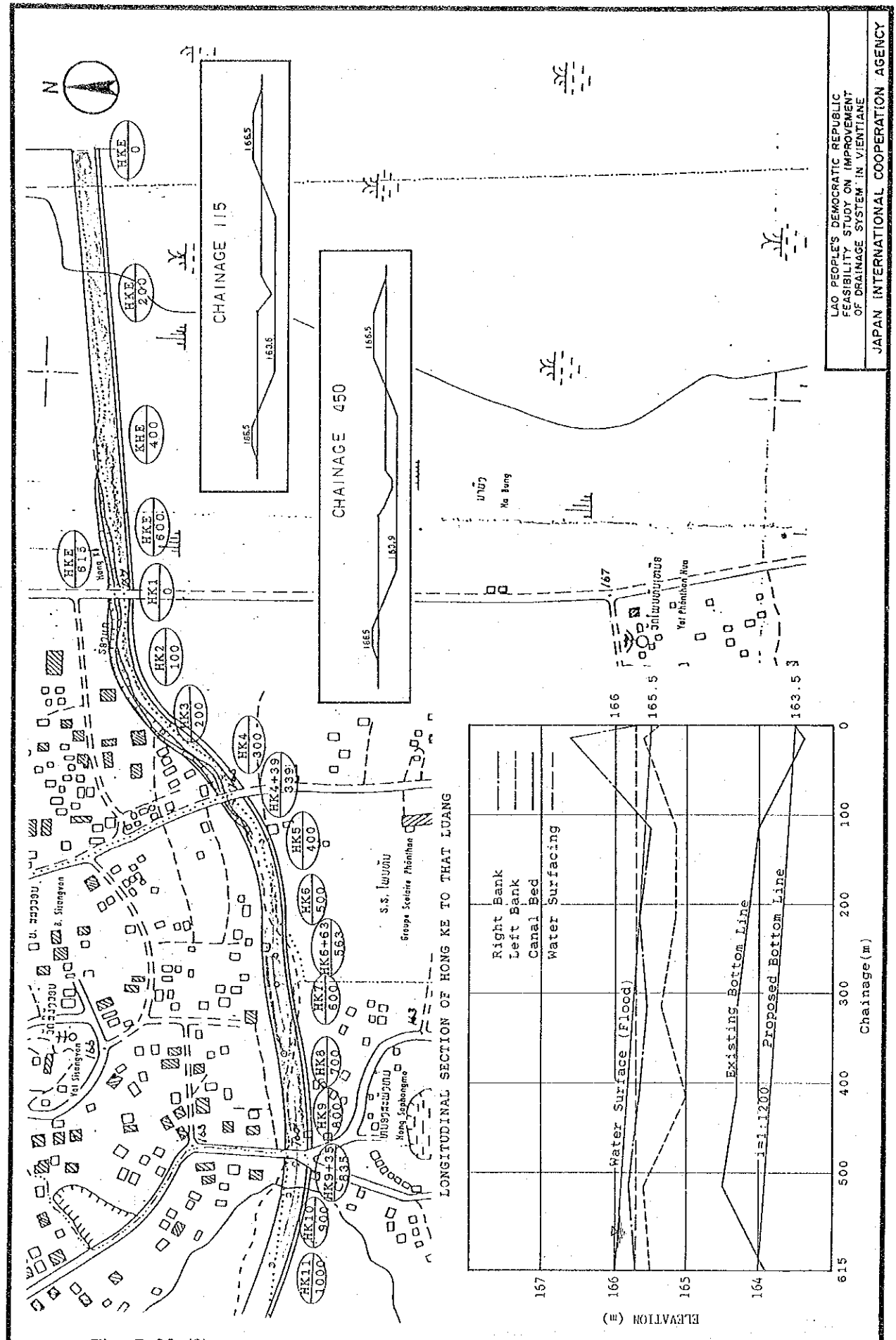

Fig. D.20 (2) Proposed Improvement Plan for Hong Ke Extension

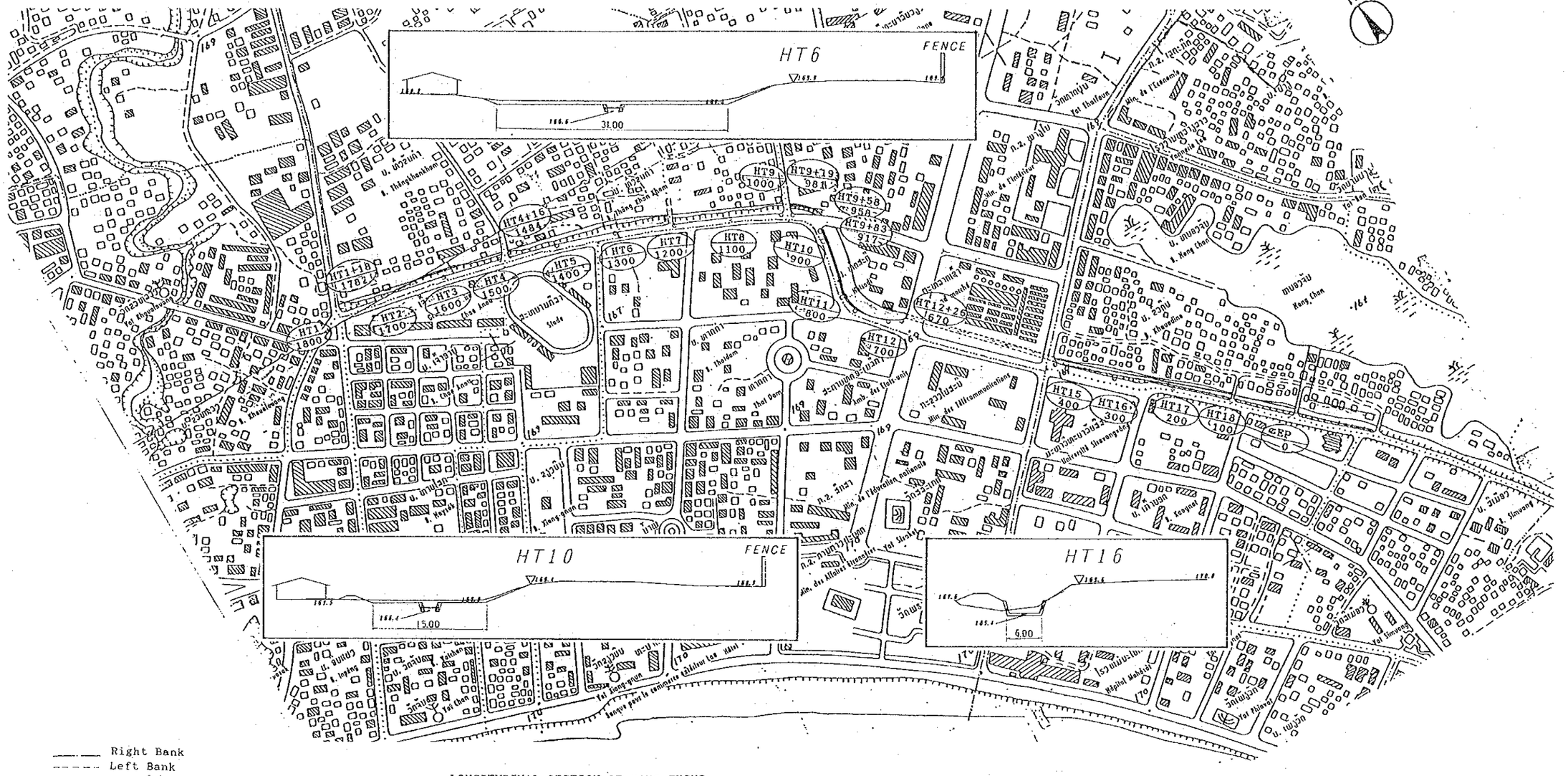

Fig. No. D.21	Proposed Improvement Plan for Hong Thong
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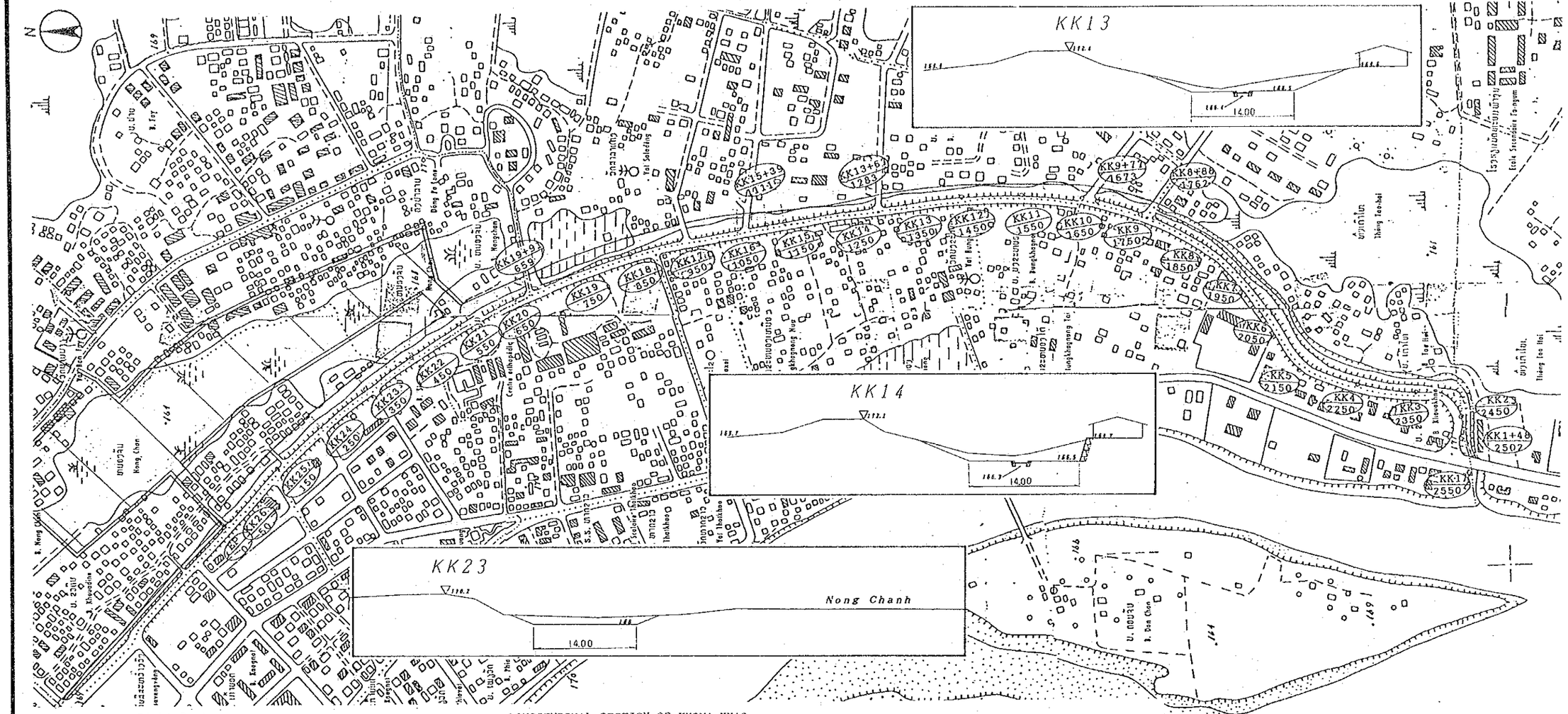
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE

JAPAN INTERNATIONAL COOPERATION AGENCY



LONGITUDINAL SECTION OF KHOUA KHAO

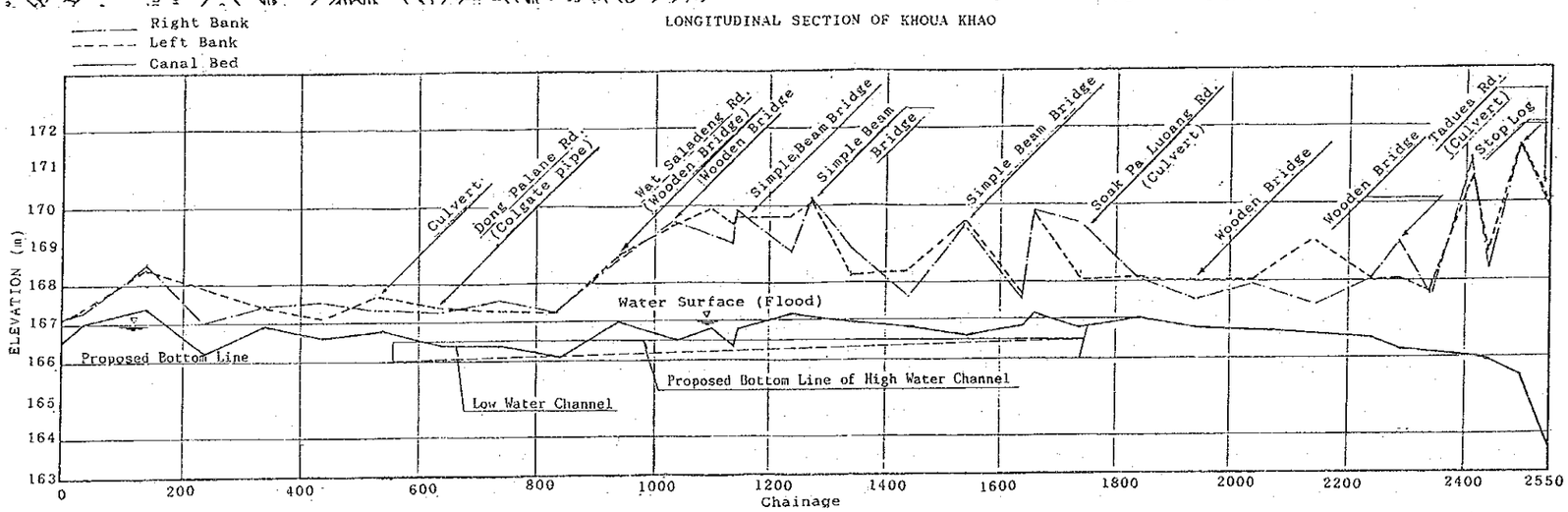


Fig. No. D.22	Proposed Improvement Plan for Khoua Khao
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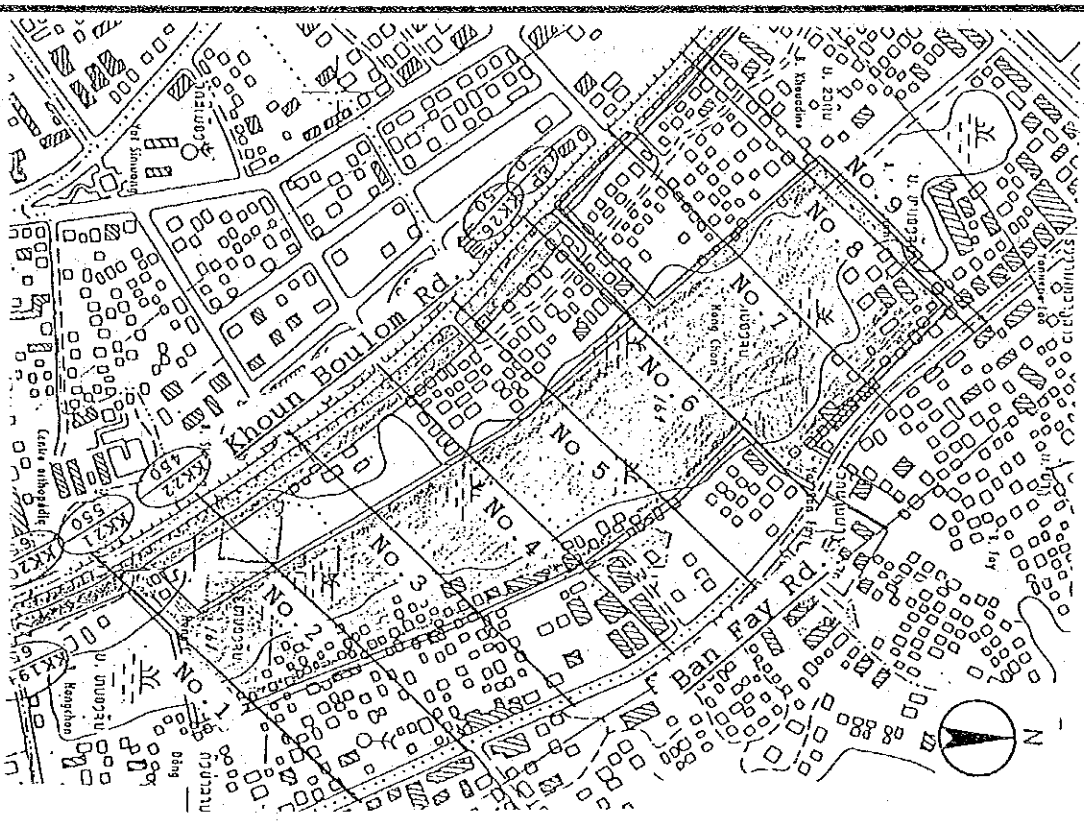
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE

JAPAN INTERNATIONAL COOPERATION AGENCY



Cross Section of Nong Chanh Retarding Pond

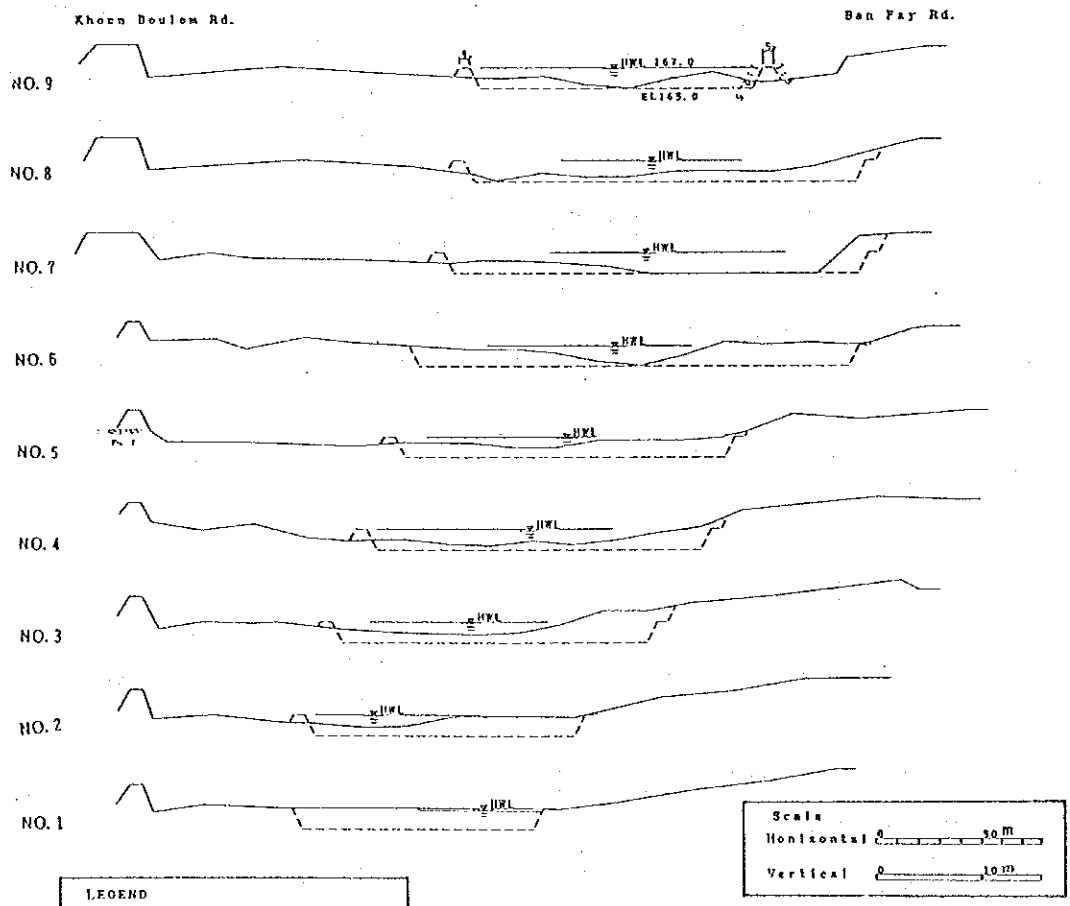


Fig. D.23 Proposed Improvement Plan for Nong Chanh Retarding Pond

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

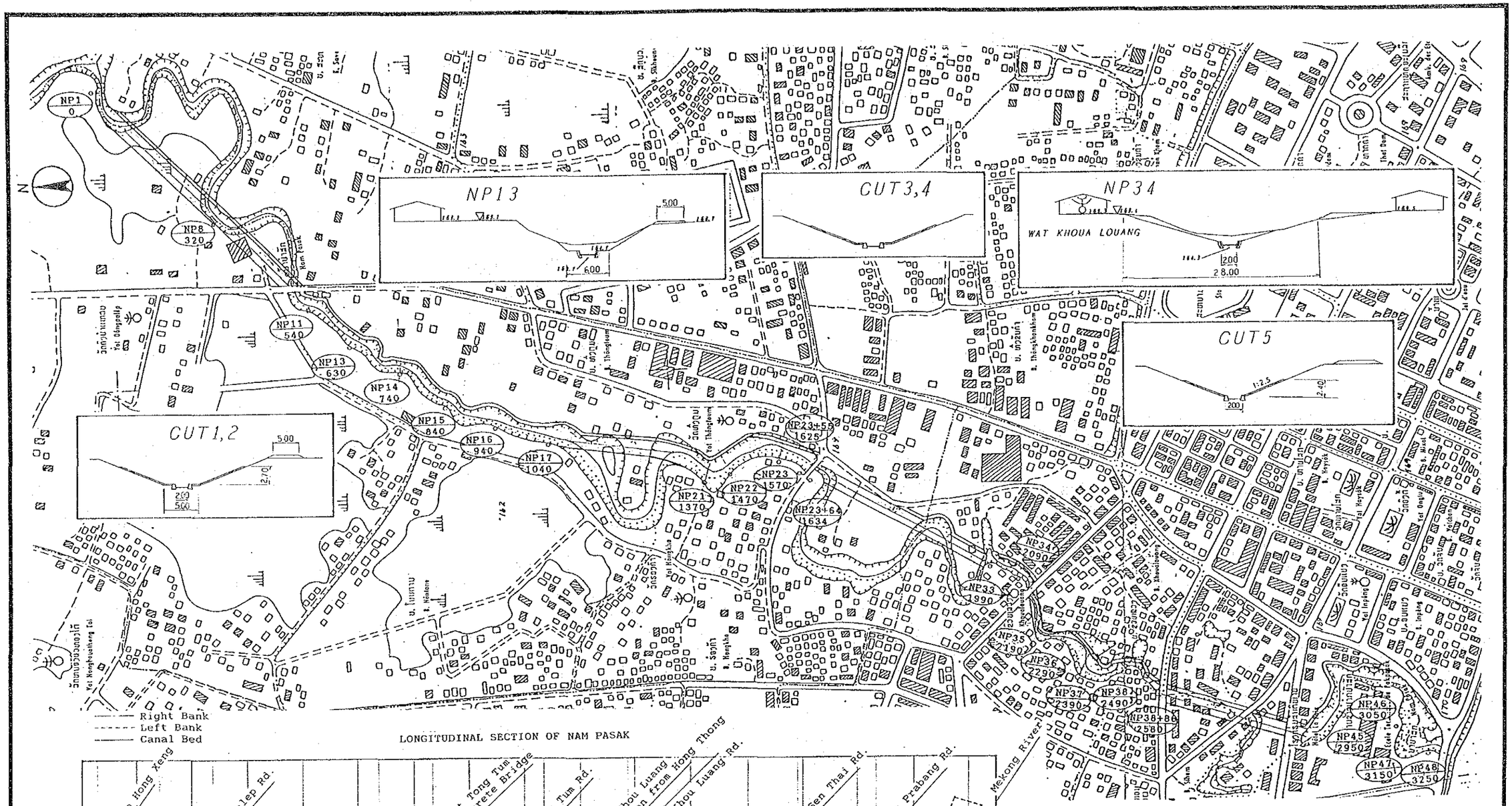


Fig. No.	Fig. D.24
Date :	Proposed Improvement Plan for Nam Pasak
	LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
	JAPAN INTERNATIONAL COOPERATION AGENCY

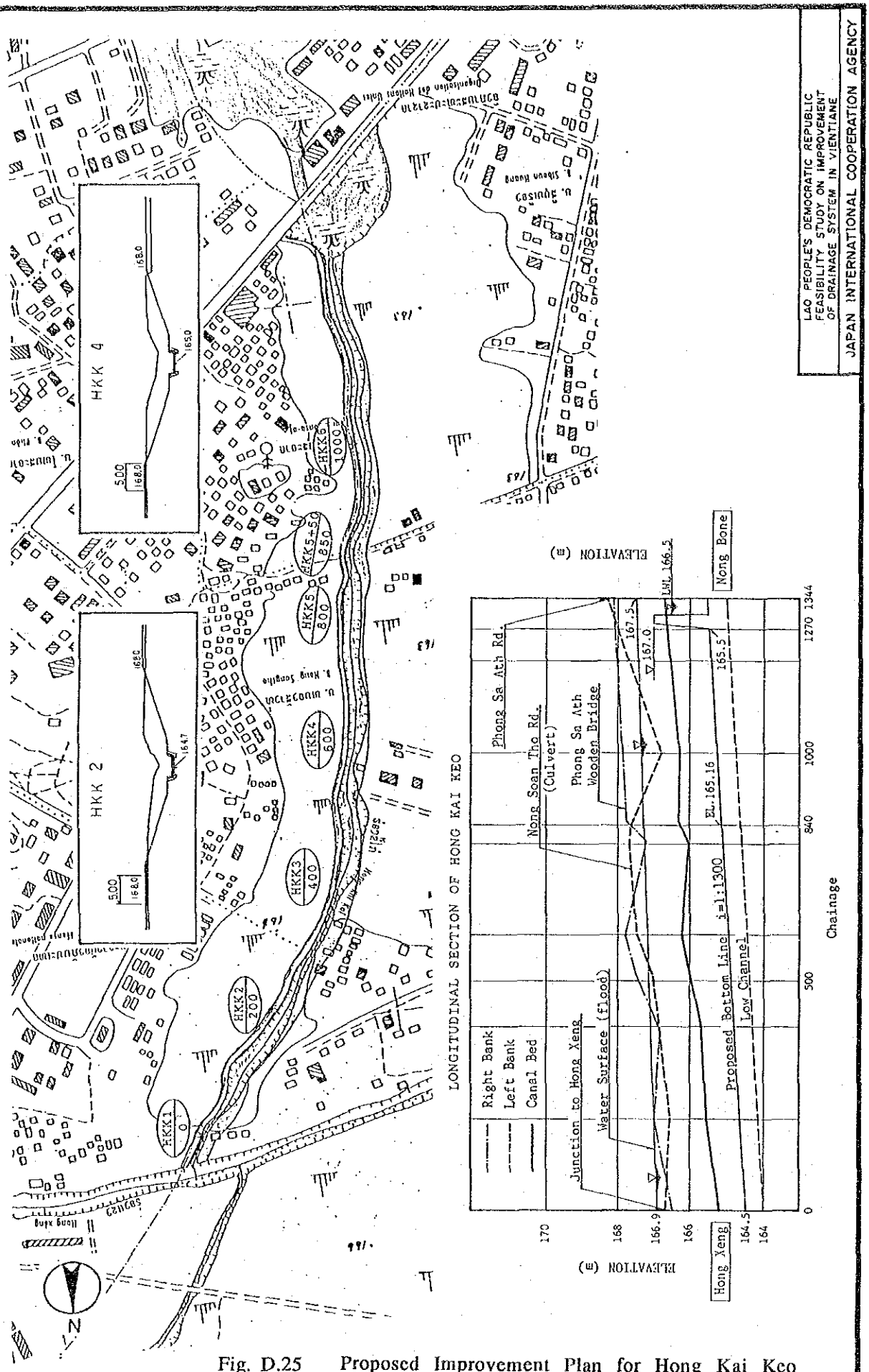
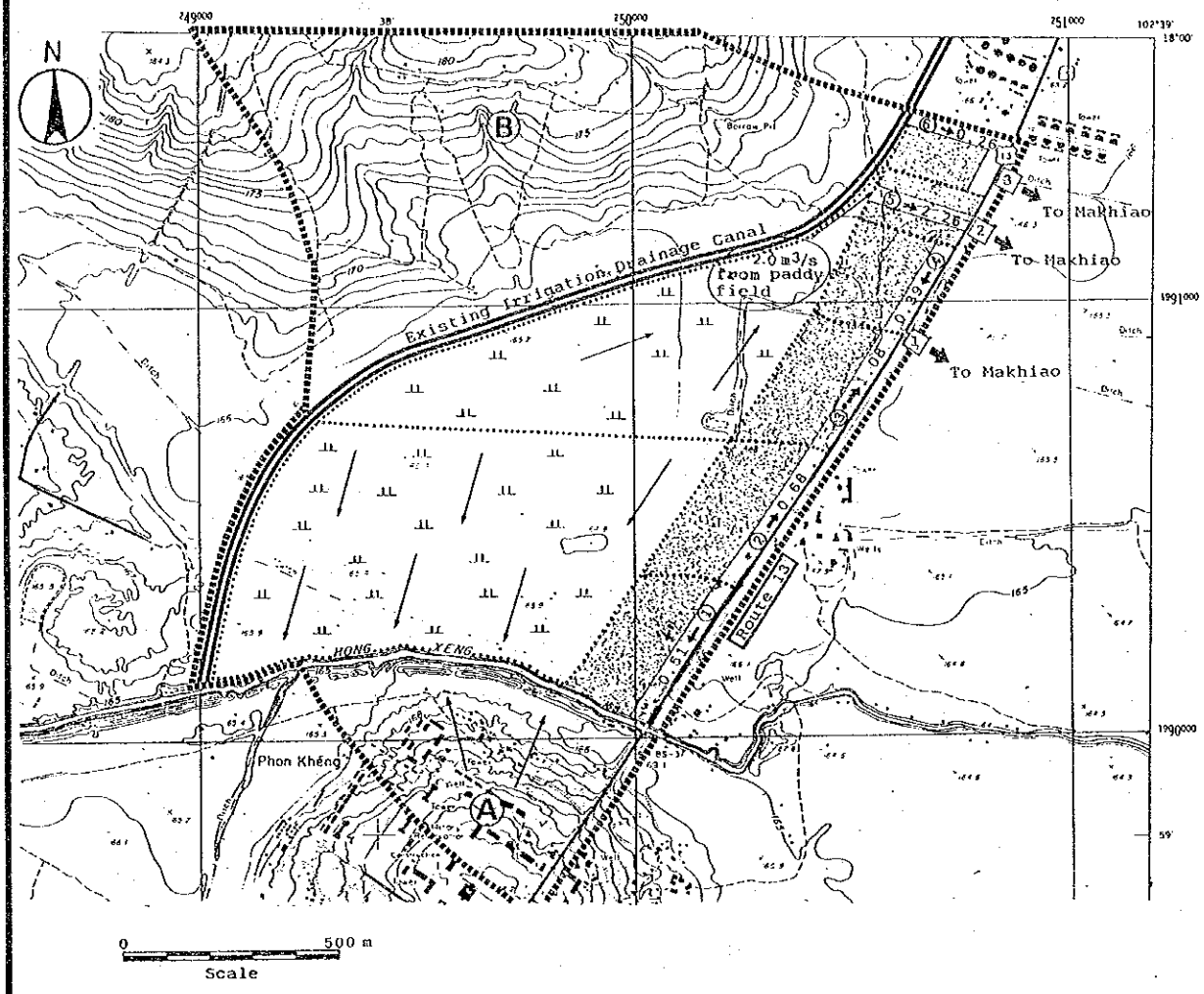


Fig. D.25 Proposed Improvement Plan for Hong Kai Keo



LEGEND

- Boundary of sub-area K
- Boundary of catchment
- Flow direction
- Ⓐ Ⓑ Hill
- Paddy field
- Estimated built-up area by the year 2020
- ①→ 0.51 Proposed lateral canals ①: Canal No. 0.51: Design discharge in m3/sec
- 1 Proposed culverts crossing the Route 13 1: Culvert No.

Proposed Canal and Culvert

Canal No.	Length (m)	Width (m)	Height (m)	Slope (o/oo)	Capacity (m3/s)	Design Discharge
1	370	0.60	0.80	2.70	0.60	0.51
2	390	0.80	0.60	1.50	0.68	0.68
3	270	1.00	1.00	1.50	1.24	1.08
4	230	0.70	0.70	1.50	0.48	0.39
5	230	1.30	1.30	1.50	2.50	2.26
6	310	0.60	0.60	1.50	0.32	0.26

Culvert No.	Length (m)	Width (m)	Height (m)	Design Discharge (m3/s)
1	20	1.25	1.25	1.42
2	20	1.50	1.50	2.26
3	20	1.00	1.00	0.26

Remarks: (1) Both canal and culvert are rectangular.
(2) Dimension is described in inner size.

Fig. D.26 Proposed Improvement Plan for Sub-area K

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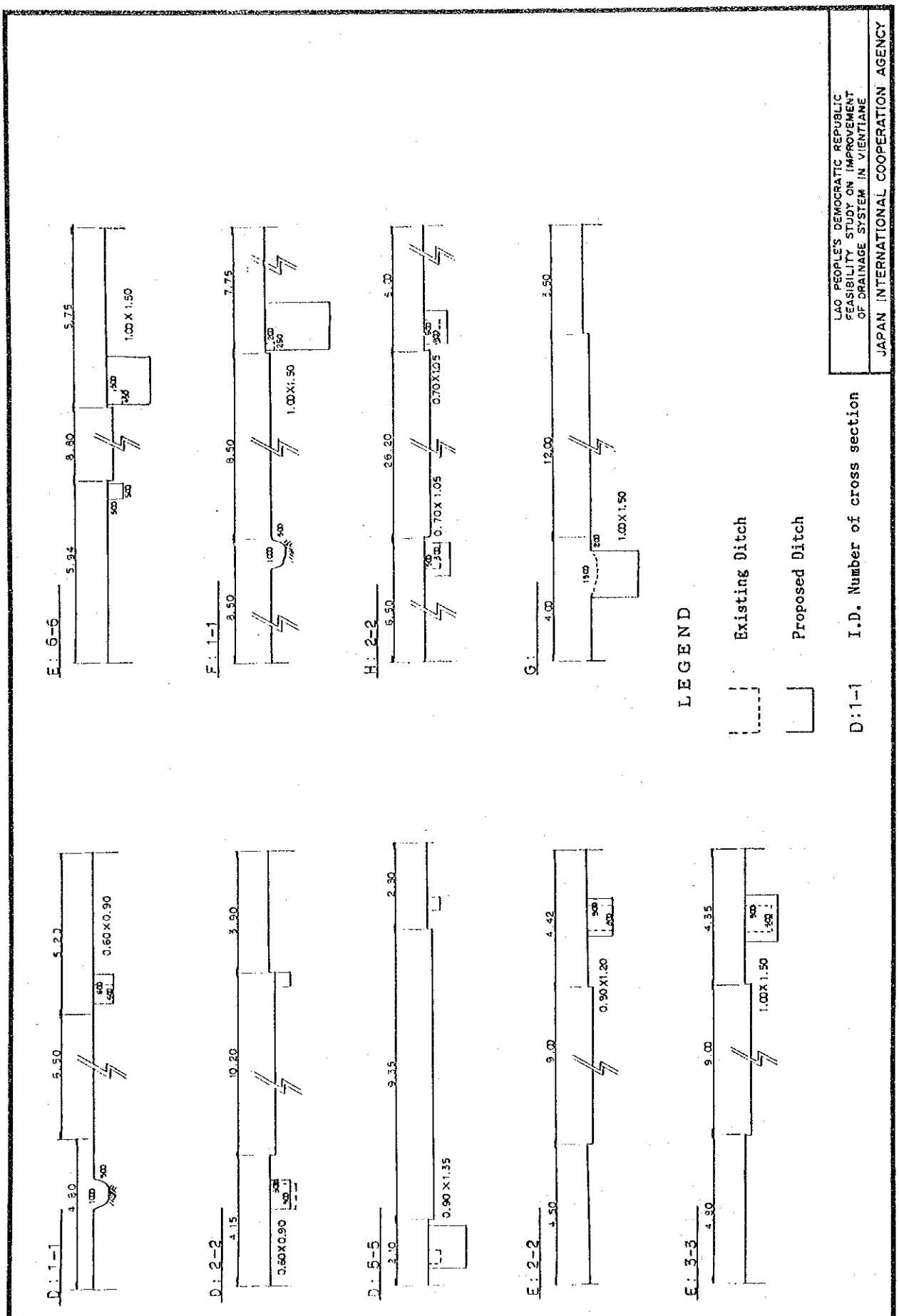

Fig. D.27 Cross-section of Proposed Lateral Canal in Sub-area H

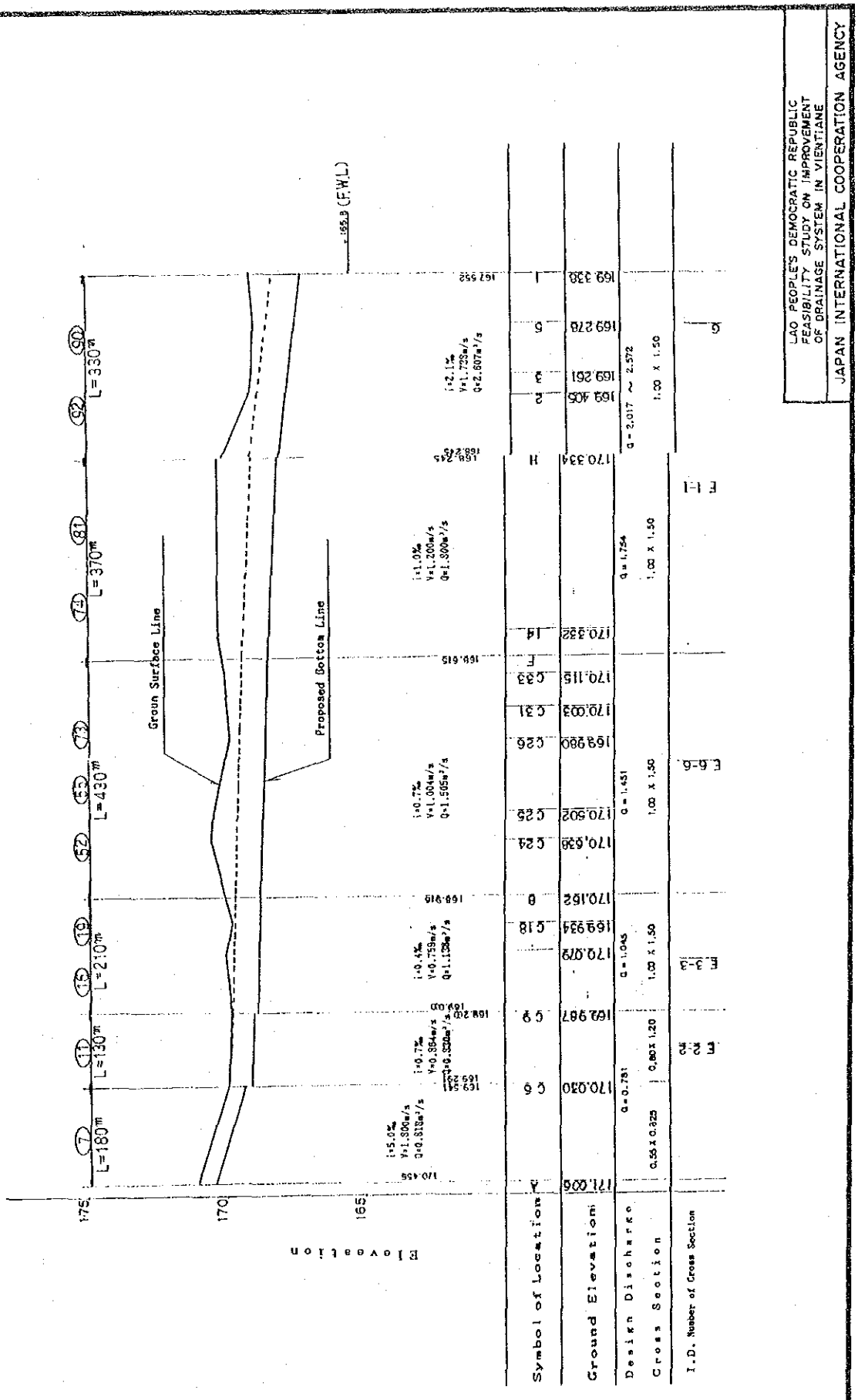

Fig. D.28 (1) Longitudinal Profile of Proposed Lateral Canal in Sub-area H

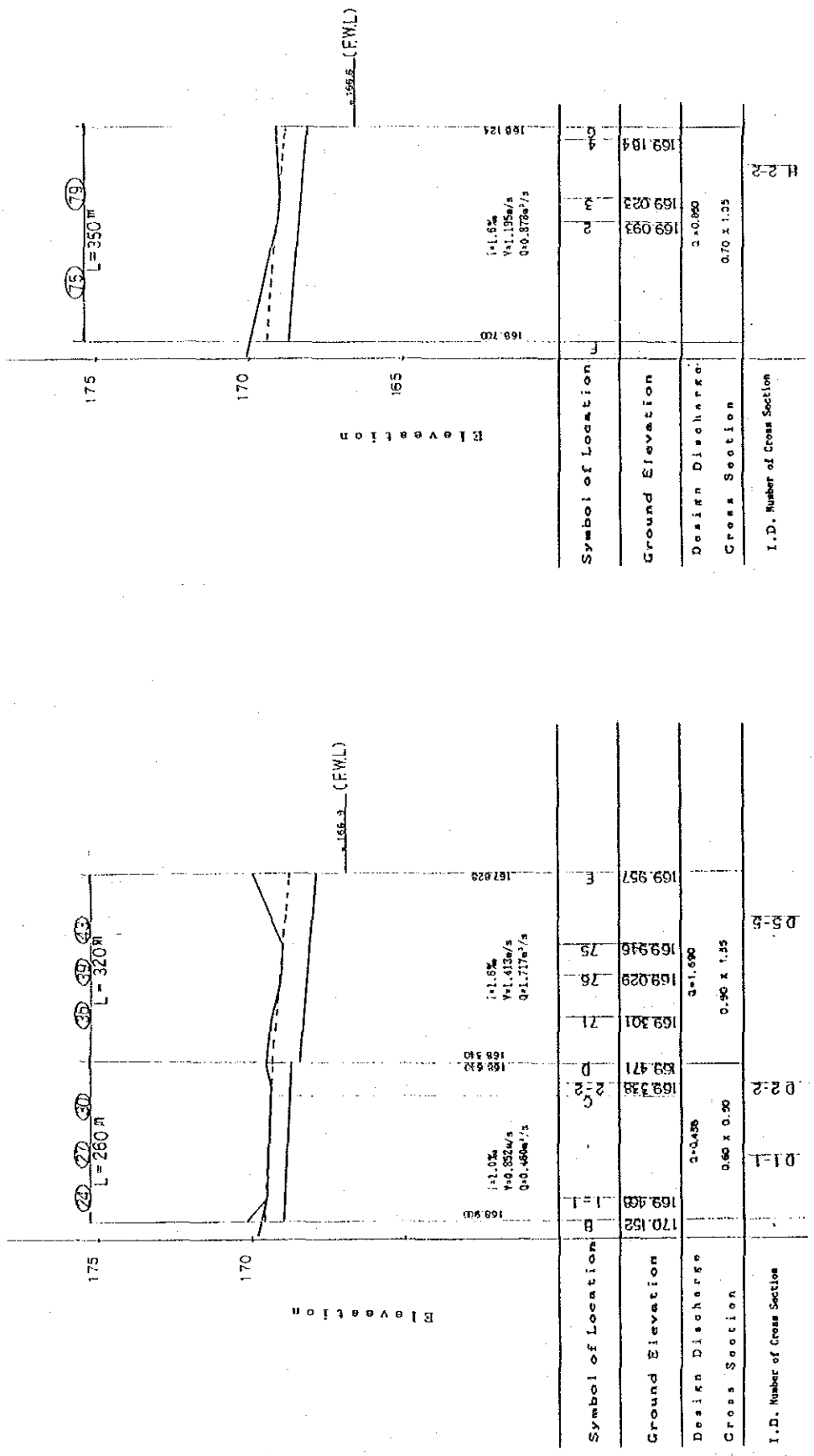

Fig. D.28 (2) Longitudinal Profile of Proposed Lateral Canal in Sub-area H

APPENDIX E

FACILITY PLAN

APPENDIX E. FACILITY PLAN

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Annex

E.1 Inventory of the Existing Structures

Inventory survey for the existing drainage facilities were conducted during the first and the second field study periods.

In the first field survey, the survey was carried out for the principal structures on the five main canals. In the second field survey, additional survey for the above principal structures and the survey for the lateral canals in the selected sample area. In this connection, sub-area "H" were selected as the sample area.

E.1.1 Principal Structures on the Main Canals

The principal structures located along the main canals are culvert, bridge, gate, pump and natural retarding basin. The location of the structures are shown in Fig. E.1.1. The principal structures are given in Table E.1.1. And further detailed survey result is given in Annex. The observations of the surveyed structures are briefed below:

(1) Culvert

Concrete culvert with rectangular section, concrete pipe and steel corrugate pipe are generally utilized as road crossing structure in the main canals. No serious damage is observed in the structure and it is not appeared that roughness of the inner surface is so large that the flow capacity is reduced considerably. Although some slopes face of earth embankment are damaged and there are a few sites where the pipes are exposed, the minimum thickness of earth covering is generally secured. In view of hydraulic design, however, most of the culverts appear to lessen the flow areas as compared with those of canals. At present actual discharge in the canal is not so large, and the problems are not obvious. However, the flow capacity is far from being enough to accommodate the discharge to be increased by urbanization and canal improvement in the future.

Weeds and moss flourish around the inlet and/or outlet portion and silting due to the deficient tracting force is observed on the channel

bottom and around the inlet and outlet portion. These conditions have reduced the flow capacity of structures.

Removal and new construction of the existing culverts should be planned together with the canal improvements.

(2) Bridge

Generally steel truss type or concrete rigid type of bridge is constructed for the main road and simple beam and slab bridge or wooden bridge is provided for side ways and private roads. The abutment of a highway bridge is made of concrete. Meanwhile, abutment of other bridge are made of brick with mortar finishing. No special problem is observed in the sub-structures of the existing bridges. Most of the super-structures are outdated for the laps of time. It is noted that width of steel truss bridges over Hong Xeng and Nam Pasak rivers are insufficient and the wooden slab is considerably damaged due to heavy traffic. The existing conditions of bridge have hampered the traffic.

Considering the effect on the flow capacity of main canal, bridges on the main roads do not bring about unfavorable effect on the flow capacity. However, at small bridge sites on main canals, particularly on the Khoua Khao and Hong Thong, the flow areas are rather reduced in comparison with that of the canal. Flow discharge at present is not so large but may be disturbed seriously when it is increased.

Construction of new bridges together with canal improvements should be considered in this drainage plan in order to secure the required flow capacity.

(3) Gate

Gates installed in the Study area are either sluice gates with steel frame and wooden leaves or wooden stop logs. The type of gate well suit to the purpose and the frequency of operation. Piers are made of reinforced concrete and abutments are made of either reinforced concrete or brick structure. No serious damages are observed in the concrete structures and gate leaves, but leakage from the gate sills is observed.

Operation of gates in the Study area is manual. For stop log type gate it would be necessary to install some appurtenant structure such as hoist deck to place and remove the stop logs more smoothly.

The operation is often manipulated by local residents for their own benefit, such as fishing, and the drainage conditions are affected thereby in the upstream reaches.

(4) Pump

No drainage pump set is installed in the Study area. Most of pumps installed are for the irrigation purpose except for the ones in the municipal water supply system. The largest pump is installed in Nam Pasak irrigation system having the intake capacity of 0.6 m^3/s and the effective head of 30 m. It taps water from the Mekong and releases it to the Nam Pasak. The pump is fixed to a simple wooden deck which floats in the Mekong. Power for the pump is taken from the commercial power supply. No significant difficulty is encountered for its operation and maintenance. Spare parts are available in Thailand. The owner of each facility has repaired the pump when it was damaged. No special difficulty is foreseeable in pump O.M.R.

(5) Natural retarding basin

The Nong Chanh and the That Luang marshes are presently used for agricultural purpose such as paddy and water spinach cultivation. Municipality has a plan to reclaim a part of the Nong Chanh Marsh to develop a public utility area and the That Luang Marsh to develop as an intensive irrigation field.

The Nong Douang Marsh and the Nong Bone Marsh have been reclaimed and residential areas have developed. No special facilities are provided to use these marsh areas as retarding basins.

(6) Construction material and facility

Laterite, aggregate, brick, concrete form and precast concrete material are available in Lao PDR. The production capacity thereof are deemed to

be sufficient for the implementation of the project. No difficulty is foreseeable to obtain electricity and water.

Meanwhile following materials are imported from Thailand, Japan, and USSR;

Cement; reinforcement bar; steel material; metal and PVC pipes and asphalt tar

Construction equipment made in USSR is prevailing but some are outdated.

E.1.2 The Lateral Canal

The site survey conducted during the heavy rainfall proved that the improper arrangement of lateral canals forms one of the bottlenecks in the existing drainage system. In order to investigate the present conditions thereof and to propose a method to improve, an inventory survey was conducted in the selected sample area. The sub-area H was selected as the sample area. The individual results is presented in Table E.1.2. Detailed survey result is given in Annex.

(1) Total length of ditch

The lateral canals are provided on the side of most streets and side roads. However densities between the south area and the north area of Hong Thong river in sub-area H have much difference. The total length of canal in the north area is far less than that in the south area.

(2) Structure

There are 6 types of channel section as shown in Fig. E.1.2, that is, rectangular, U-shape, half circular; circular, trapezoid and unlined soil type. Most of these ditches are precast concrete structures and partially made of brick. Canals along the main streets have concrete covers or are constructed under the pavement with maintenance hole. Most of canals

along side roads also have concrete covers. However, there are many cases that those are rather deteriorated or lost.

(3) Flow condition

Silting and garbage disposal are observed in almost all canals. In the soil canals flourishing of weeds and moss is also observed. So that flow areas of ditches are reduced considerably. There are some canals newly constructed. However flow in the canal is controlled by the bottle neck points, such as concrete pipe which is almost clogged. Therefore canals newly constructed or even a well maintained canal do not successfully function.

Canal with side inlet is constructed along the main street but the flow capacity of side inlet is rather small. There are some, intervals thereof are long. The blockade due to silting is commonly observed. In such a case, rainfall water does not flow into the drainage canal as planned and inundation is caused in some places.

(4) Structures on the canal

There are some small structures on the lateral canal as below.

- concrete pipe
- steel pipe.
- concrete slab bridge.
- wooden bridge.

These structures are installed in or over the canals for the access to private houses or buildings. Pipes are generally damaged and the flow area is considerably reduced by silting and garbage. No serious damage is observed in the concrete slab and wooden bridge. However, the flow area of canal under these structures is also reduced by silting and garbage. There are some structures newly installed in canals but water flow in the whole drainage system is restricted by the bottle neck points as mentioned above.

E.1.3 Disposal of Wastewater

Ordinary disposal methods of waste water were surveyed and the following results were obtained;

(1) Disposal of water from toilet

The water is retained in a septic tank provided for each toilet. And the final disposing places are paddy field, marsh and other fields.

(2) Disposal of domestic water

Water is directly discharged into a canal or a side ditch. These are the main pollutant source of drainage water.

E.1.4 Disposal of Garbage

Garbage is disposed to marshes, fields and canals. However there are some cases to excavate pits to dispose garbages. The garbage disposal in canals have caused silting of canal and the deterioration of drainage water quality.

E.2 Criteria for Facility Plan

Selection of structure type for facility plan is made on the basis of the criteria mentioned in the following sections. The criteria is provided considering the design standard adopted to the existing principal structures in Vientiane, actual resuls of construction works in Lao, and further the availability of construction material and construction method. In addition, several types of structures are conceived taking into consideration the local conditions at the structure site.

E.2.1 Revetment Works

(1) Bank Slope and Assumed Coefficient of Roughness

Type of revetment works	Bank slope	Coefficient of roughness
No revetment work	1:2.5	0.035
Sod facing	1:2.5	0.03 or more
Concrete plate pitching (2D)	1:1	0.025
Concrete plate pitching (3D)	1:1	0.02
Concrete block (2D)	1:0.5 - 1:0.3	0.025
Concrete block (3D)	1:0.5 - 1:0.3	0.02
Concrete block (3D with finishing)	1:0.5 - 1:03	0.015
Stone masonry	1:2	0.035

* 2D: Protection of 2 dimensions
* 3D: Protection of 3 dimensions

(2) Flow Velocity

Applying of no revetment work and sod facing is dependent on the flow velocity in occurrence of design flood as well as the bank slope. These two types are to be provided in case that the flow velocity is less than 1 m/s.

E.2.2 Crossing Structure

(1) Box Culvert

Box culvert is constructed by placing of concrete at site and applied to the large scale structure in comparison with the pipe culvert mentioned below.

Box culvert is mainly provided to the crossing point of lateral canal with existing road and inspection road and bank along the proposed main canal in this project.

(2) Pipe Culvert

Pipe culvert is constructed by site installation of precast concrete pipe. Therefore it is applied to comparatively small scale structure.

Pipe culvert is mainly provided to the crossing point of lateral canal with existing road and inspection road and bank along the proposed main canal in this project.

E.2.3 Bridge

(1) Bridge Type

Bridge type is selected mainly considering the necessary span length and clearance from the elevation of channel bottom.

Basically RC slab type bridge is adopted, but in case that the necessary span length exceeds 10 m, steel I-girder type bridge is adopted. Meanwhile in case that clearance from the elevation of channel bottom is small or that the road width is considerable large in comparison with the channel width, rigid frame type bridge is adopted.

(2) Bridge Width and Design Load

Bridge width and design load are selected corresponding to the existing road scale and the traffic condition as listed below.

Road Width	Design Live Load	Applied Case
- More than 7 m	TL-20	- In case that constant heavy traffic and passing of heavy vehicles are assumed.
- 4 m	TL-14	- In case that passing of normal scale of vehicle is assumed but the traffic is small.
- 2 m	Self weight of bridge dominates the load	- In case that passing of vehicle is not considered and it is designed as a way for man, bicycle and motorcycle.

E.3 Alternative Facility Plan

E.3.1 Basic Condition for Facility Plan and Design

The conceptual drainage plans for the Priority Project were selected among the several alternatives. The proposed plans comprise the facilities of canals, retarding basins and storage ponds. The structures related to the facilities mentioned above are listed below;

Canal	:	Channel (Section), revetment works and crossing structure
Retarding basin	:	Revetment works and outlet.
Storage pond	:	Channel (Section), revetment works and crossing structure

The proposed conceptual plans specify the hydrologic and hydraulic figures such as the design water level and design discharge at the strategic points of the proposed drainage systems.

Several conceivable types were compared for each structure. And subsequently the most suitable ones were adopted in the plan. In this connection, several conditions of the project sites were considered and referred to as follows;

I) The topography is flat and the depth of channel is limited mostly to less than 3 meters and slope is less than 1 to some thousands.

II) Soils are mostly sandy clay and silt.

III) The Study area is located in the center of the town.
Accordingly the available land area is limited and yet the plan should produce good views.

IV) The construction methods being adopted in the prevailing construction works in and around the Study area are considered to be the suitable method and materials to the local condition.

V) The complicated operation and maintenance should be avoided.

E.3.2 Conceivable Alternative Structure

In the light of the considerations mentioned in the previous section, the following types were adopted as the alternatives of each structure;

Channel	:	Single section and compound section.
Revetment works	:	Sod facing, concrete block (2D), concrete block (3D), concrete block 3D with finishing and Stone masonry.
Crossing structure	:	Box culvert, pipe culvert, rigid frame bridge, RC slab bridge and steel I-girder bridge.
Outlet structure	:	Free overflow weir with flush gate, sluice gate and pump.

In addition to the types given in the list, RC T-girder bridge is considered. However the girder, thereof is relatively deep and may not afford the sufficient clearance for the drainage channel, and further construction work is complicated in comparison with that of steel I-girder bridge. Consequently this type is discarded.

The technical features of each type are summarized as follows;

Single section :
- Construction is simple.
- Work volume is comparatively small.
- The discharge of low flow is not smooth.
- Stage wise construction is not suitable.

Compound section :
- The discharge of low flow is smooth.
- Multipurpose utilization of the high water channel is possible.
- Suitable for stage wise construction.
- Work volume is large.
- Construction is slightly complicated.

Sod facing :
- Domestic supply of material is possible.
- The coefficient of roughness is large (0.030 or more).
- A gentle slope is required (1 to 3 or more).

Concrete block(2D)	:	- The stability of slope can be controlled (1 to 0.3). - Required concrete volume is small as compared with the 3D-type. - A wider channel is required as compared with the 3D-type. - The coefficient of roughness is moderate (0.025).
Concrete block (3D)		- The stability of slope can be controlled (1:0.3). - A width of channel can be the most narrow. - The coefficient of roughness is small (0.020). - Maintenance is easy. - A considerable concrete volume is necessary.
Concrete block (3D) With finishing	:	- Same as the type of concrete block (3D). The coefficient of roughness is small (0.015).
Stone masonry	:	- Domestic supply of material is possible. - Manual construction is necessary. - Required slope is moderate (1 to 2). - The coefficient of roughness is large (0.035).
Box culvert and Rigid frame bridge	:	- Girder is not necessary. - Special foundation treatment is not necessary. - The required concrete volume is larger as compared with a concrete slab bridge. - The increase in the flow area is proportional to the increase in the water level.
Pipe culvert	:	- Mostly be precast concrete made. The placing of concrete at site is difficult. - Accordingly a pipe culvert is suitable for only a small scale works.

RC Slab bridge :
- Girder is not necessary.
- Foundation works may be necessary.
- The required concrete volume is small.
- The original river section therein can be secured.
- The span length should not exceed 10 meters.

Steel I-girder bridge :
- A girder with a depth of less than 500 mm is available if the span length is less than 10 meters
- Foundation works may be necessary.
- The original river section therein can be secured.
- The construction cost is high.

Free overflow weir with flush gate :
- Major work is concrete works.
- Operation for flood control is unnecessary.
- Only simple water level control can be afforded.
- Maintenance is easy.
- Durability of structure is high.

Sluice gate :
- Major work is metal works.
- Operation is necessary.
- Power for operation is necessary.
- A complicated water level control can be afforded.
- Maintenance is necessary.
- Durability of structure is rather high.

Pump :
- Major work is metal works.
- Operation is necessary.
- Power for operation is necessary.
- A complicated water level control can be afforded.
- Water can discharged from lower elevation to higher elevation.

- Maintenance is necessary.
- Durability is low.

The typical channel sections and revetment works are shown in Fig. E.3.1. Fig. E.3.2 presents the typical bridge and culvert.

E.3.3 Comparative Study for Main Canal

The several alternative combination of channel section and revetment works for the channel were compared to obtain the most advantageous plan for the improvement of the main canal.

(1) Hong Ke System

Comparative study was performed for Hong Ke main canal. Meanwhile for Hong Thong and Khoua Kao canal, comparative study was not performed because the area available for the canals are very restricted and the flow velocity in the channel which has a function as storage pond in flooding is small, therefore no revetment work of concrete block is necessary for both banks, and further the channel should discharge the low flow from the urbanized areas in the dry season.

The Hong Ke is divided into two stretches as follows:

Stretch 1 : From the weir to the bridge of Bang Fay (370 m)
Stretch 2 : From the immediate downstream from the bridge to the outlet to the That Luang (2,200 m)

The following five alternatives were examined for Hong Ke main canal.

Stretch	Channel	Single section		Compound section		
		Case 1	Case 2	Case 3	Case 4	Case 5
Stretch 1	HW channel	-	-	SOD	CB3D	CB3D
	LW channel	CB2D	CB3D	CB2D	CB2D	CB2D
Stretch 2	HW cannel	-	-	SOD	CB2D	CB2D
	LW channel	CB2D	CB2D	CB2D	CB2D	CB2D

Where CB2D and CB3D mean the revetment works by concrete block for 2 dimensions and for 3 dimensions respectively. The cases are featured as follows;

Case 1 :
- The construction work such as excavation is simple.
- The discharge of low flow may have difficulties.
- A stage wise construction is not suitable.

Case 2 :
- The construction work is simple.
- The width of the stretch 1 can be narrow.
- The volume of concrete is large.
- The discharge of low flow may have difficulties.
- A stage-wise construction is not suitable.

Case 3 :
- Domestic supply of material is possible.
- Coefficient of roughness is large (0.03 or more).
- The discharge of low flow is smooth.
- The multipurpose utilization of the high water channel is afforded.
- A stage wise construction may be applied.
- Large quantity of concrete is not necessary.

Case 4 :
- The discharge of low flow is smooth.
- The multipurpose utilization of the high water channel is afforded.
- A stage wise construction may be applied.
- The construction works such as excavation become complicated.

Case 5 : - The discharge of the low flow is smooth.
- The multipurpose utilization of the high water channel is afforded.
- A stage-wise construction may be applied.
- The width of the stretch 1 is narrow.
- The construction works such as excavation is a little complicated.
- The concrete volume is large.

Applying the tentative unit prices, the construction cost is estimated for each case as follows;

Case 1	US $ 2.4 x 10^6
Case 2	US $ 3.1 x 10^6
Case 3	US $ 1.7 x 10^6
Case 4	US $ 2.7 x 10^6
Case 5	US $ 3.3 x 10^6

The costs for concrete, canal excavation and the construction of bridges dominated the costs presented above, in addition land acquisition cost for the extension of channel section is considered.

According to the above result, it is clear that case 3 is the least cost alternative. In this case the high water channel is lined with sod facing, therefore it is easy to maintain the natural water purification function. Furthermore it is considered that the case is also advantageous from the view point of river environment and creation of good scenery. Along this line, case 3 was adopted as the feasibility plan for Hong Ke.

(2) Nam Pasak System

The proposed Nam Pasak system comprises the existing Nam Pasak channel and the short cut channel proposed at the heavily meandering stretches. The design discharges thereof varies from the upstream reach to the downstream reach. The maximum discharge of 23.3 m^3/s is for the lowest reach of the river. Meanwhile that in the upstream reach is 6.8 m^3/s. Since the meandering is heavy, the width of the existing river varies from section to section. Some section have the width of

more than 30 m. A corrugate pipe with a diameter of 900 mm is provided as a road crossing.

In accordance with the future land use plan, the river stretch is divided into the following two portions;

Stretch 1 : From the origin to the crossing with Sam Sen Thai road (900 m)

Stretch 2 : From the crossing with Sam Sen Thai road to the confluence with the Hong Xeng.

Since the area of the Nam Pasak is one of the most densely populated zone, the land acquisition is difficult. However the low flow must be discharged without any stagnation. In this accord, the compound section is considered throughout the channel. And in respect of the revetment works, the following three alternatives were examined;

Stretch	Channel	Case 1	Cases 2	Case 3
Stretch 1	Existing canal			
	HW channel	CB2D	SOD	SOD
	LW channel	CB3D	CB3D	CB3D
	Short cut portion			
	HW channel	CB3D	CB3D	CB3D
	LW channel	CB2D	CB2D	CB2D
Stretch 2	Existing canal			
	HW channel	CB2D	SOD	CB2D
	LW channel	CB3D	CB3D	CB3D
	Short cut portion			
	HW channel	CB3D	CB3D	CB3D
	LW channel	CB2D	CB2D	CB2D

Where CB2D means a revetment work by concrete blocks for 2 dimensions. CB3D means a revetment work by concrete blocks for 3 dimensions. SOD means a revetment work by sod facing. The width of a shortcut portion is minimized by applying 3 dimensional revetment works in the high water channel.

All the cases are featured as follows;

Case 1 : - The width of canal is small as compared with the alternative having sod facing portions.
- The requisite concrete volume is large.

Case 2 : - The requisite concrete volume is small.
- The side slope is gentle and the right-of-way become large
- Amenity spaces are provided.
- The existing purification function of the river may be maintained.

Case 3 : - The construction cost may be the medium of the case 1 and 2.

Applying the tentative unit prices, the construction costs for three cases are estimated. The results of the estimation is shown below;

Case 1 : US $4.3 x 10^6
Case 2 : US $3.3 x 10^6
Case 3 : US.$4.2 x 10^6

The cost for concrete, canal excavation and the construction of bridges dominate the costs presented above.

According to the above result, case 2 is the least cost alternative. From the view point of river environment and creation of good scenery, the green areas can be secured in the area along the stretch 1. However it might be difficult in the area along the stretch 2 in the shortcut portion. Sod facing is preferable to conserve a natural environment. Along this line, case 2 was adopted as the feasibility plan for the Nam Pasak.

E.4 Proposed Facility Plan for Hong Ke System

The Hong Ke system comprises the Hong Thong canal, Khoua Khao canal, Nong Chanh retarding basin and the Hong Ke canal. Proposed facility plan is prepared on the basis of the examination of conceivable alternative structure and the comparative study made in the previous chapter.

General layout of facility plan for whole system is illustrated in Fig. E.4.1.

E.4.1 Hong Thong Canal

(1) Main Canal

Hong Thong canal may be divided into the storage pond, the crossing canal at morning market and the narrow canal along the proposed bus terminal.

Upstream reach of inlet portion of culvert at Morning Market has a function as storage pond to regulate flood water in the rainy season. The flow velocity in the high water channel is set at 0.8 m/s and no revetment work of concrete block is necessary. Therefore sod facing lining is planned for bank slope and high water channel bottom.

Meanwhile the ponds should discharge the low flow from the urbanized areas in the dry season. To handle the low flow discharge, the compound section is provided. The concrete block of 3D is provided in the low flow channel. Thereby the cleaning of the low flow channel by flushing become easy. Typical section of channel is shown in Fig. E.4.2.

The hydraulic analysis entailed that the elevations of the sill of the crossing canal in the morning market are El.166.0 m at the lowest reach and El.166.3 m at the uppermost reach. Meanwhile the ground elevation of the market is around El.169.0 m. The canal should discharge the design flow of about 15.5 m^3/s within this space. Accordingly, no space for the girder could be allocated from the clearance of 2.4 m.

Consequently 2 lanes of box culverts with a length of 270 m as shown in Fig. E.4.3 are provided in the portion.

The portion from the culverts mentioned above up to the proposed Nong Chanh retarding basin is narrowed by the proposed bus terminal and Khoun Boulon road. The discharge therein is about 20 m^3/s including the runoff from the remnant catchment area. The bank slopes should be steep to secure the flow section. Further the coefficient of roughness should be the minimum to minimize the loss due to the friction. In this respect, a channel with a single section of which the bottom width is 6 meter is planned and the revetment works of concrete block and slab of 3 dimensions with finishing work is provided. Typical section of channel is shown in Fig. E.4.2.

(2) Canal Crossing Structure

Crossing structures are planned at seven crossing points of roads or footways with the canal. In order to secure the necessary capacity of storage pond bridge is planned at all these sites. RC slab bridge is adopted in consideration with the necessary span length corresponding to the extension of channel width. Plan, profile and section of bridge are shown in Fig. E.4.4.

E.4.2 Khoua Khao Canal

(1) Main Canal

The Khoua Khao canal is also designated to be a storage pond in order to regulate the inflow as much as possible. The flow velocity in the high water channel is set at 0.8 m/s and no revetment work of concrete is necessary. Therefore sod face lining is planned for bank slope and high water channel bottom.

Khoua Khao canal should also discharge he low flow from urbanized areas in the dry season. For the purpose of handling the low flow discharge, the compound section is provided. The concrete block of 3D is provided in the low flow channel. Thereby the cleaning of the low flow

channel by flushing become easy. Typical section of channel is shown in Fig. E.4.2.

(2) Canal Crossing Structure

Crossing structures are planned at ten crossing points of roads with the canal and at present box culvert, pipe culvert or small bridge is installed at these crossing points. For the purpose of securing the necessary storage capacity and avoiding the unfavourable effect to the flow condition, it is planned that all existing structures are demolished and new bridge is constructed. In consideration with the necessary span length corresponding to the extension of channel width RC slab bridge is adopted. Plan, profile and section are shown in Fig. E.4.5.

(3) Gate

For the existing gate facility at the outlet portion of Khoua Khao canal to the Mekong river, rehabilitation work is planned. Repair of abutment structure is planned and further steel frame and manual type winch are provided in order to make stoplog operation easy.

E.4.3 Hong Ke Canal

(1) Main Canal

Based on the result of the comparative study described in the previous chapter, a channel with a compound section is planned and the revetment works of sod facing and concrete block 2 dimensions are provided for high water channel and low water channel respectively. Typical section of channel is shown in Fig.E.4.2.

(2) Canal Crossing Structure

Crossing structures are planned at five crossing points of roads with the canal. In order to secure the necessary flow area in flowing of design flood existing bridges or culverts are demolished and new bridges are planned.

Taking into consideration the necessary span length corresponding to the extension of channel width, steel I girder bridge is adopted for That Luang bridge and No. 1 to No. 3 bridge illustrated in Fig. E.4.1. For That Luang bridge road width of two lane is adopted. Plan, profile and section are shown in Fig. E.4.6.

Ban Fay road which connect the residential and commercial zone located in the south of the Nong Chanh to the national high way, route 13, crosses the Hong Ke about 370 m downstream from the outlet of the Nong Chanh. The road has two lanes and has a heavy traffic. The Hong Ke passes under the road through the double-laned box culverts with a width of 2.4 m each. The box culvert is to be demolished and a rigid type bridge will be provided. The bridge may have four spans with a length of 5.3 m each. In order to save the space for the clearance a bridge with girders was not considered. The width of the bridge is as wide as 17.0 m and the concrete slab bridge is not adopted. Plan, profile and section are shown in Fig. E.4.7.

(3) Irrigation Water Pipe

At That Luang bridge site, an irrigation canal crosses the Hong Ke along the road described above. The design discharge of the canal is 100 l/s. The elevation of the canal sill is El.165.4 and be submerged by the flood water level of El.166.0. An aqueduct of fiber reinforced plastic pipe with dia. 0.5 m is provided along the bridge. The duct of a plastic pipe is removable and be folded during high flood which submerge the duct so that it will not disturb the flood flow.

(4) Pipe and Box Culvert

These structures are provided to the crossing point of the lateral canal with existing road and inspection road and bank along the main drainage canal. Typical section of pipe and box culverts that connect the lateral and main canals are shown in Fig. E.4.8.

E.4.4 Nong Chanh Retarding Basin

(1) Retarding Basin

The Nong Chanh retarding basin regulate flood discharge with a flood control space of 0.12×10^6 m^3. The slope of the bank can be gentle. And the coefficient of roughness is insignificant from the technical view point. For the revetment works, combination of stone masonry, sod facing and partially concrete block is proposed to provide a preferable conditions to fauna and flora. It is expected to produce a good scenery view which well fit to the views of Vientiane.

(2) Free Overflow Weir

A concrete free overflow weir is provided at the outlet of the proposed retarding basin. The elevation of the weir crest is designated to be El. 166.0 by the hydraulic analysis. The spill-out from the free overflow section avoid a complicated operation during the flood. The discharge of 31.8 m^3/s requires a weir length of 22.0 meters at the flood water level of El. 167.0. In order to flush the sands and solid materials silted in front of the weir, a sand flush of a steel sluice gate system is provided. The operation thereof can be carried out anytime of high water period. Fig. E.4.9 shows the plan, profile and weir section.

E.4.5 Principal Features of the Proposed Facilities

As discussed in the previous sections, the comparative study for the Hong Ke system entailed that the case which envisages a compound section with a sod facing works is the least costly alternative . In this case the Nong Chanh retarding basin discharge flood water through the weir with a free overflow section. The case is the most preferable plan in view of environment as well. Consequently the case is adopted for the feasibility plan.

The principal features of the feasibility plan are proposed as presented below.

Design water level :

That Luang	El. 166.0
The Nong Chanh retarding basin (FWL)	El. 167.0
The Nong Chanh retarding basin (LWL)	El. 166.0
The Hong Thong storage pond (FWL)	El. 168.0
The Hong Thong storage pond (LWL)	El. 166.6
The Khoua Khao storage pond (FWL)	El. 168.0
The Khoua Khao storage pond (LWL)	El. 166.0

The Hong Ke channel :

Design discharge (Max.)	58.1 m^3/s
Design discharge (Min.)	31.8 m^3/s
Length	2570 m
Width (Max.)	34 m
Revetment works (compound)	5140 m
Nos. of bridge	5
Movable aqueduct (100 lit./sec)	40 m

The Nong Chanh retarding basin :

Storage volume		0.12 x 10^6 m3
Surface area		12 ha
Length of spillway (weir)		22.0 m
Type of gate (steel)	Sluice	(1 m x 1 m)
Nos. of gate leaf		1 leaf
Revetment works (Stone masonry)		2,000 m

Culvert in the Hong Thong :

Design discharge	15.5 m^3/s
Length	270 m
Nos. of lane	2
Required flow section	12.0 m^2
Elevation of sill (Outlet)	El. 166.0
Elevation of sill (Inlet)	El. 166.3

The Hong Thong storage pond

Storage volume (Compound section)	16,000 m^3
Revetment works (Concrete block)	2,260 m
Concrete headrace channel to the Nong Chanh retarding basin (Single section)	400 m
Nos. of bridge	7

The Khoua Khao storage pond

Storage volume (Compound section)	32,000 m^3
Revetment works (Concrete block)	2,500m
Nos. of bridge	10

The lateral canal (Saya Settathirath) 3 km

E.5 Proposed Facility Plan for the System for Sub-area L (Nam Pasak)

Proposed facility plan is provided on the basis of the examination of conceivable alternative structure and the comparative study made in the previous chapter.

General layout of facility plan for whole system is illustrated in Fig. E.4.1.

E.5.1 Nam Pasak Canal

(1) Main Canal

The proposed Nam Pasak system comprises the improvement portion of the existing channel and the new shortcut channel portion. For the purpose of discharging smoothly the river flow, of which the fluctuation is rather large between the dry season and the rainy season, and especially discharging the low flow without stagnation, compound section is provided throughout the channel. The high water channel of an improved reach is lined with sod facing to conserve the green area and to maintain the natural water purification function.

Meanwhile the high water channel of shortcut channel is lined with concrete plate block of 3D to save the required land acquisition for channel excavation. Typical section of channel is shown in Fig. E.4.2.

(2) Canal Crossing Structure

Canal crosses at seven points with the main roads or footway. In order to secure the necessary flow area in flowing of design flood existing culverts or concrete pipes are demolished and bridge is planned. RC slab bridge is adopted in consideration with the necessary span length corresponding to the extension of channel width.

Plan, profile and section of bridge are shown in Fig. E.5.1.

E.5.2 Principal Feature of the Proposed Facilities

The principal features of each feasibility plan are provisionally envisioned as presented below. A preliminary images of the improved channel are shown in Plate 4.9.

The Nam Pasak system

Design water level (Hong Xeng)	El. 167.2
Design discharge (max.)	23.3 m^3/s
Design discharge (min.)	6.8 m^3/s
Length of channel (compound)	3,220 m
Nos. of shortcut channel	5
Total length of shortcut channel	1,140 m
Width of shortcut (max)	21.5 m
Revetment works (concrete block)	6,440 m
Nos. of bridge	7

E.6 Proposed Facility Plan for the System for Sub-area I (Hong Kai Keo) and Sub-area K

E.6.1 Hong Kai Keo System

(1) Main Canal

Based on the examination of the conceivable alternative structure, a channel with a compound section is planned and the revetment works of sod facing and concrete block 3 dimensions are provided for high water channel and low water channel respectively. Typical section of channel is shown in Fig. E.4.2.

(2) Canal Crossing Structure

Crossing structures are planned at two crossing points of roads with the canal. In order to secure the necessary flow area in flowing of design flood existing bridges are demolished and new bridges are planned.

Taking into consideration the necessary span length corresponding to the extension of channel width, RC slab bridge is adopted. Plan, profile and section of bridge are shown in Fig. E.6.1.

(3) Nong Bone Retarding Basin

The Nong Bone retarding basin regulates flood discharge with a flood control space of 0.05×10^6 m^3. The slope of the bank can be gentle. And the coefficient of roughness is insignificant from the technical view point. For the revetment works, combination of stone masonry, sod facing and partially concrete block is proposed to provide a preferable conditions to fauna and flora. It is expected to produce a good scenery view which well fit to the views of Vientiane.

(4) Free Overflow Weir

A concrete free overflow weir is provided at the outlet of the proposed retarding basin. The elevation of the weir crest is designated to be El. 167.0 by the hydraulic analysis. The spill-out from the free overflow section avoid a complicated operation during the flood. The discharge of

El. 167.5. In order to flush the sands and solid materials silted in front of the weir a sand flush of a steel sluice gate system is provided. The operation thereof can be carried out anytime of high water period. The sill of the stoplog is set at El. 166.5 m so that the water surface could keep the elevation of El. 166.5 m in the ordinary case. Total stoplog length is 4 m and drawdown of water level from El. 167.0 to El. 166.5 m is possible in less than half day.

Fig. E.6.2 shows the views of the weir with flush gate and stoplog sill. Principal features of the system are presented below:

Design water level:

The Hong Xeng	El. 166.9 m
Nong Bone retarding basin (FWL)	El. 167.5 m
Nong Bone retarding basin (LWL)	El. 166.5 m

The Hong Kai Keo canal:

Design discharge (Downstream)	20.2 m^3/s
Design discharge (Upstream)	23.5 m^3/s
Length	1,300 m
Bed slope	1 : 1,300
Width (channel bed)	6 m
Bank slope	1 : 2.5
Low flow channel (W x H m^2)	2.0 x 0.5 m^2

Nong Bone retarding basin

Water surface area		50,000 m^2
Flood control space		50,000 m^3
Concrete weir crest el.		El. 167.0
Concrete weir length		20 m
Flush gate	Sluice	1 m x 1.5 m x 1 leaf
Stoplog width		2 m x 2 lane

Maintenance road

Elevation	El. 168.0 m
Width	5 m
Pavement	Asphalt

Pavement		Asphalt
Road crossing culvert		1 m x 1 m
Road crossing concrete pipe		Dia. 600 mm

Bridge

Nong Soan Tha road	type	Concrete slab
	width	4 m
	load	TL-14
Phong Sa Ath road	type	Concrete slab
	width	2 m

E.6.2 System for Sub-area K

The improvements of 6 lateral canals and 3 culverts are proposed for the drainage system in the subarea K. the main features are summarized as follows;

Lateral No. 1

Design discharge	0.51 m^3/s
Length	310 m
Width	0.6 m
Slope	1 to 370

Lateral No. 2

Design discharge	0.68 m^3
Length	390 m
Width	0.8 m
Slope	1 to 670

Lateral No. 3

Design discharge	1.05 m^3/s
Length	270 m
Width	1.0 m
Slope	1 to 670

Lateral No. 4

Design discharge	0.39 m^3/s
Length	230 m
Width	0.7 m
Slope	1 to 670

Lateral No. 5

Design discharge	2.26 m^3/s
Length	230 m
Width	1..3 m
Slope	1 to 670

Lateral No. 6

Design discharge	0.26 m^3/s
Length	310 m
Width	0.6 m
Slope	1 to 670

Culvert No. 1

Design discharge	1.42 m^3/s
Length	20 m
Width	1.25 m
Slope	1.25 m

Culvert No. 2

Design discharge	2.26 m^3/s
Length	20 m
Width	1.5 m
Slope	1.5 m

Culvert No. 3

Design discharge	0.26 m^3/s
Length	20 m
Width	1.0 m
Slope	1.0 m

E.7 Plan of Treatment Facility

Deterioration of water quality in the drainage canal, and further unfavourable effect to the river environment due to canal improvement must be avoided. Therefore some kinds of measures by facility are planned for the purpose of controlling inflow of suspended solid into drainage canal and alleviating the increase of pollutant load in the drainage water.

In this project the following 3 types are planned considering that

the construction cost is small,
the operation is not necessary and
the maintenance work is simple.

(1) Mesh Screen in Sewage Inlet

As shown in Fig. E.7.1, mesh screen is installed in sewage inlet in a house lot. Flowing of suspended solid into the drainage canal is prevented by the mesh screen.

(2) Gravel Purification

As shown in Fig. E.7.2, gravel bed is provided in the high water channel at the outlet portion of lateral canal. Pollutant load in sewage is reduced by the gravel layer before flowing into the drainage canal.

(3) Sand Basin

As shown in Fig. E.7.3., small pond is provided in the drainage canal. Suspended solid and silt is settled in the pond by decrease of flow velocity.

In this plan this pond is provided at an interval of 100 m in the main canal.

TABLES

Table E.1.1 Inventory of Canal Related Structures

Structure No.	Sub-area	Canal Name	Type of Structure	Construction Marerial	Present Condition of Structure			Flow Condition		
					exhaustion	roughness of inner-surface	influence on land scape	reduction of flow area	sediment condition	flourishing of weeds
N-1	C	Khoua Kao	box culvert	concrete	A	A	A	A	A	A
N-2	C	"	gate with stop log	brick,wooden	A	A	A	A	A	A
N-3	C	"	box culvert	concrete	B	B	-	B	B	B
N-4	C	"	slab bridge	concrete	A	A	-	B-C	B	C
N-5	C	"	slab bridge	concrete	A	A	A	B	B	B
N-6	C	"	slab bridge	concrete	B	B	A	B	B	B
N-7	C	"	slab bridge	concrete	B	A	A	B	B	C
N-8	C	"	slab bridge	concrete	B	B	A	B	-	C
N-9	C	"	wooden bridge	wood	B	C	B	C	-	C
N-10	C	"	wooden bridge	wood	A	A	A	B	-	C
N-11	C	"	corrugate pipe	steel	A	-	B	B	-	A
N-12	C	"	corrugate pipe	steel	B	-	A	B	-	C
N-13	H	Hong Thong	box culvert	concrete	A	B	A	A	-	A
N-14	H	"	box culvert	concrete	A	A	A	A	A	A
N-15	H	"	box culvert	concrete	A	B	A	A	B	B
N-16	H	"	wooden bridge	wood	B	-	B	A	A	A
N-17	H	"	box culvert	concrete	B	B	A	B	B	A
N-18	H	"	box culvert	concrete	A	B	A	B	B	B
N-19	L	"	box culvert	concrete	A	B	A	B	B	B
N-20	G	Hong Ke	box culvert	concrete	A	A	A	A	-	A
N-21	E	"	culvert(box,pipe)	concrete	B	B	A	B	A	B-C
N-22	F	"	culvert(box,pipe)	concrete	B	A	A	A-B	A-B	A
N-23	F	"	culvert(box,pipe)	conc.,steel	A	B	A	A	A	A
N-24	L	Nam pasak	sluice gate	concrete	A	B	B	B	-	B
N-25	L	"	pipe culvert	concrete	A	B	A-B	B-C	B-C	B
N-26	L	"	box culvert	concrete	A	B	A	A	B	A
N-27	L	"	pipe culvert bridge	concrete	A	A	A	A	A	A
N-28	L	"	box culvert	concrete	B-C	B	A	B	-	B
N-29	L	"	pipe	concrete	B	B	B-C	B	B	B
N-30	L	"	corrugare pipe	steel	B	B	B	B	B	B
N-31	L	"	T-beab bridge	concrete	A	-	A	B	B	B
N-32	L	"	culvert bridge	concrete	A	A	A	A	-	B
N-33	M	"	truss bridge	steel	A	-	A	-	-	A
N-34	J	Hong Xeng	truss bridge	steel	A	-	A	-	-	A
N-35	J	"	wooden bridge	wood	B	-	A	B	-	B
N-36	K	"	box culvert	concrete	A	A	A	A	A	A
N-37	K	"	gated weir	concrete	A	-	A	A	A	B

Remarks A: There are no serious ploblems effecting on the structure and flow capascity and the structure does not produce some unfavorable effecst on the landscape.

B: There are not so sesrious problems but some problems such as follows are observed .
- the structure is outdated for the laps of times and some damages are observesd.
- the flow area is reduced by silting and/or garbage disposal.
- roughness in channel is high due to sitting and/or flourishing of weeds and moss.

C: Serious problems such as follows are observed.
- the structure is considerably damaged.
- more than around 50% of flow area is blokaded by silting and garbage and far from being enough to flow water with original capacity.
- the structure produces unfavorable effect on the land scape.

Table E.1.2 Summary of Road Side Ditch in Sub-area "H"

Items	South Area of Hong Thong		North Area of Hohg Thong		Whole Area	
	(m)	(%)	(m)	(%)	(m)	(%)
Ditch Length for Section Type						
- Rectangular	9835	58.5	2715	39.8	12550	53.1
- U-shape flume	2300	13.7	0	0.0	2300	9.7
- Half circular	1625	9.7	0	0.0	1625	6.9
- Circular	680	4.0	70	1.0	750	3.2
- Trapezoidal	90	0.5	0	0.0	90	0.4
- Soil	2275	13.5	4030	59.1	6305	26.7
total length	16805	100	6815	100	23620	100
Length of Covered Ditch	10955	65.2	2410	35.4	13365	56.6
Length of Ditch with Side Inlet	5870	34.9	1760	25.8	7630	32.3
Structure on ditch						
- Concrete pipe or culvert (nos.)	15		30		45	
- Steel pipe (nos.)	1		1		2	
- Concrete bridge (nos.)*	140		60		200	
- Wooden bridge (nos.)*	200		220		420	

* Bridge length is assumed to be about 2 m/no. in average

FIGURES

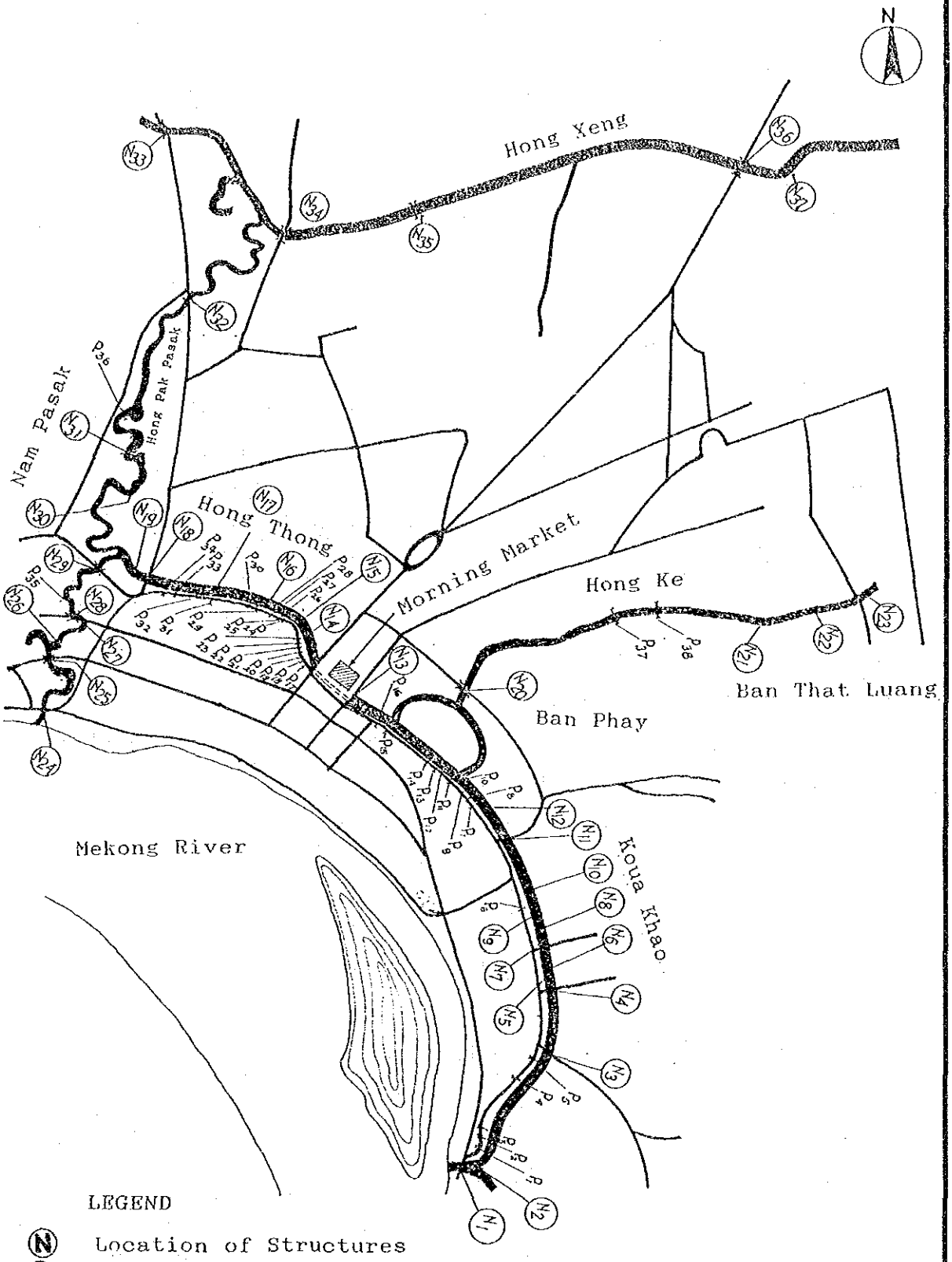
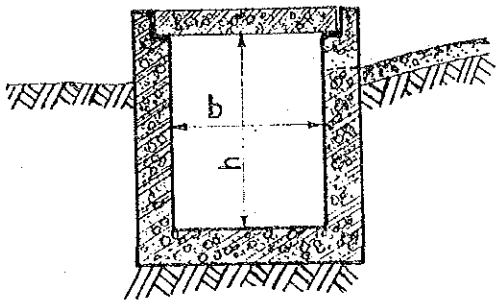


Fig.E.1.1 Location of Canal Related Structures

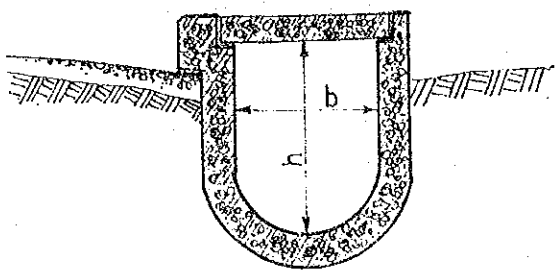
LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY



h= 0,4 m ~ 1,0 m

b= 0,3 m ~ 1,2 m

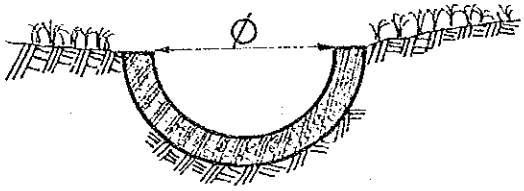
RECTANGULAR TYPE



h= 0,5 m ~ 0,8 m

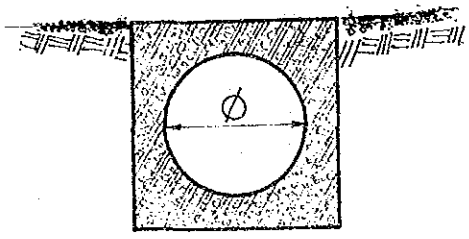
b= 0,7 m ~ 1,0 m

U-SHAPE TYPE



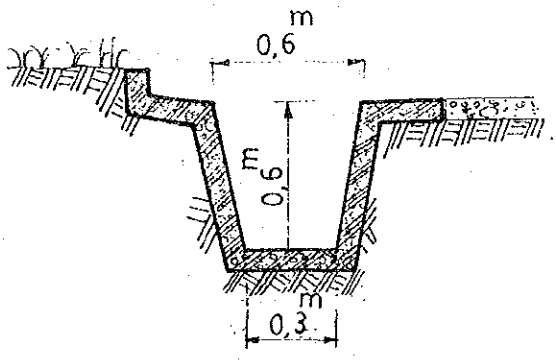
Ø = 0,3 m ~ 0,5 m

HALF CIRCULAR TYPE

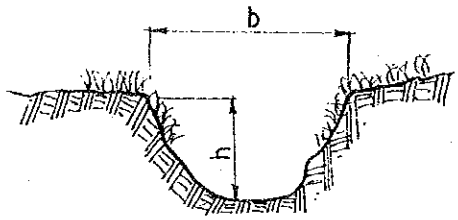


Ø= 0,4 m ~ 0,6 m

CIRCULAR TYPE



TRAPEZOIDAL TYPE



h= 0,2 m ~ 1,2 m

b= 0,4 ~ 2,0 m

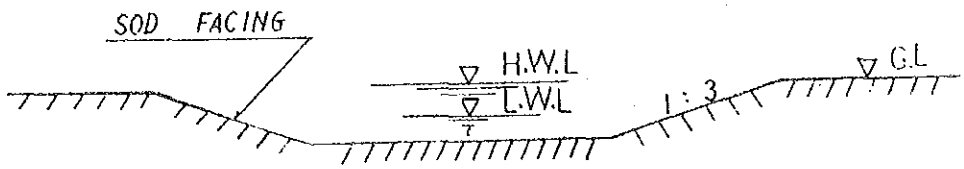
SOIL DITCH

Fig.E.1.2 Result of Inventory Survey (Section Type of Road Side Ditch)

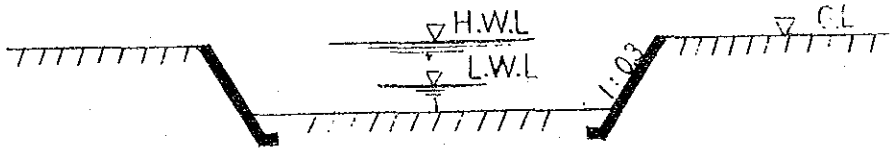
LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

TYPE OF CROSS SECTION

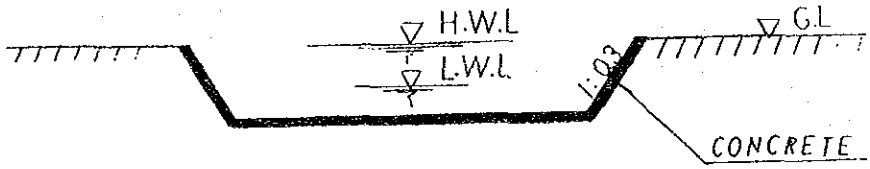
TYPE 1



TYPE 2



TYPE 3



TYPE 4

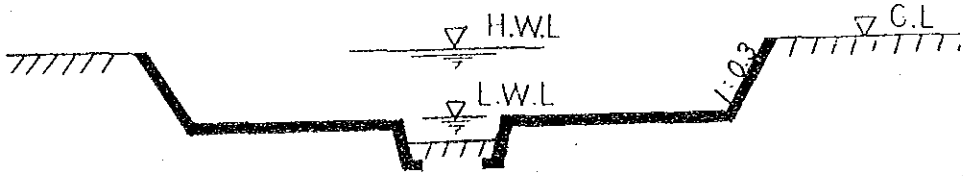
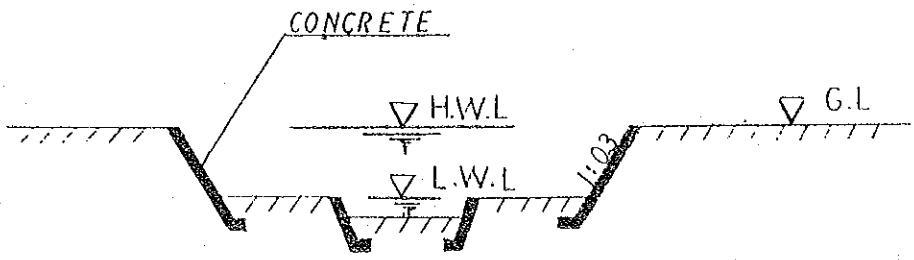


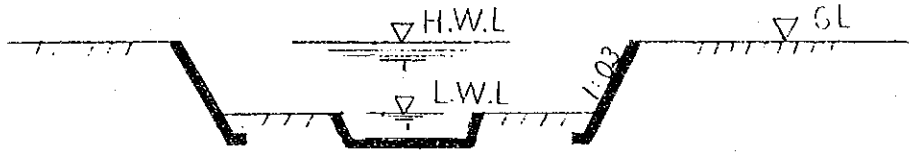
Fig.E.3.1 Facility Alternatives for Section and Revetment of Main Canal (1)

LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

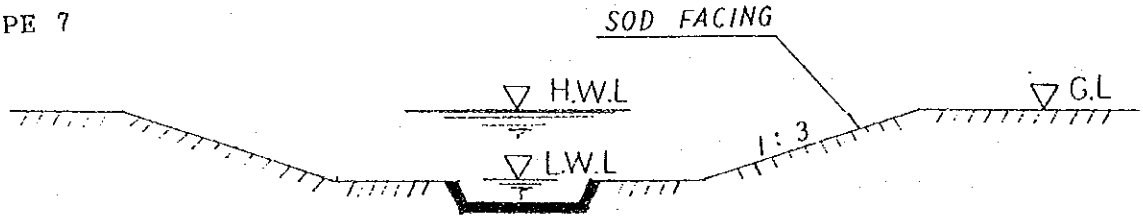
TYPE 5



TYPE 6



TYPE 7



TYPE 7'

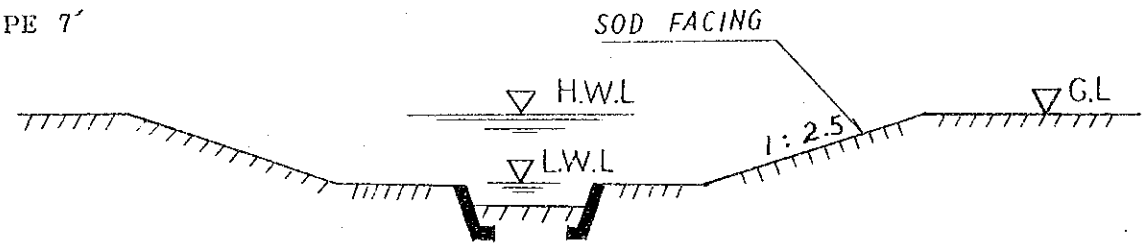
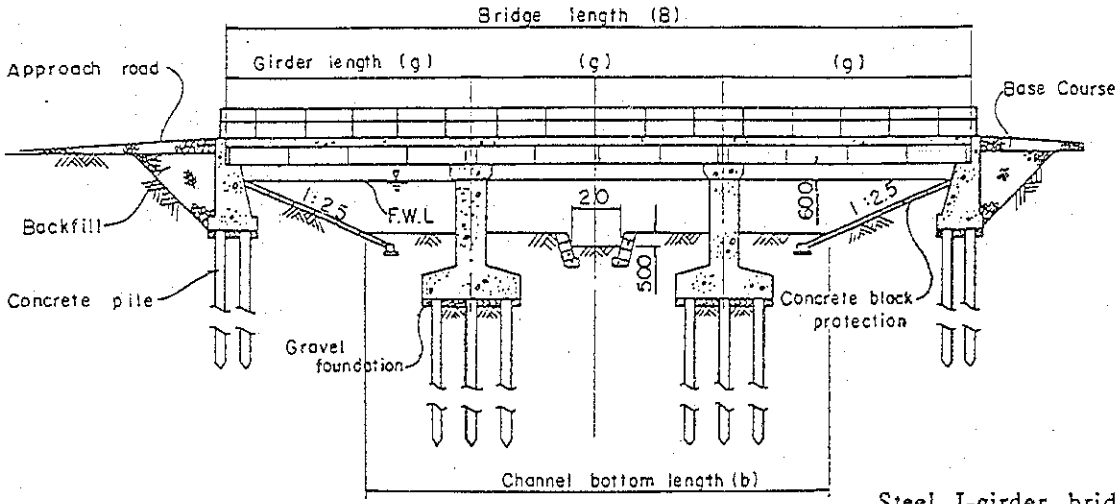
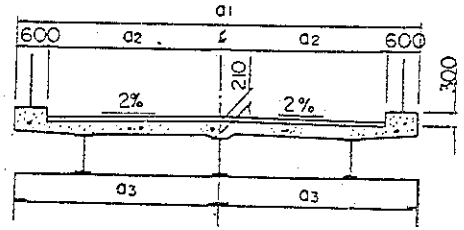


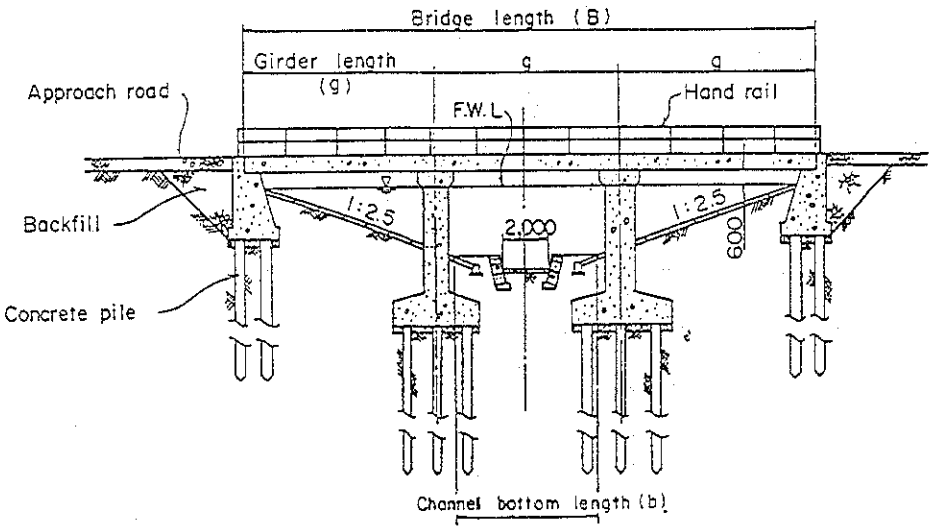
Fig.E.3.1 Facility Alternatives for Section and Revetment of Main Canal (2)

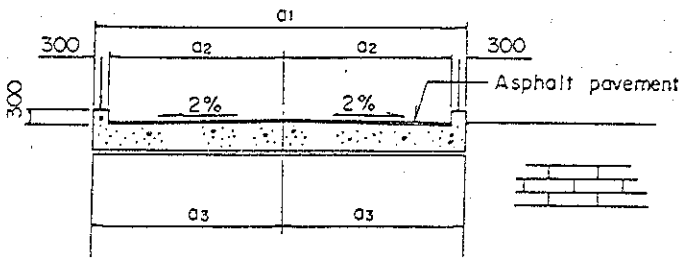
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY





Steel I-girder bridge



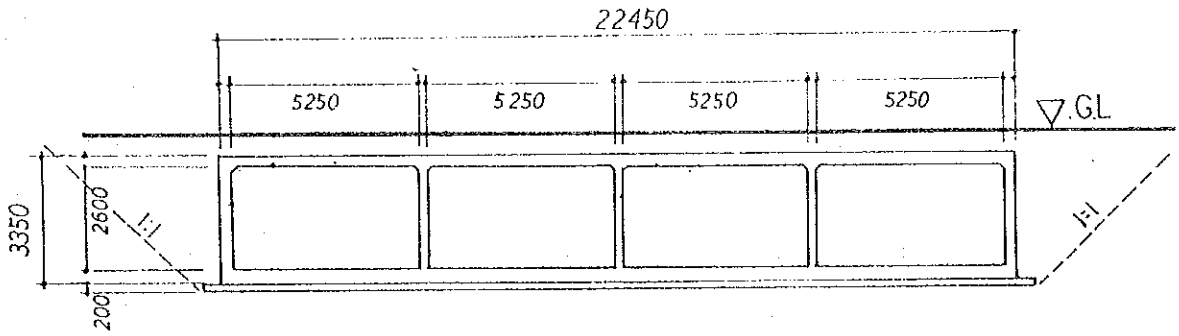


RC Slab bridge

Fig. E.3.2 Bridge and Culvert (1)

LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

Ban Fay Bridge



Morning culvert

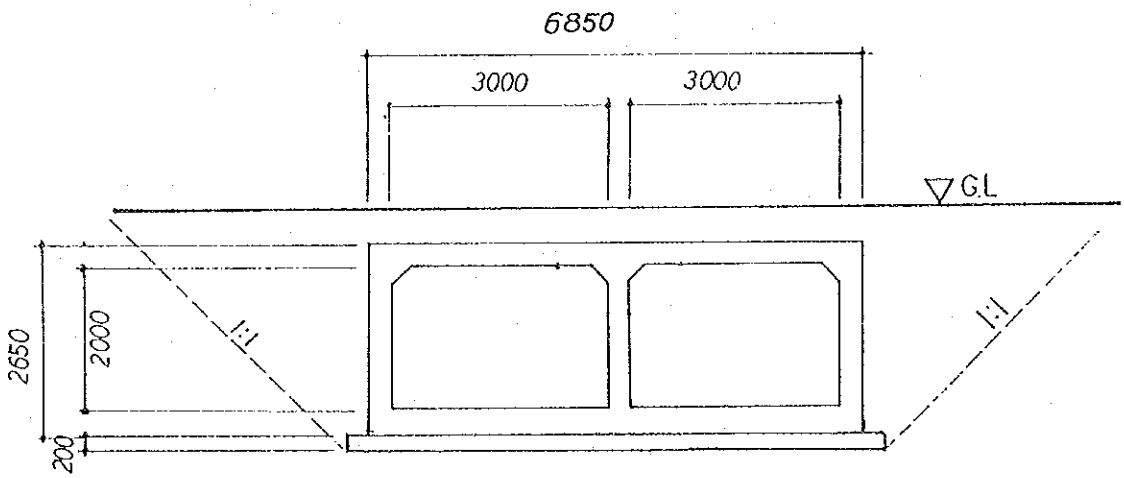


Fig.E.3.2 Bridge and Culvert (2)

LAO PEOPLE'S DEMOCRATIC REPUBLIC FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

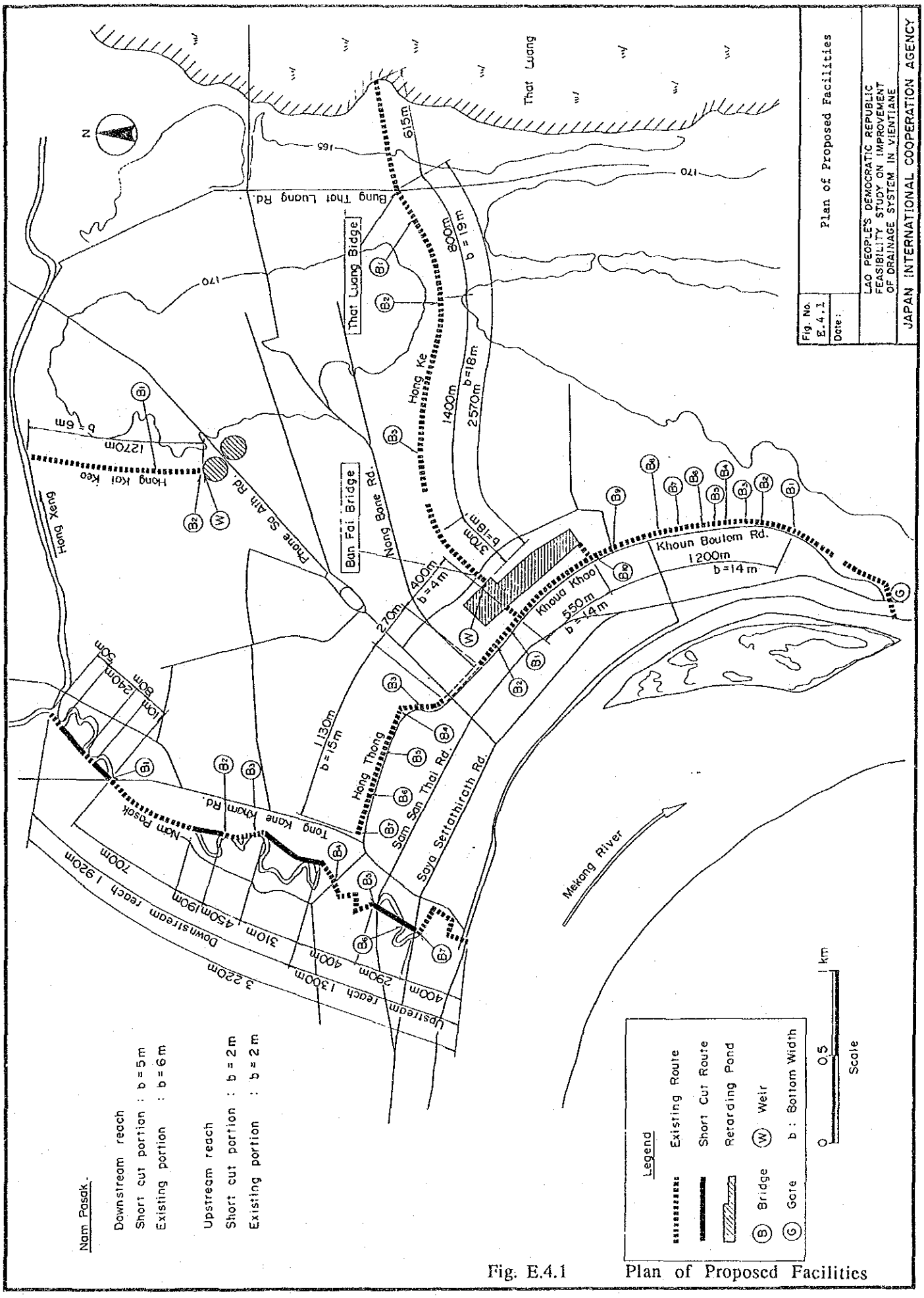
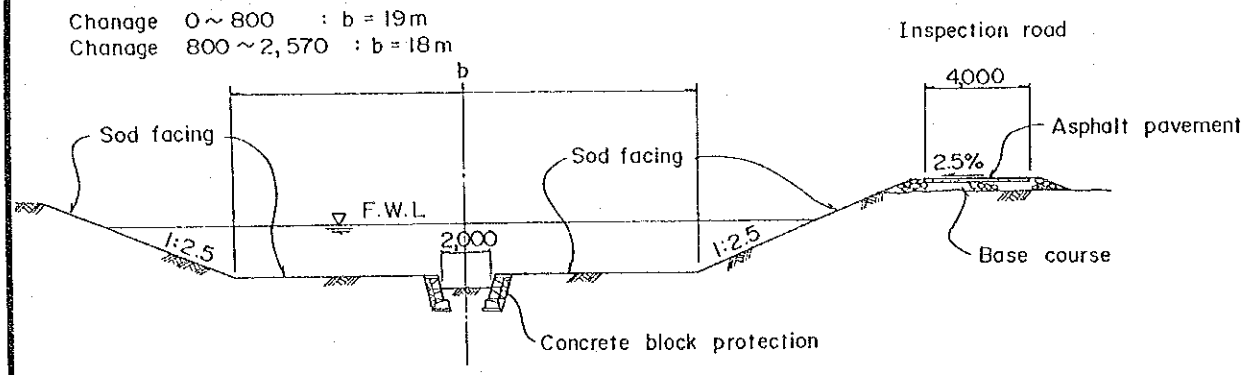
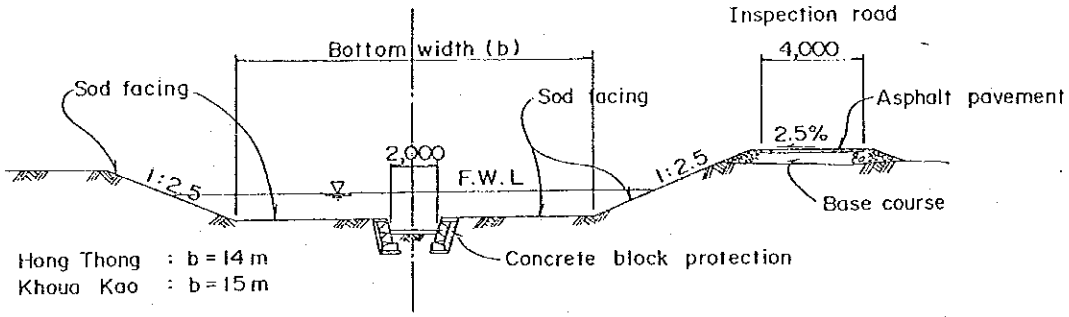


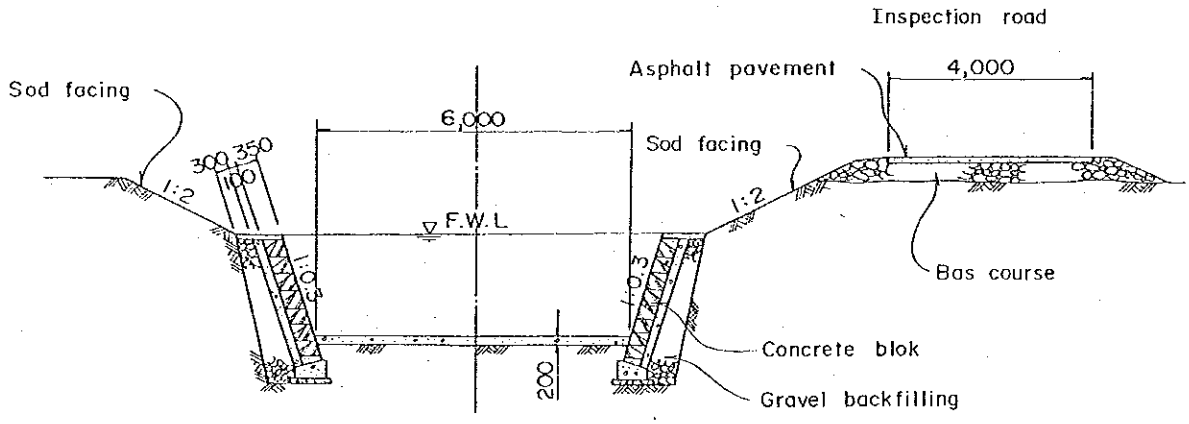
Fig. E.4.1 Plan of Proposed Facilities



HONG KE MAIN CANAL Scale A



HONG THONG MAIN CANAL (Upstream reach of culvert)
KHOUA KAO MAIN CANAL
Scale A



(Downstream Reach of Culvert)

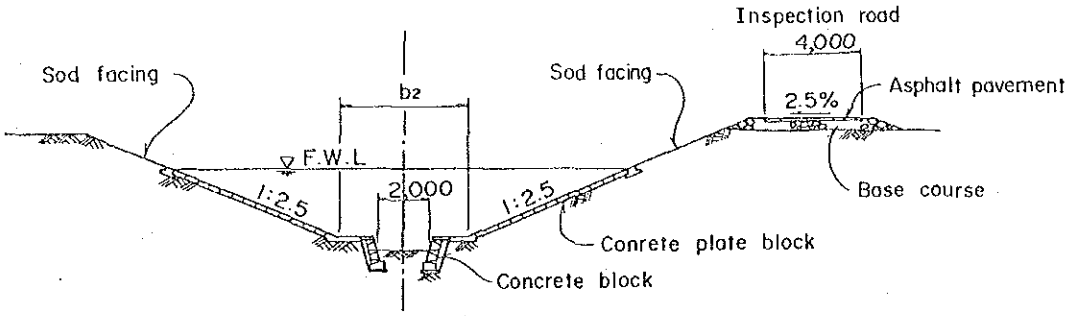
HONG THONG MAIN CANAL Scale B

0 5 10m
Scale A

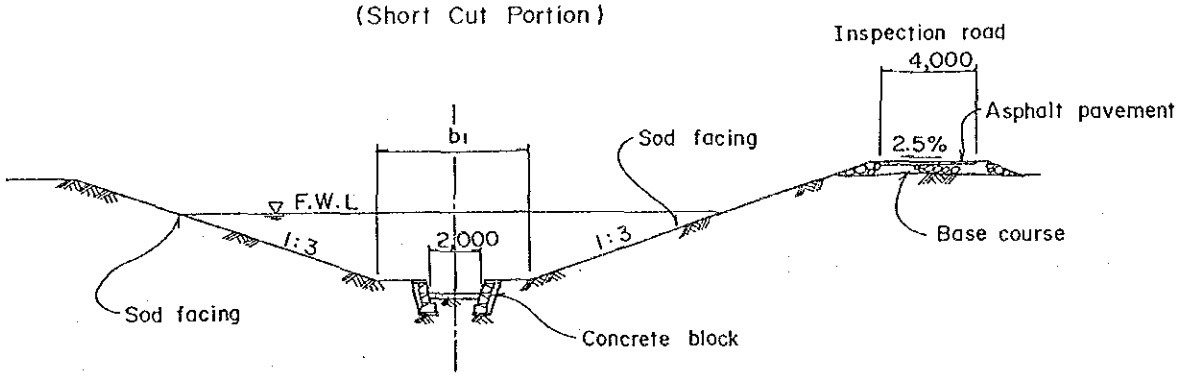
0 5m
Scale B

Fig. E.4.2 Typical Section of Main Canals (1)

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT
OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY



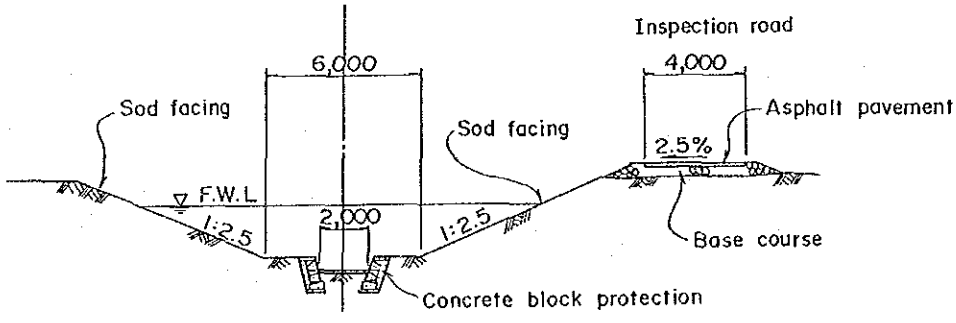
(Short Cut Portion)



(Existing Route Portion)

Chanage 0 ~ 1,920 : $b_1 = 6m$, $b_2 = 5m$
Chanage 1,920 ~ 3,220 : $b_1 = 2m$, $b_2 = 2m$

NAM PASAK MAIN CANAL



HONG KAI KEO MAIN CANAL

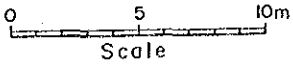
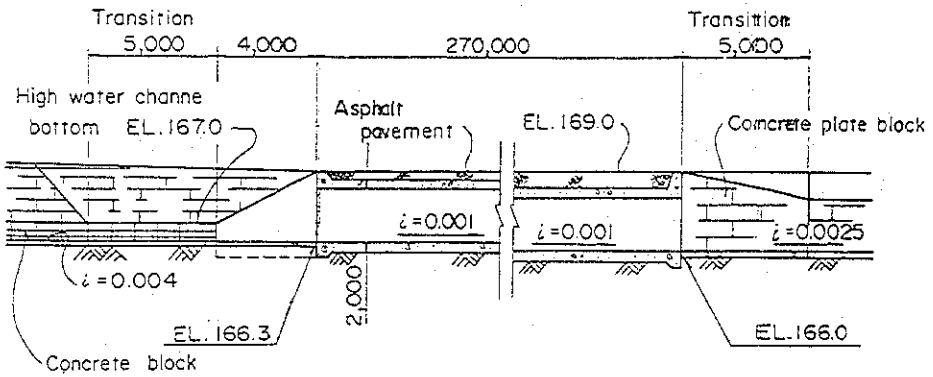
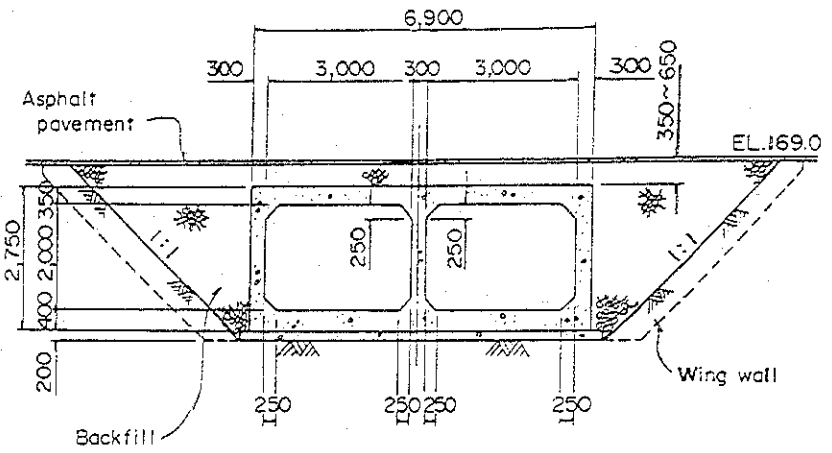


Fig. E.4.2 Typical Section of Main Canals (2)

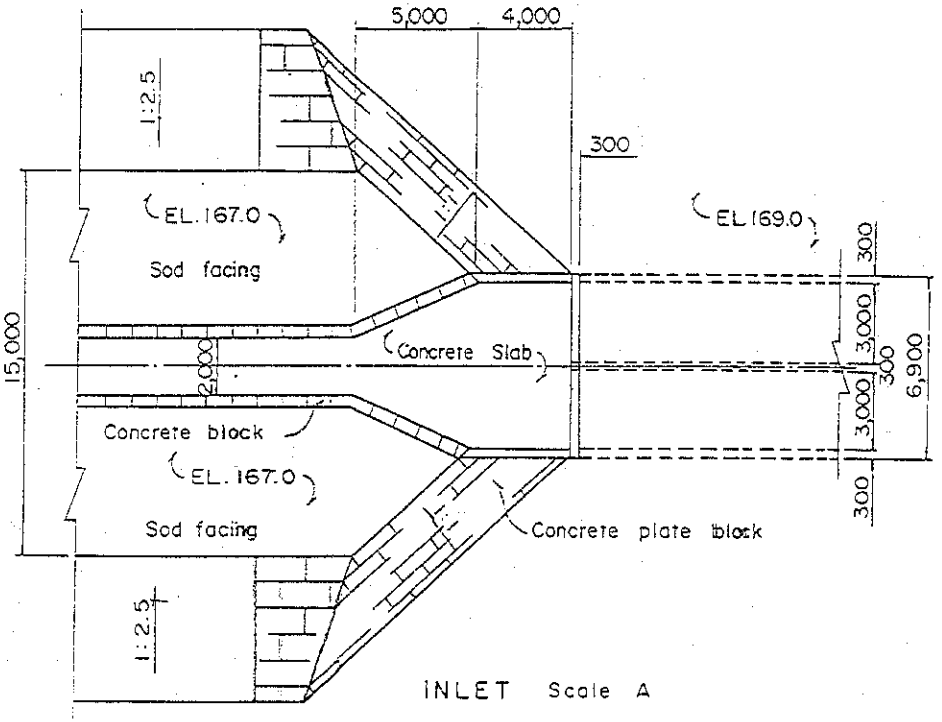
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT
OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY



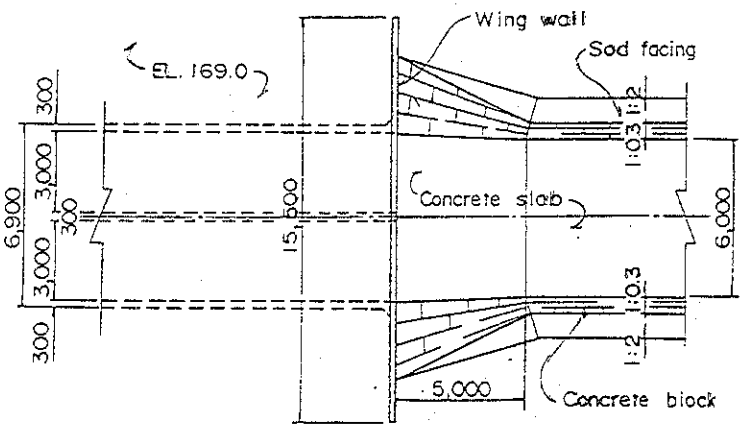
PROFILE Scale A



CROSS SECTION Scale B



INLET Scale A



OUTLET Scale A

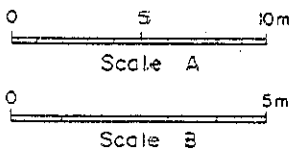
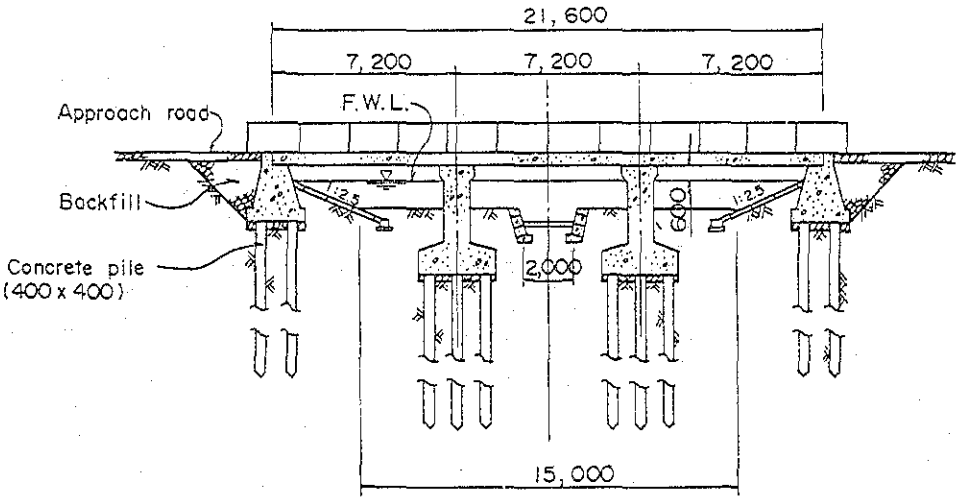


Fig. No. E.4.3	Box Culvert at Morning Market
Date :	

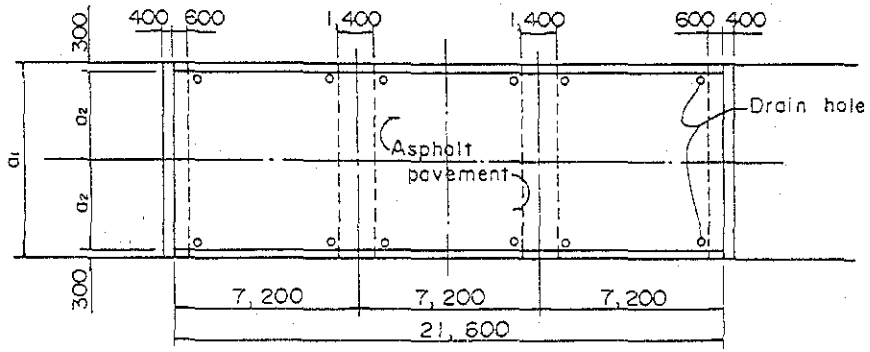
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT
OF DRAINAGE SYSTEM IN VIENTIANE

JAPAN INTERNATIONAL COOPERATION AGENCY

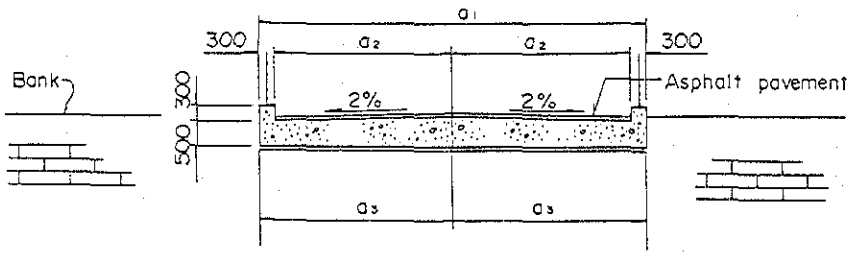
Fig. E.4.3 Box Culvert at Morning Market



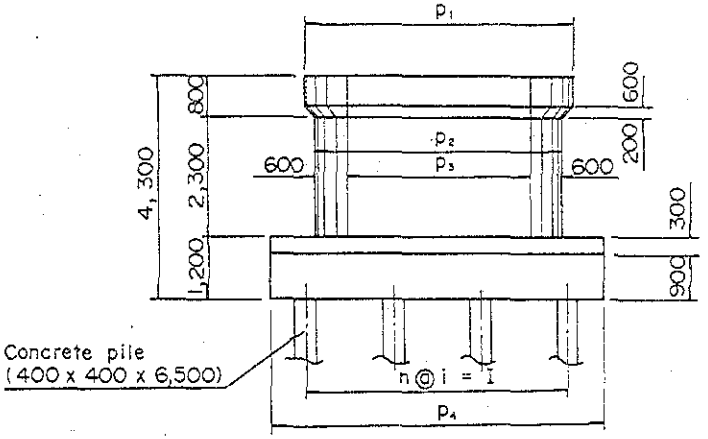
PROFILE Scale A



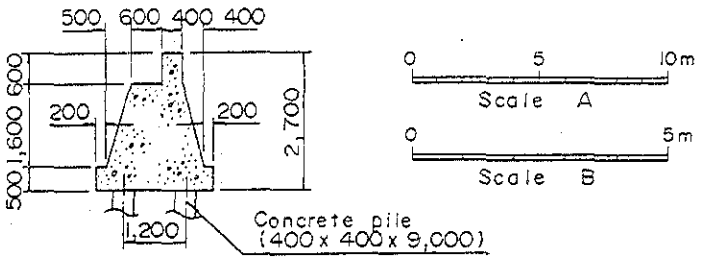
PLAN Scale A



CROSS SECTION Scale B



PIER Scale B



ABUTMENT Scale B

(m)

	No. 1 & 2 Bridge	No. 3, 4 & 7 Bridge	No. 5 Bridge	No. 6 Bridge
a_1	2.6	7.6	2.6	4.6
a_2	1.0	3.5	1.0	2.0
a_3	1.3	3.8	1.3	2.3
p_1	2.6	7.6	2.6	4.6
p_2	2.2	7.2	2.2	4.2
p_3	1.0	6.0	1.0	3.0
p_4	3.9	8.9	3.9	5.9
I	1.3	1.8	1.3	1.4
n	2 nos	4 nos	2 nos	3 nos
I	2.6	7.2	2.6	4.2

Fig. E.4.4 Bridge on the Hong Thong Main Canal

EF - 11

Fig. No. E.4.4	Bridge on the Hong Thong Main Canal
Date:	

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT
OF DRAINAGE SYSTEM IN VIENTIANE

JAPAN INTERNATIONAL COOPERATION AGENCY

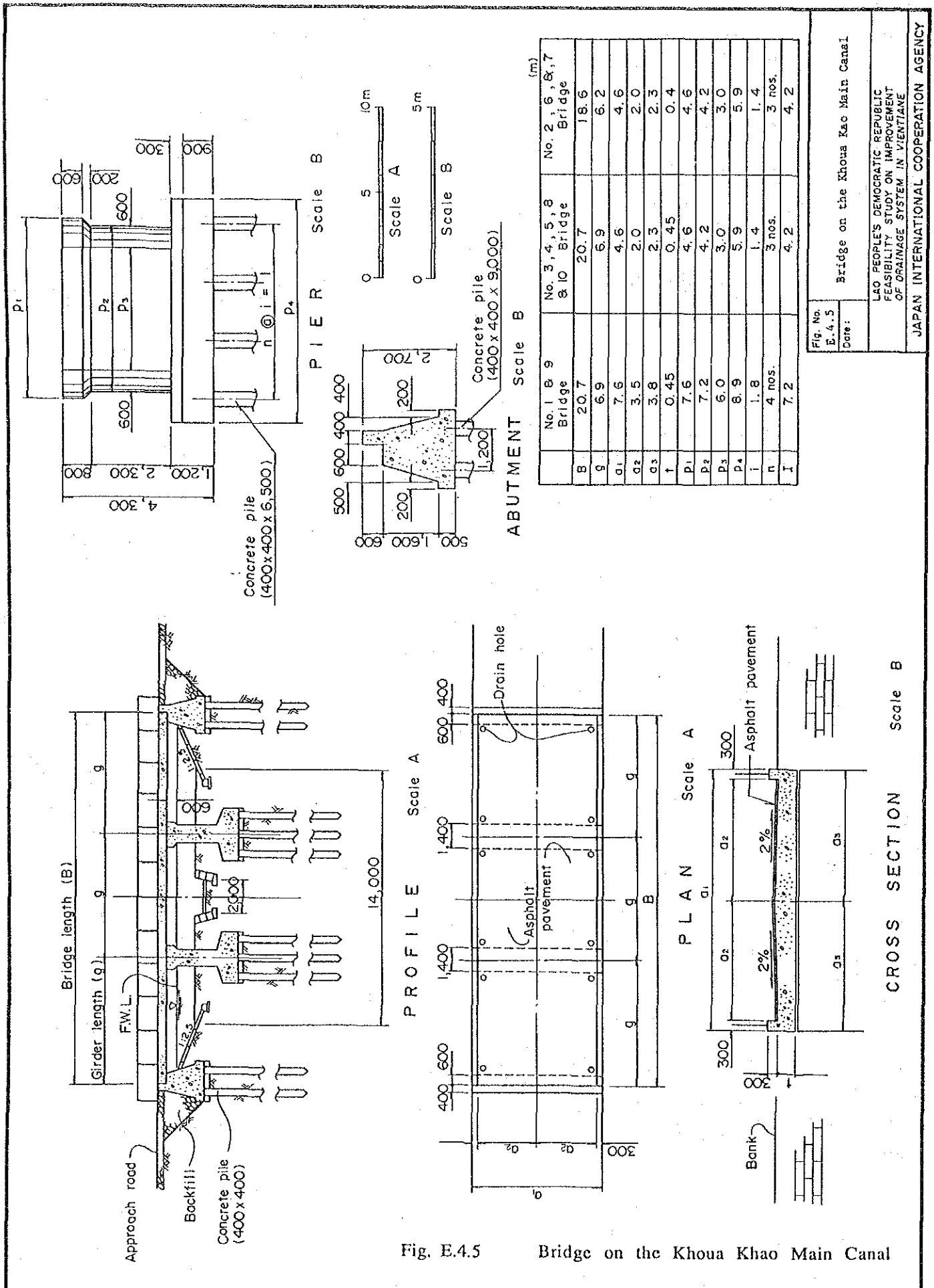
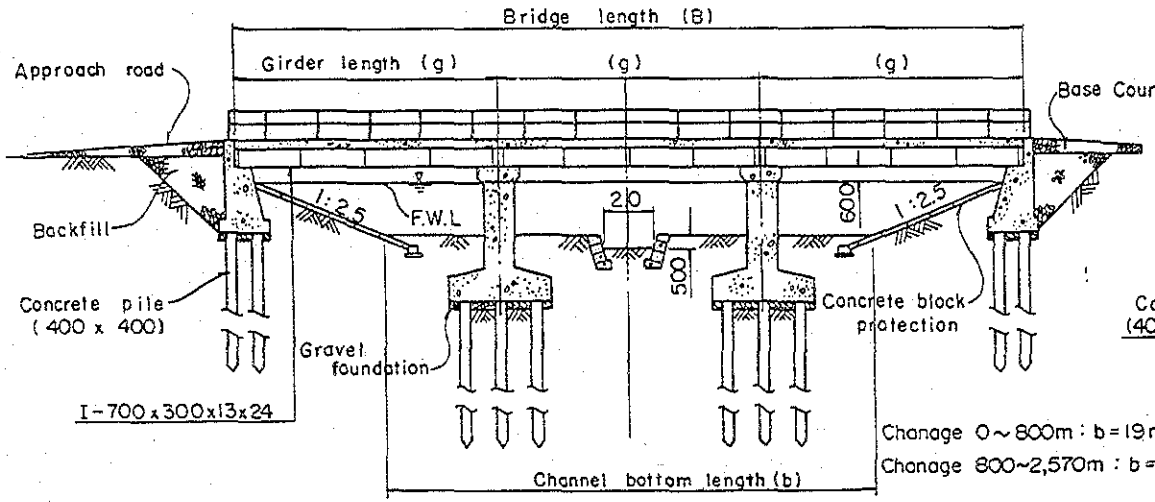
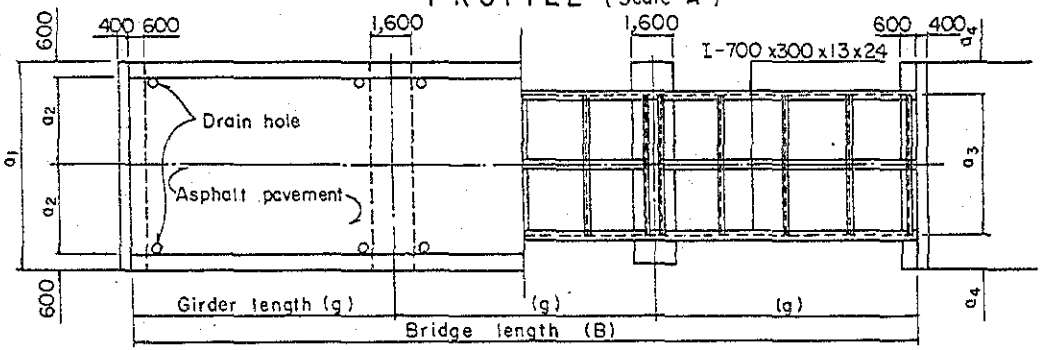


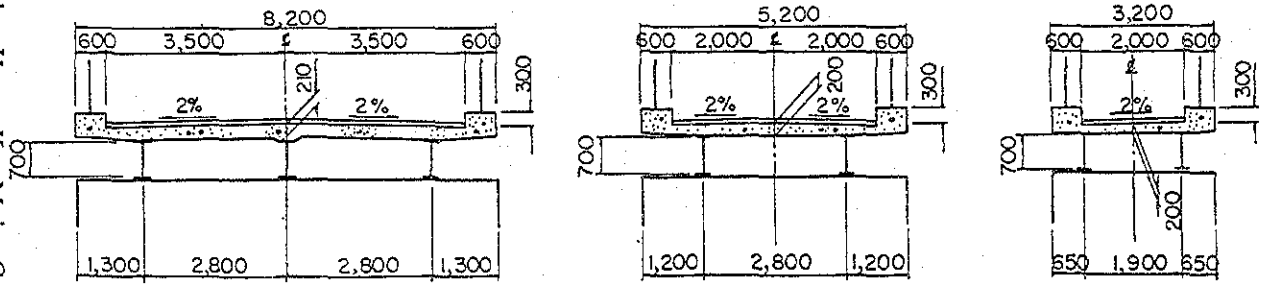
Fig. E.4.5 Bridge on the Khoua Khao Main Canal



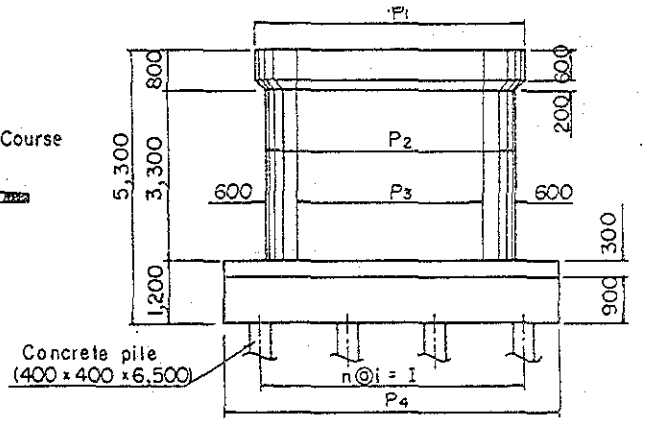
PROFILE (Scale A)



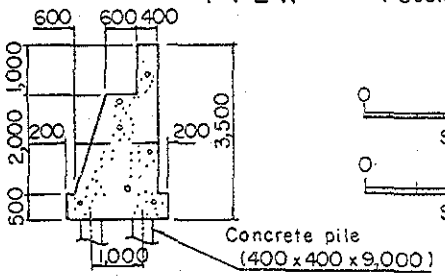
PLAN (Scale A)



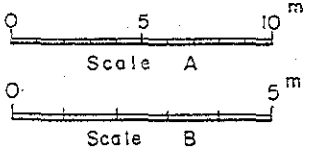
CROSS SECTIONS (Scale B)



PIER (Scale B)B



ABUTMENT Scale B



(m)

	That Luang Bridge	No.1 & 2 Bridge	No.3 Bridge
B	30.6	30.6	29.7
g	10.2	10.2	9.9
a_1	8.2	5.2	3.2
a_2	3.5	2.0	1.0
a_3	5.6	2.8	1.9
a_4	1.3	1.2	0.65
p_1	8.2	5.2	3.2
p_2	7.8	4.8	2.8
p_3	6.6	3.6	1.6
p_4	9.5	6.5	4.5
n	4 nos.	3 nos.	2 nos.
i	1.9	1.7	1.5
I	7.6	5.1	3.0

Fig. No. E.4.6	Bridge on the Hong Ke Main Canal
Date :	

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Fig. E.4.6 Bridge on the Hong Ke Main Canal

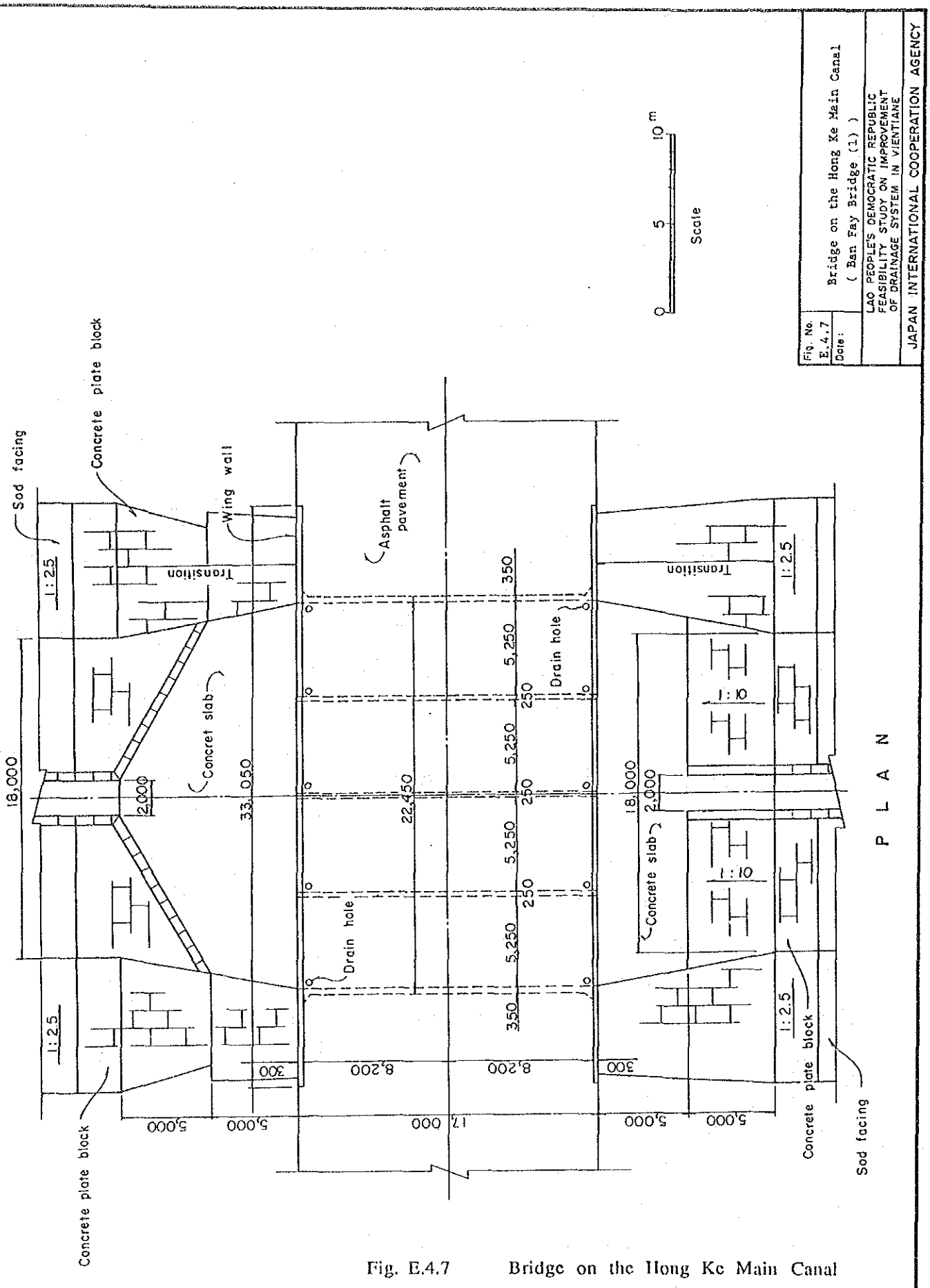

Fig. E.4.7 Bridge on the Hong Ke Main Canal
(Ban Fay Bridge (1))

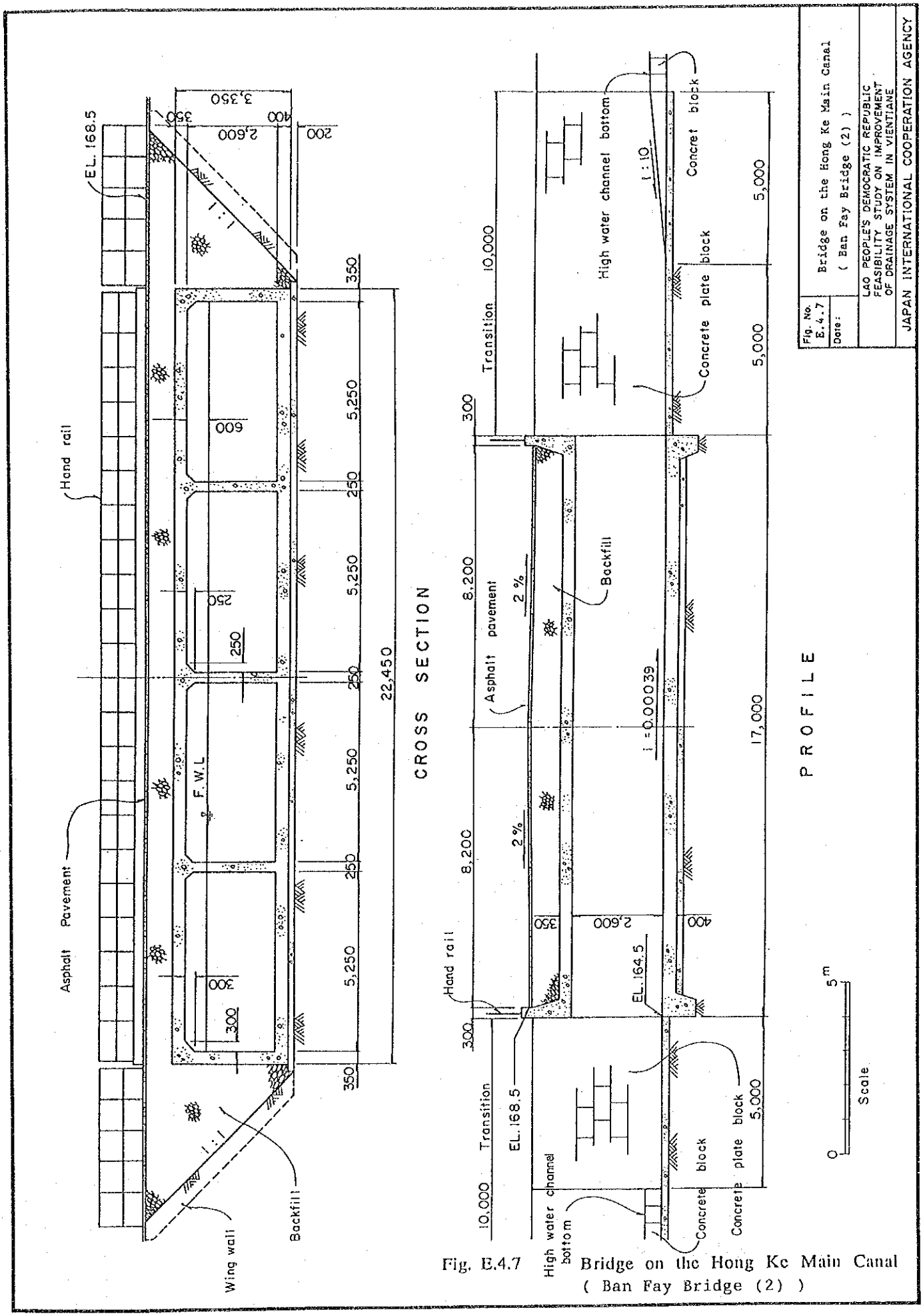

Fig. E.4.7 Bridge on the Hong Ke Main Canal
(Ban Fay Bridge (2))

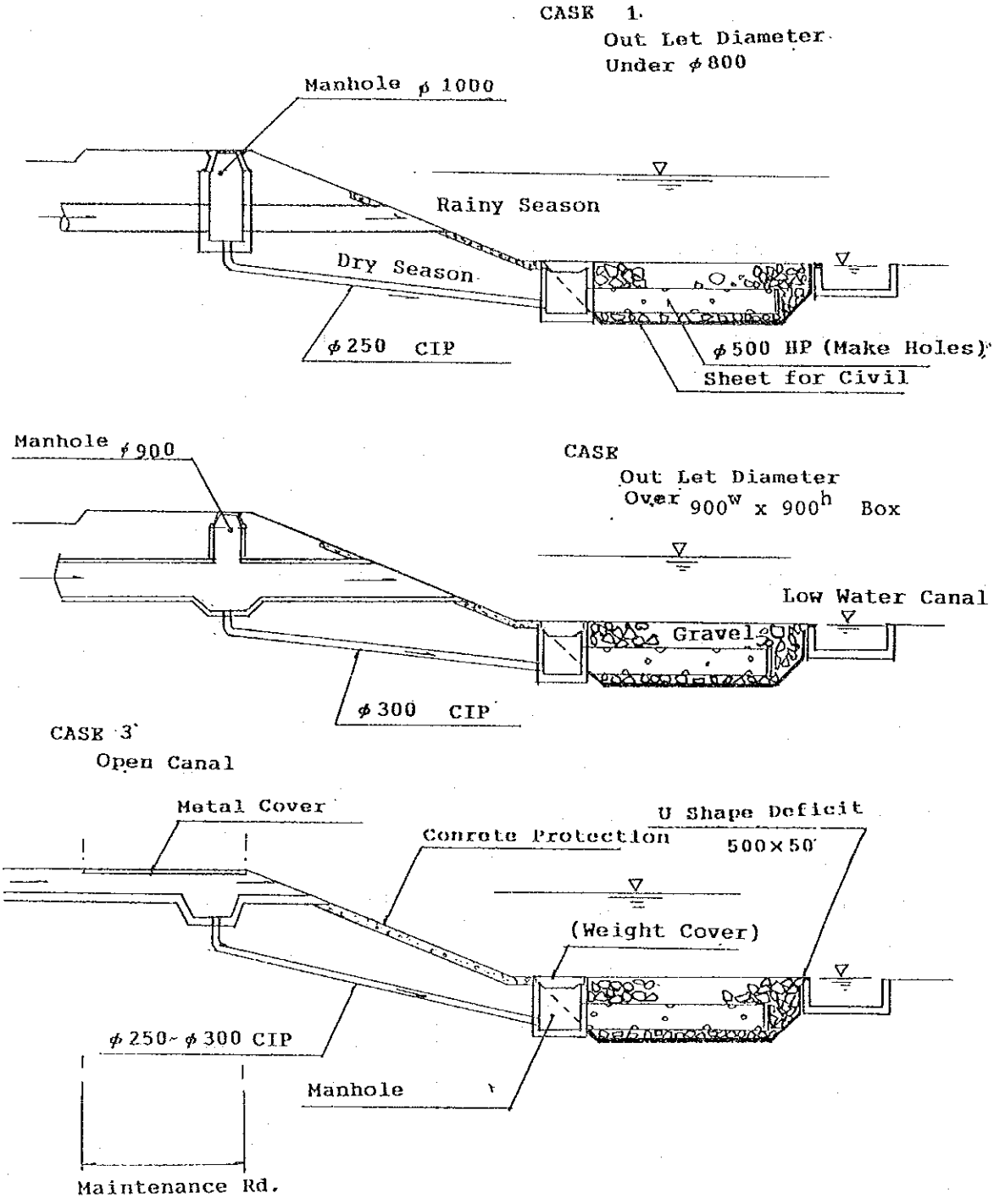

Fig. E.4.8 Typical Section of Box and Pipe Culverts

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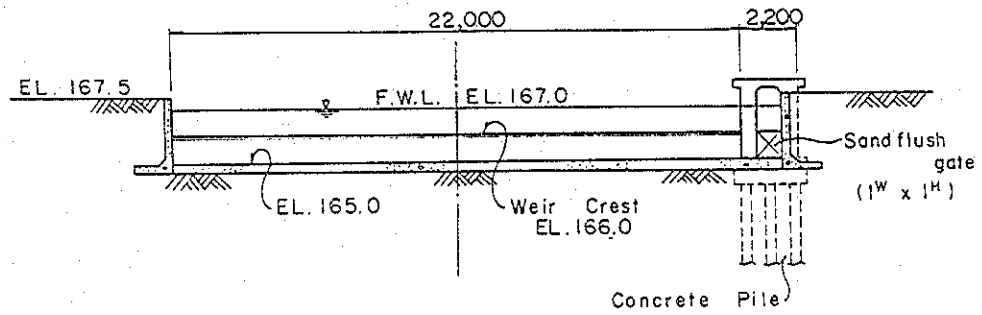
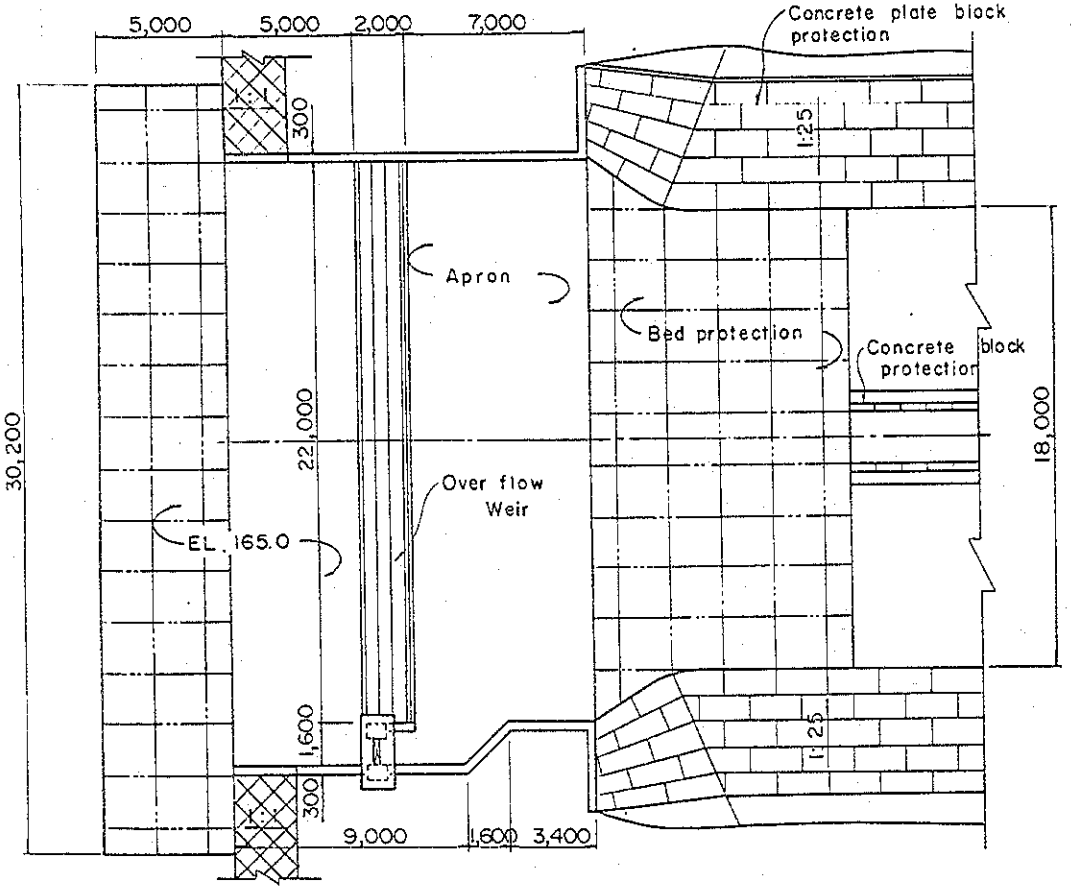
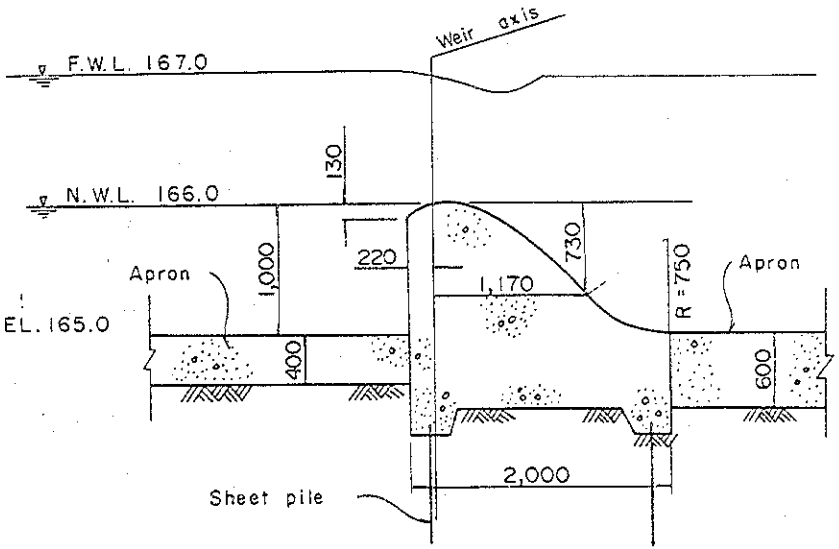


FRONT VIEW (Scale A)



PLAN (Scale A)



CROSS SECTION OF OVER FLOW WEIR
(Scale B)

Scale A 0 5 10 m

Scale B 0 1 2 m

Fig. No. E.4.9	Free Overflow Weir in Nong Chang
Date:	Retarding Basin
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Fig. E.4.9 Free Overflow Weir in Nong Chanh Retarding Basin

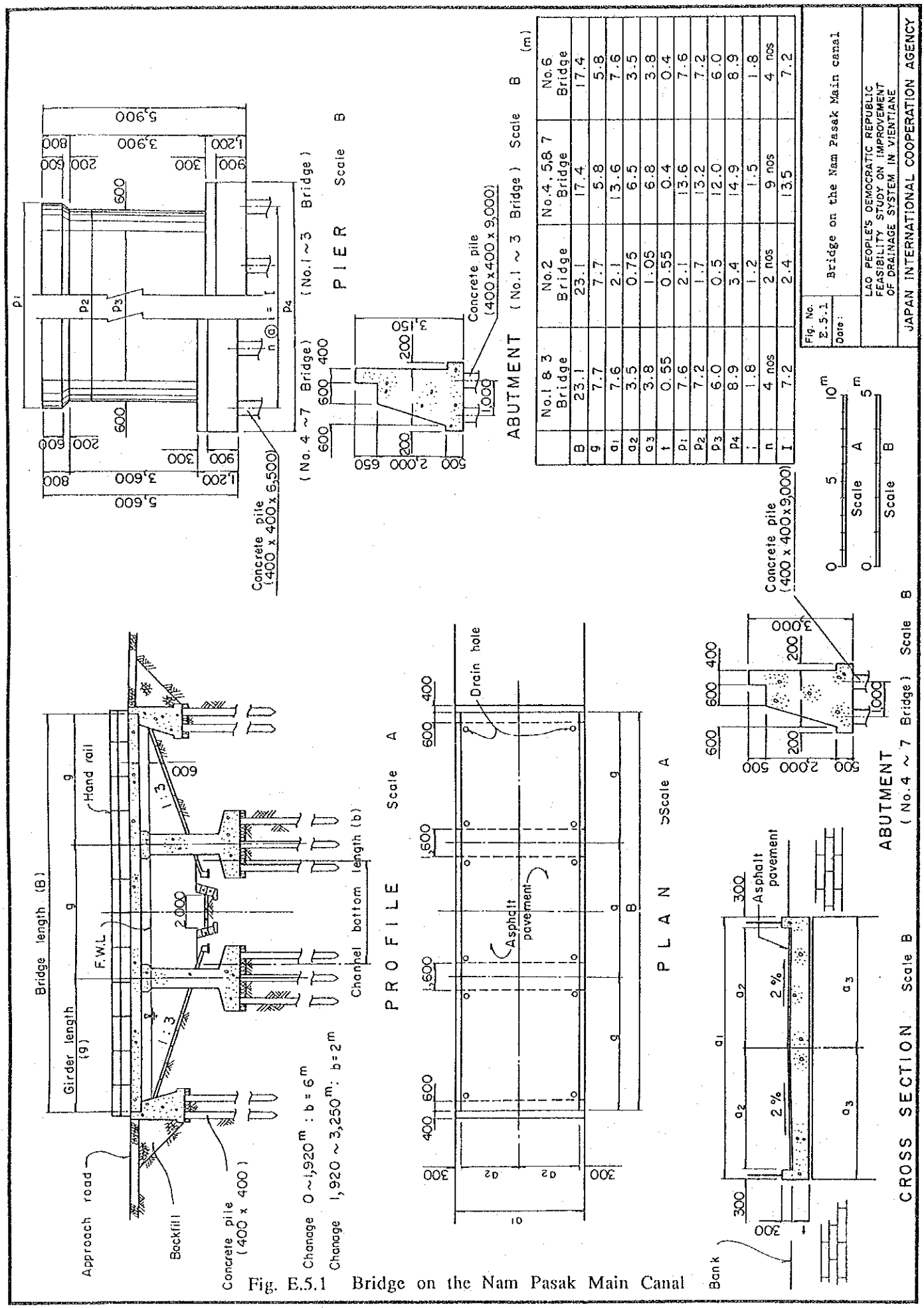

Fig. E.5.1 Bridge on the Nam Pasak Main Canal

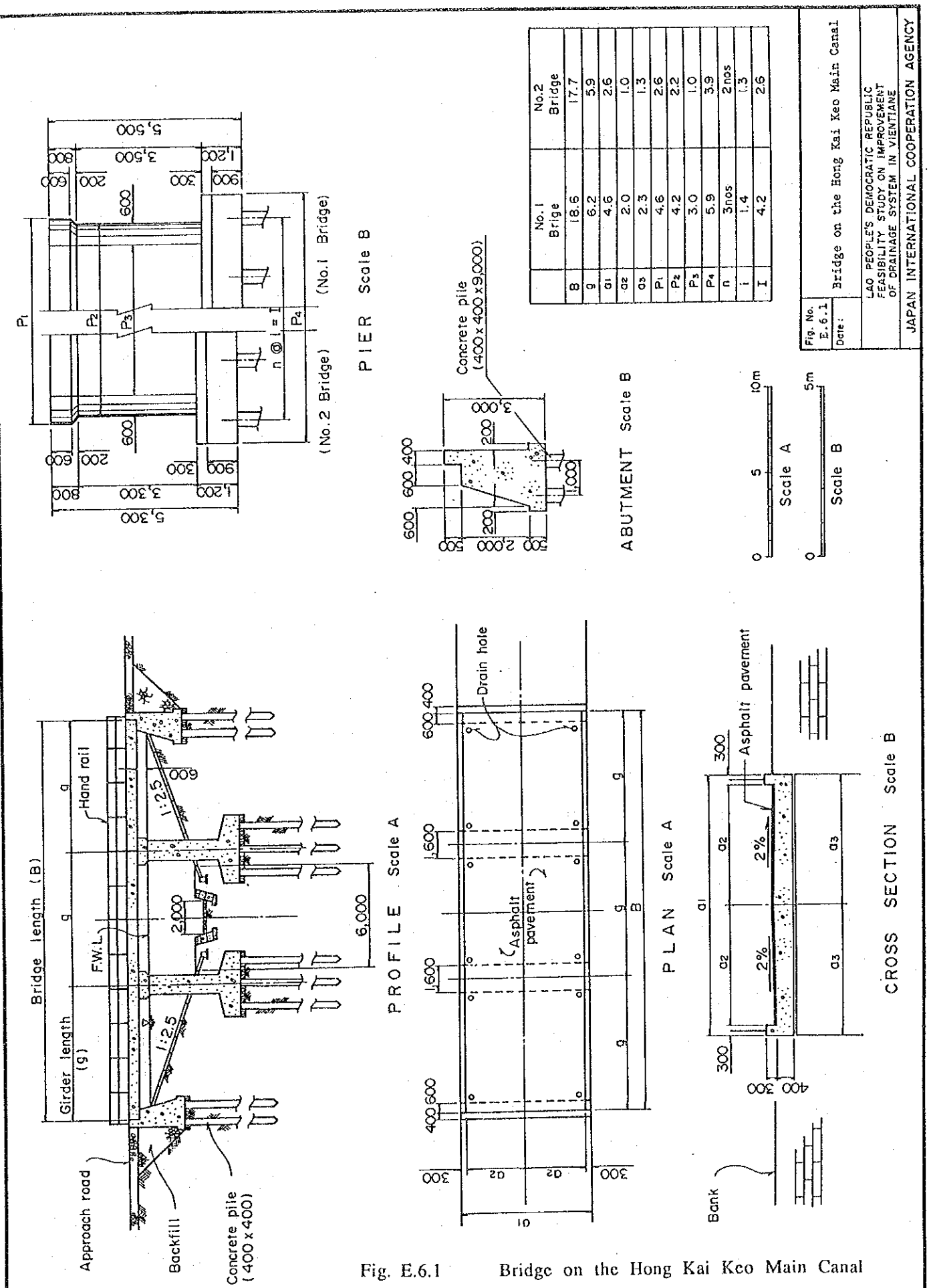

Fig. E.6.1 Bridge on the Hong Kai Keo Main Canal

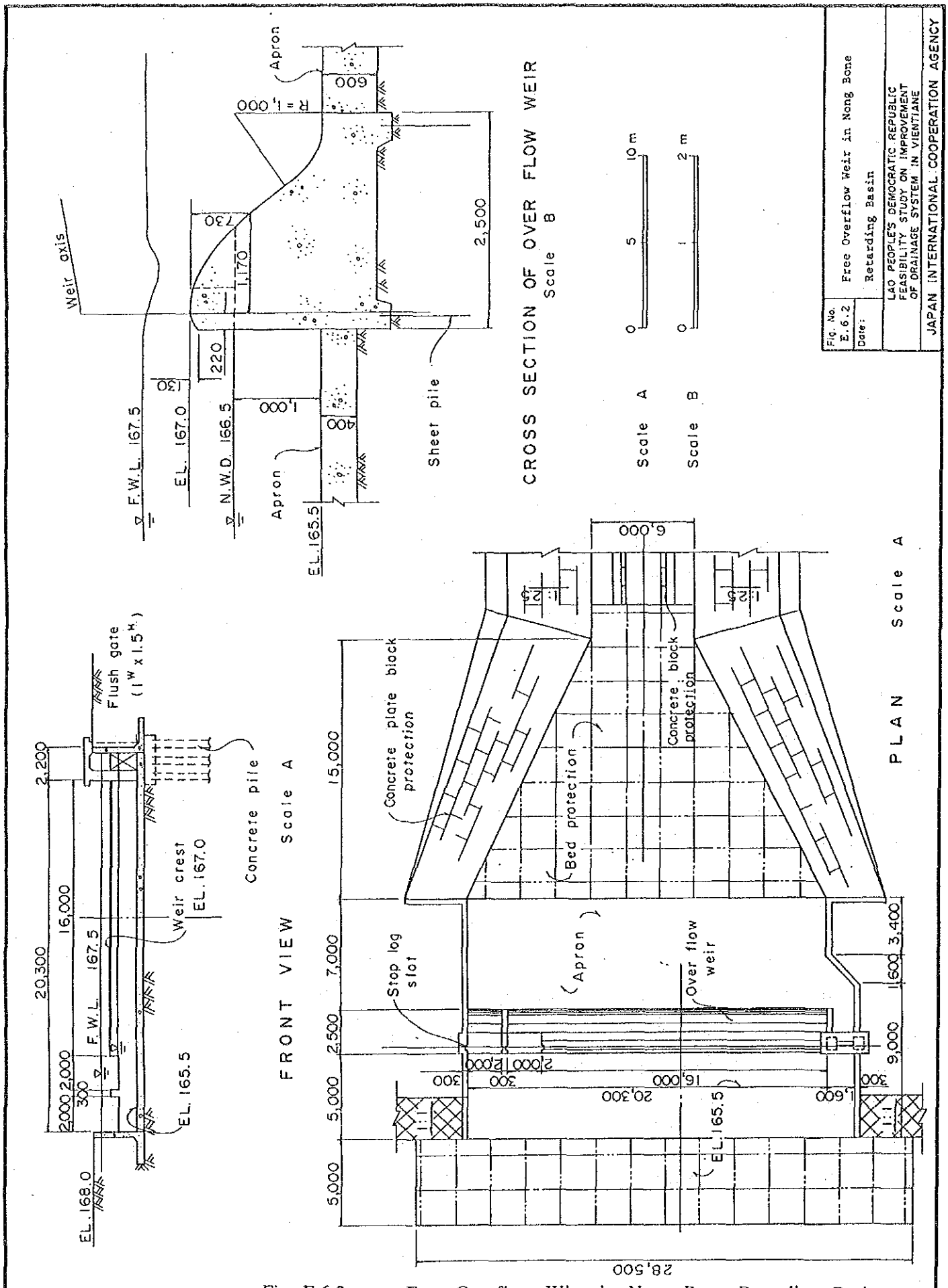

Fig. E.6.2 Free Overflow Wire in Nong Bone Retarding Basin

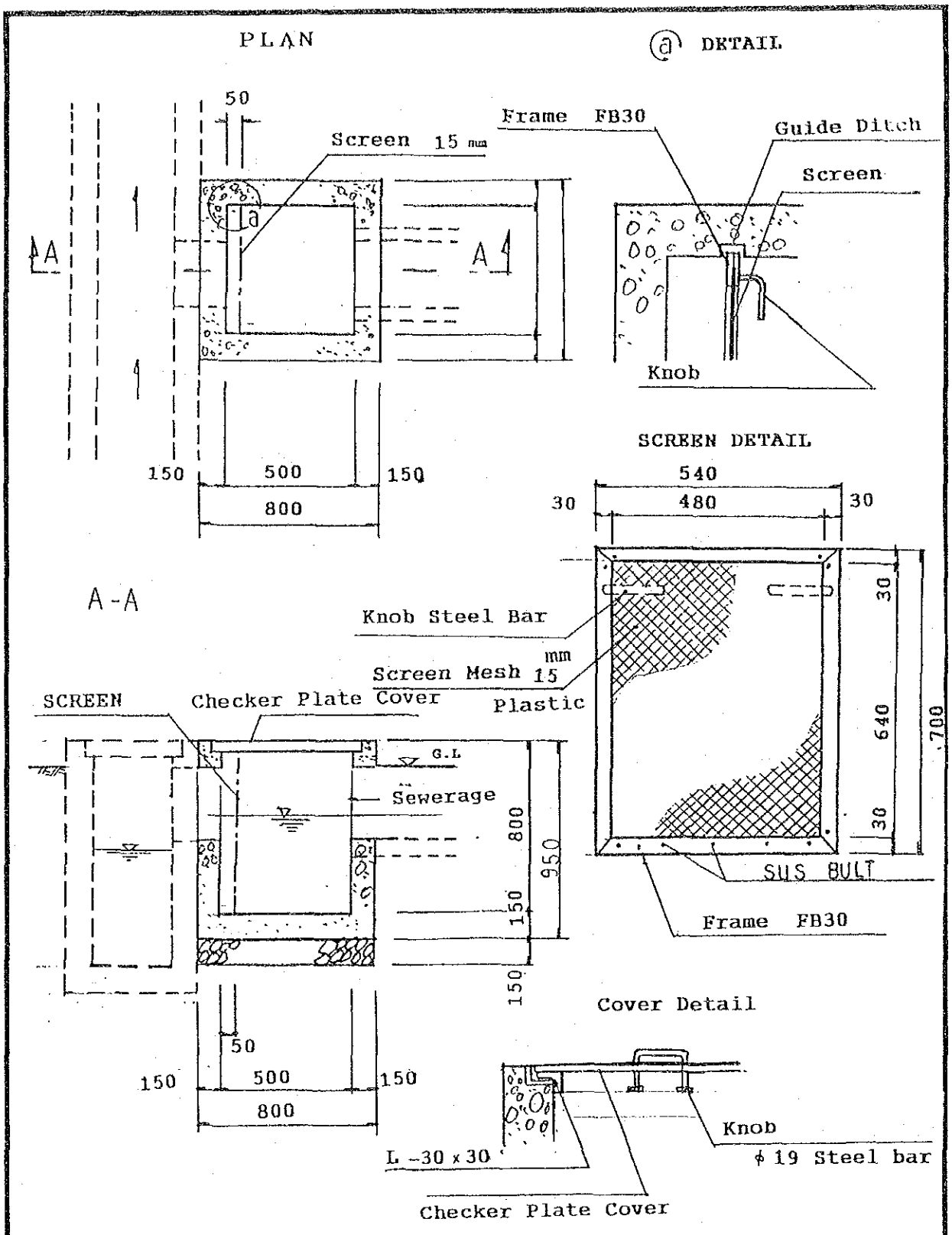

Fig.E.7.1 Treatment Facility (1)
Mesh Screen

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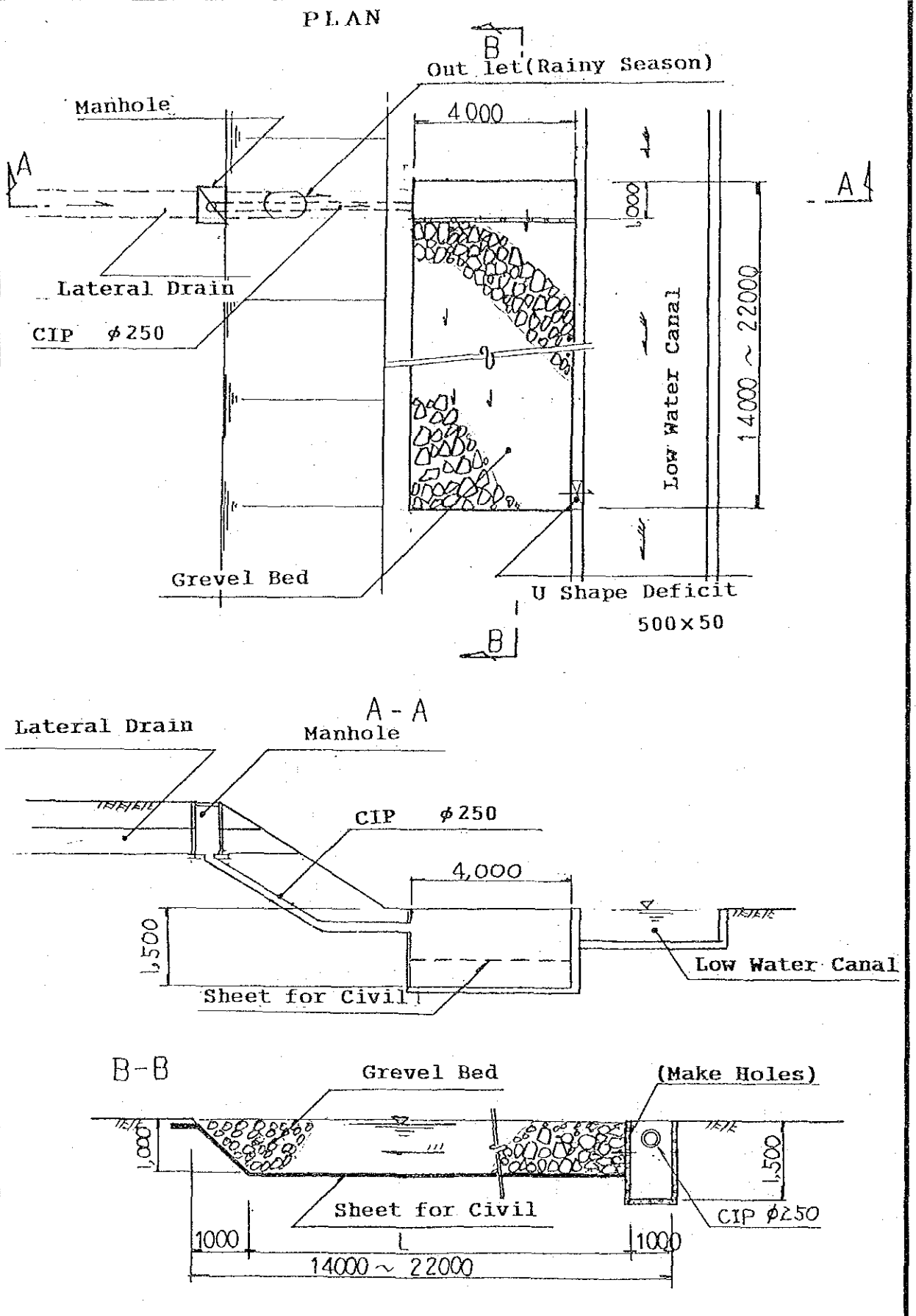

Fig.E.7.2 Treatment Facility (2)
Gravel Purification

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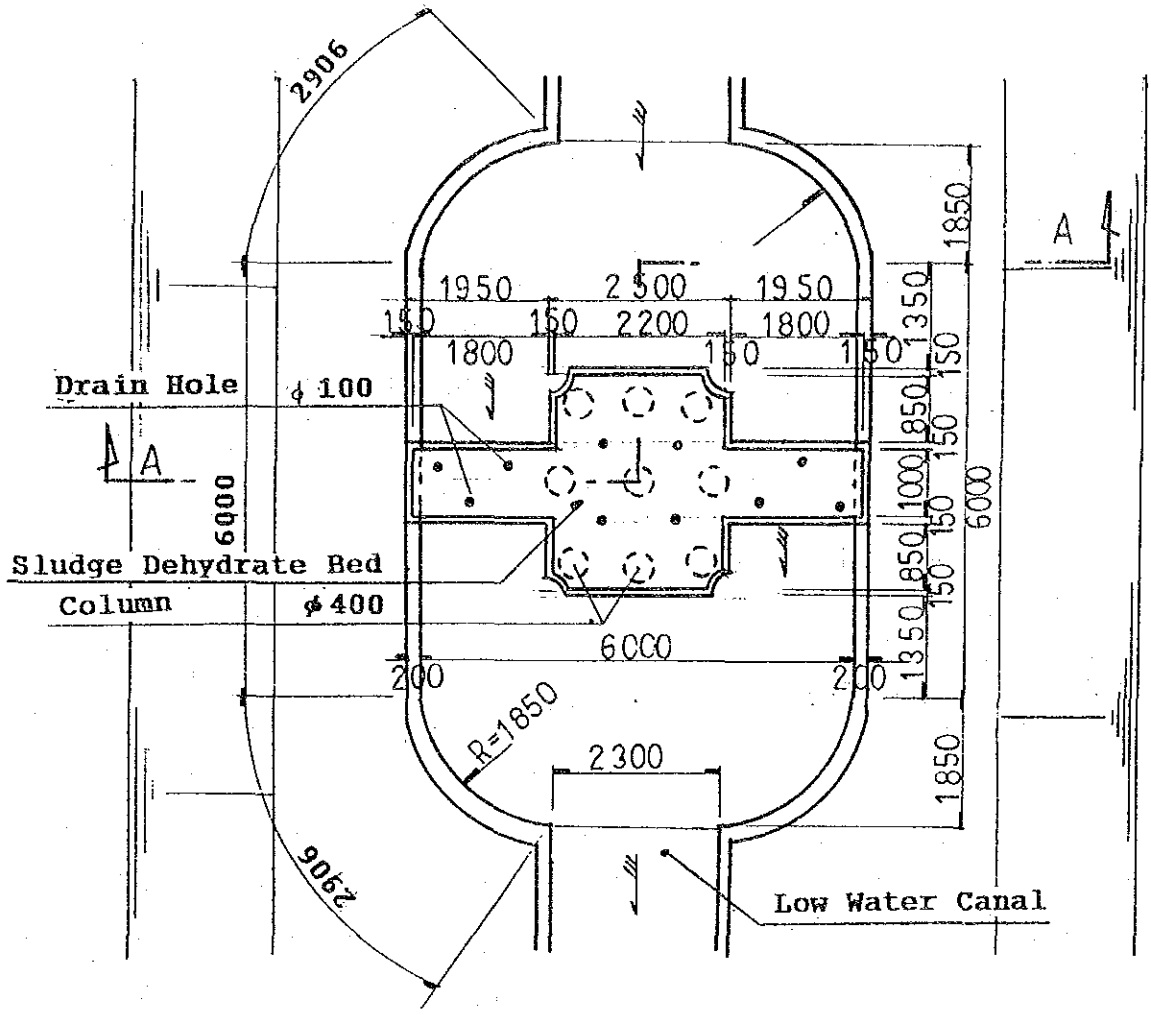
PLAN



A - A

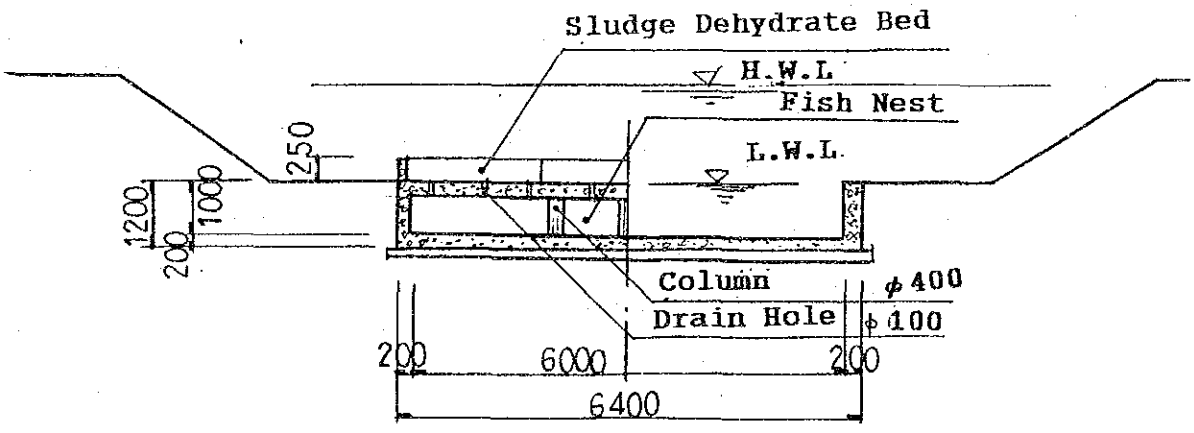


Fig.E.7.3 Treatment Facility (3)
Sand Basin

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